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Patent Portfolio Structure for Single Technology Companies

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Abstract

Patent Portfolio Structure for Single Technology Companies

Single technology companies (STCs) are defined in this thesis as companies that (a) have the fundamental rights to a new technology, (b) have development of that technology as their core competence, (c) seek to exploit that technology primarily by licensing the patent rights, and (d) are driven primarily by 'technology push'. These factors often result in much of the value of the STC residing in its patent portfolio. This in turn may place significant – and often conflicting - demands on the Intellectual Property (IP) Manager of the company. A review of the literature reveals a lack of guidance for the IP Manager, exacerbated by inconsistent terminology.

To provide the IP Manager with suitable tools, this thesis explores the logic behind patent portfolios, optimal patent portfolio structure for STCs and a risk management (RM) approach to patents. Three stages in the patenting decision process are identified together with associated responsibilities, some of which extend beyond the IP department. Fundamental concepts of external Risk Factors/internal Objectives and Patent Relationships are also proposed.

A real-life patent portfolio belonging to an actual STC is reviewed, with a previously abstract literature method being adapted to depict that portfolio. Several Patent Relationships are found and the hitherto unexplored characteristic of 'Advantage' is identified as a way of showing other Patent Relationships. When applied to a second real-life portfolio, this reveals a new model for patent portfolio structure – the three-dimensional Scope/Advantage/Integration diagram – as well as highlighting that portfolio structure is determined by Risk Factors and Objectives that will be different for each STC.

The thesis finishes with an examination of patent risk, particularly patent invalidity. Invalidity modes in Europe and the US are considered in detail and a comprehensive review of patent data sources is carried out. Results from two previously unexplored data sources are found to be consistent with trends proposed in the literature.

Contents

CHAPTER 1
Introduction

1.0 Introduction

This thesis describes research in the field of Patent Portfolio Structure for Single Technology Companies.

This chapter of the thesis starts by explaining the background to the research and the initial research objectives. It then gives an overview of the stages of the research and the various methodologies used. It finishes with a summary of the key findings.

1.1 Background

To understand the motivation for the research, it is helpful to look at the background of the author, the type of companies that he has worked for and the state of the literature in the field in which he works.

1.1.1 Background of the Author

The author's interest in the topic of patent portfolio structure stems from his career in patents: having graduated in engineering and qualified as a Chartered Engineer with Rolls-Royce Aero Engines, he joined the European Patent Office (EPO) in 1989 as a Substantive Examiner in the automotive field, specialising in automotive suspensions. It was here, examining patent applications from competing companies large and small, that the author first became interested in the strategy underlying the applications that he was examining.

The author's interest became more of a need when he left the European Patent Office in 1994 to become Intellectual Property Manager (hereafter 'IP Manager') for Xaar Ltd, a 30-strong company set up in 1990 to exploit a piezoelectric inkjet printhead technology originally developed and patented by Cambridge Consultants Ltd. The author's brief was to manage the patent portfolio so as to optimally support the company's licensing business model without overstretching the (limited) company budget. However, this licensing business model also meant that most of the company's value resided in the patent portfolio: accordingly, he found himself also having to advise the company's senior management and venture capital investors whenever questions of risk to the strength of the portfolio arose. It was partly with a view to being able to provide justifiable answers to such questions that the present research was commenced in 1996.

The research continued to remain relevant when, in 1999, the researcher was asked to manage the IP for Cambridge Display Technology (CDT) Ltd. By this time, Xaar had grown to more than 100 employees, founded a niche manufacturing business and listed on the London Stock Exchange. CDT in contrast was another small, venture capital funded start up, again operating a licensing business model, this time based on light emitting polymer technology invented at Cambridge University's Cavendish Laboratory. At about the same time as the researcher joined, 90% of the company was purchased by two New York investment banks for $100 million, emphasising the value put on the company's intellectual property.

For the past three years, the researcher has worked for the firm of patent attorneys that acts for NXT plc, a licensing-based business that was valued at over a billion pounds at the height of the stock market boom in 2000. According to its mission statement, 'NXT's business is the invention, patenting, licensing and marketing of enabling technologies in sound and speech'. Although the author no longer carries direct responsibility for patent portfolio management, he is nevertheless involved in advising the company on a day-to-day basis. Accordingly, the research is as relevant as ever to the author in particular and IP Managers in general.

1.1.2 The Single Technology Company (STC)

Xaar, CDT and NXT are all examples of Single Technology Companies (hereafter referred to as STCs) which, for the purposes of this research, are defined as companies that:

(a) have the fundamental patent rights to a new technology;

(b) have development of that new technology as their core competence;

(c) seek to exploit the technology primarily, if not exclusively, by licensing the patent rights; and

(d) are driven primarily by 'technology push' rather than 'market pull'.

It will be appreciated that the first three factors above will combine to cause a high initial cash burn rate that will only be offset once the technology and accompanying licensing routes have matured sufficiently to generate income. A typical timescale for this is of the order of eight years. Obviously, until this latter stage is reached, there is heavy pressure on costs. The same factors may also result in the majority of the company's value residing in the patent portfolio. This puts particular pressures on the IP management of such companies as discussed below.

1.1.3 Pressures on the IP management of an STC

Satisfy Investors

Although a patent portfolio is only a means to an end, namely a return on an investment made in a company, investors nevertheless look for growth in a company's patent portfolio as a sign of company health. This can be particularly the case if the company is short of other signs of progress. Yau (1999) notes that investors can be encouraged to value companies based on sheer numbers of patents filed. Such a concern with numbers is not restricted to investors, who might be forgiven for concentrating on numbers if they do not understand the technology and/or the market. Warshofsky (1994) reports Microsoft's Bill Gates as having advocated 'patenting as much as we can'.

Against such patent portfolio growth is not merely the fact that the associated filing and prosecution activity consumes scarce cash. There is also the question of the patentability of new developments made in the company given that they will mostly relate to an existing technology which is already known. Furthermore, since this existing technology is already the subject of patents, it can be questioned what, if any, extra value new filings will add: as noted by Jorda (2003), in most patent transactions a package of patents (issued patents, pending applications, rights to apply for patents) is the merchandise, but the purchase price or royalty is not cumulative.

These latter concerns were summed up by Helen Young, CEO of US technology company Motorola, in her comment that 'Motorola has over 1000 US patents granted each year, but we are now looking hard at what we have patented and asking - was it really worth the time, effort and cost to patent in all these cases ?'.

Satisfy Senior Management

The senior management of a single technology company should, by definition, be more familiar with the technology than investors and consequently in a better position to judge the likely value of new filings. They may also be more aware of the day to day impact of patent bills on the company's cash reserves.

Nevertheless, they are likely to be finance or technology professionals and as such uncomfortable with the uncertainties and intricacies inherent in the patent system. These uncertainties include the possibility of a patent not being granted, or overturned after grant. A similar situation exists with R&D where Roussel (1991) notes that CEOs are temperamentally and culturally uncomfortable dealing with what they perceive as uncertainty.

As a result, senior management typically avoid involvement in management of the patent portfolio, leading to ignorance of the risks and increasing the likelihood of a mismatch between the portfolio and the company's business strategy. This is not helped by patent attorneys whose legal training equips them to identify all the possible pitfalls but does not provide them with the data to put the risk of those pitfalls in the perspective of the business overall. Thus, when problems do arise, there is often surprise, anger and blame.

As all management should know, a better approach from the perspective of both the individual and the corporation is to manage the risks associated with patenting. Chapman and Ward (1997) list the corporate benefits of a risk management culture inter alia as less wasted effort, fewer crises, better communication and more congruent objectives.

Furthermore, risk management does not necessarily mean increased expenditure on risk avoidance. Barnes (1993) points out that those who are successful are neither risk averse nor are they gamblers: they calculate the risks, establish where risk may be taken / should be avoided and take actions to reduce costs / increase risks before taking the decision to go ahead.

Satisfy Technologists

A company's technologists typically see patent filings as an acknowledgement of technological merit and having patent applications filed for their new ideas is important to their motivation. Without such motivation, the likelihood of the company successfully achieving its objectives is much reduced.

However, as inventive individuals, technologists are quite likely to come up with ideas that fall outside the core technology on which a single technology company may have been founded. An unfocused programme of patent filings to such ideas will consume substantial resources to no commercial effect and so be damaging to the success of the company.

1.1.4 State of Knowledge regarding Patent Portfolio Structure

A detailed discussion of the literature follows later in the thesis. However, to summarise, it was the lack of information of use to the STC IP Manager in dealing with the problems mentioned above that prompted the current research.

As a European Patent Attorney himself, the researcher was familiar with many books and journals dealing with the practices of the various patent offices that grant patents and the various courts where patents are litigated. Aimed at patent attorneys, IP solicitors and barristers, such literature is concerned with the patent offices' and courts' interpretations of the patent statutes as evidenced by their decisions on particular patents and patent applications. As such, it can be said to be based on hard data. However, such literature only comes into play once a patent application has been filed. Furthermore, since it never looks beyond the prosecution or litigation of individual patents, it provides no guidance to the IP Manager on the structure of a patent portfolio.

The researcher had initially been introduced to literature on the commercial aspects of patents by means of a 'Review of Press Articles relating to Patents' that was circulated within the EPO on a monthly basis. This was subsequently supplemented by the journals and proceedings from the international Licensing Executives Society and the R&D Society in the UK. Although addressing some of the problems of the IP Manager, this literature was overwhelmingly based on opinion and personal experience, often of very specific circumstances, rather than on hard data. As such, it was difficult to defend against the opinions of others and was therefore not really suitable as the basis for a patenting strategy that an IP Manager might wish to justify to the company board.

The researcher was aware that hard data on patenting had been published by academic institutions such as the Science Policy Research Unit (SPRU) at Sussex University. However, initial investigations revealed that this was very much at the macro level, being based on patent office statistical and bibliographic information. Although perhaps of interest to government policy makers and certain companies having very large patent portfolios, it provided nothing of use to the IP Manager of the STC.

Finally, there was the launch in 1996 of a Research Programme on Intellectual Property by the UK Department of Trade and Industry and the Economic and Social Research Council. This is discussed in more detail in the Literature Review chapter. Although generally of value in highlighting broader issues surrounding intellectual property, none of the research projects addressed the question of patent portfolio structure for the single technology company.

1.2 The Research Objectives

The research objectives address the aforementioned problems facing the IP Manager and deficiencies in the state of knowledge. They are:

1.2.1 Research Objective: Investigate structure and logic of patent portfolios

In particular, understand what the properties of a patent portfolio are or should be and how they influence the commercial effect of the portfolio. Ideally, find a means of visualising those properties so as to facilitate communication and discussion.

1.2.2 Research Objective: Investigate optimal Patent Portfolio Structure for STCs

In particular, build on the results of the first objective to establish the optimal properties of a patent portfolio for a single technology company. Such information should allow an optimal patent portfolio to be assembled for any set of technological and commercial circumstances. Where a patent portfolio is already in existence, it should provide a basis on which to decide whether to file patent applications to any new technological developments.

1.2.3 Research Objective: Investigate a Risk Management Approach to Patents

In its broadest sense, this objective was to investigate the extent to which a risk management approach, with the concomitant 'soft' benefits mentioned above, might be applied to IP management. Of specific interest, however, was the management of the risk of invalidity of components of a patent portfolio on which an STC is based.

1.2.4 Research Objective: Investigate Data rather than Opinion

A final objective was to base the research on hard data rather than mere opinion in the belief that this would make the results more credible and therefore of more use to the IP Manager, particularly when justifying decisions relating to the structure of the patent portfolio.

1.2.5 Target Audience of the Research

This research is intended to provide guidance on patent portfolio structure to IP Managers, and in particular to IP Managers of Single Technology Companies.

Experience from the Cranfield R&D Management Centre, which runs short courses on various aspects of intellectual property, suggests that many IP Managers – particularly those in small companies - do not have any patent qualifications. Rather, they are simply technologists to whom the responsibility for managing the patent portfolio has been given.

With this in mind, and in view of the fact that other readers of this thesis may also not have a background in patent law, this Introduction chapter has been followed by a chapter on Patent Fundamentals. Intentionally brief, it sets out the basic principles and procedures that underlie patent systems and that should belong to the common general knowledge of every IP Manager. The teaching of the literature on the more weighty issues of patent portfolio structure is then presented in the Literature Review chapter and analysed in the Literature Critique chapter.

1.3 The Research Methodology

The methodology of the present research is summarised in table 1.1 below. It has two notable characteristics:

Firstly, the poorly developed nature of the literature - particularly the terminology - in the area of patent portfolio structure has required that a significant amount of preliminary interpretation be carried out before empirical research could begin. Thus, in addition to a substantial Literature Review chapter, there is a significant Literature Critique chapter in which it has been attempted to distil out the teaching of the literature as regards patent portfolio structure. This distillation has then been used as the basis of empirical research aimed at obtaining further insight into patent portfolio structure.

Phases	Elements	Outputs	Chapters
Research Project Definition	Literature Review Literature Critique	Tables for each of the three stages of the patent filing decision detailing the risk factors that apply and the measures that can be taken	One Two Three Four
Development of Portfolio Structure Theory	First Portfolio Analysis	Patent Analysis Methodology Scope/Time Diagram Architecture Results of Scope/Time Diagram for partial portfolio of Renishaw plc	Five
	Second Portfolio Analysis	Patent Analysis Methodology Scope/Advantage Diagram Architecture Results of Scope/Advantage Diagram for portfolio of Torotrak plc	Six
	Development of Theory	Three Dimensional Framework for a patent portfolio Risk Management Approach to Patent Portfolio Structure	Seven
Investigation of Patent Invalidity Risk.	Review of Patent Statutes Review of Data Sources Analysis of Data Sources	Three-part categorisation of patent invalidity risk Preliminary data on effect of technology area size on likelihood of long-term extrinsic risk Preliminary data on effect of technology area growth rate on likelihood of short-term extrinsic risk	Eight
Consolidation		Review of extent to which the concerns that prompted the research have been addressed by the research	Nine

Table 1.1: The Research Plan

Secondly, the objective that the research be based on hard data has resulted in the investigation of the actual patent documents making up patent portfolios and the actual legal decisions issued by the patents courts. Such an approach has in part been made possible by the author's familiarity with such specialised documentation. Had this not been the case, it would have been necessary to rely simply on the bibliographic details of patents and/or 'softer' approaches such as interviewing practitioners. However, this approach has required the development of new methodologies for processing such information. Moreover, it has been discovered that such information has limitations of its own.

1.4 Management of the Research

The research project was carried out on a part-time basis during the period June 1996 to June 2003, seven years in total. The research period allowed by the regulations of the School of Mechanical Engineering (SME) at the time of starting the research was five years minimum to eight years maximum for part-time research. The research progress was subject to several formal review meetings during the period of registration for which the review panel members were:

Dr Hoi Yeung, (Head of Process Engineering Group, School of Engineering, Cranfield University)

Graham Fuller (Lecturer, School of Industrial and Manufacturing Science, Cranfield University)

The researcher also travelled to Cranfield periodically for review meetings with his supervisor.

As outlined in the 'Background of the Researcher' section above, the researcher changed jobs twice during the course of the research. Inevitably, these changes had a disadvantageous effect on the progress of the research. However, this was offset by the advantage to the author of being able to compare the emerging research findings with the patent portfolios of the new companies (although confidentiality reasons mean that it has not been possible to include details in the present thesis).

Furthermore, at the same time as moving to work with NXT, the researcher secured sponsorship that allowed him to dedicate two days per week for one year to the risk management aspects of the research. As part of the sponsorship agreement, three interim reports were produced as well as an article for 'Managing Intellectual Property' magazine[1], much of the content of which has been incorporated into Chapter 8 of this thesis.

Sponsorship also provided the opportunity to discuss research findings with the following professionals and academics in the field of risk management:

Ian Lewis and Andrew Catton (Miller Professional Risks, London)

Professor Chris Chapman (Professor of Management Science, Centre for Risk Research, School of Management, Southampton University)

Professor Stephen Diacon (Director of the Centre for Risk and Insurance Studies, Nottingham University)

Professor Elias Dinenis (Head of Department of Investment, Risk Management and Insurance, City University Business School)

The last three years have also seen the author presenting the patents module on the MA/LLM in Intellectual Property Management at the Centre for Intellectual Property Policy and Management, Institute of Business and Law, Bournemouth University. The enhanced understanding that comes from teaching a subject (in this case for one afternoon per week for six weeks each year) has also had a beneficial effect on the present thesis.

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[1] Hartwell, I.P. 'The Vulnerability of Granted Patents', *Managing Intellectual Property*, October 2002, 65-69.

1.5 The Contribution of the Research

The research has been successful in contributing to knowledge in the field of patent portfolio management in the following respects:

1.5.1 A model for the operation of a patent portfolio

Disparate teachings from the academic, legal practitioner, IP management and technology management literature have been formed into a single model for the operation of a patent portfolio based around three portfolio 'dimensions'. Although new, the model is nevertheless robust as a result of having been built on established concepts and having been tested on patents that have been used in real life.

1.5.2 A way of visualising a patent portfolio

The diagrammatic form of the new model allows the relationships between patents to be visualised. This in turn facilitates understanding of the patent portfolio, particularly by those not having day-to-day familiarity with patents. Such people typically have responsibility for a company's business strategy – accordingly, the diagram also provides a basis on which mutual decisions on alignment of business strategy and patent portfolio structure can be made. Such sharing of responsibility for what is a key company asset is desirable for the reasons discussed above.

1.5.3 A risk management approach to patent portfolio structure

The risk factors that influence the structure of a patent portfolio have been identified. For the IP Manager of a company, such knowledge shows how to bring company departments (such as marketing), which have control over one or more of the factors, to be brought into the patent portfolio management effort. This results in an improved portfolio as well as the sharing out of responsibility for a key company asset.

1.5.4 Preliminary data on the factors that determine patent invalidity and thus patent portfolio properties

Preliminary data has been obtained relating to the risk of a patent being declared invalid. Although such risk cannot be controlled as such, with the aid of this – admittedly preliminary - data it can at least be managed by the IP Manager. As explained in more detail later in the thesis, such management can involve risk transfer and risk reduction measures as well as a more informed assessment of the risks to be retained within the company. Moreover, the data analysis methodologies that have been developed offer the prospect of more comprehensive data in the future.

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CHAPTER 2

Patent Fundamentals

2.0 Introduction

This intentionally brief chapter sets out the basic principles and processes that underlie patents in order that the Literature Review chapter that follows may be properly understood. It is based primarily on European patent law.

It begins with a description of the so-called 'bargain' between inventor and state that is the raison d'être of the patent system. It then considers the nature of the legal monopoly that an inventor is granted as part of that bargain and that should in theory justify the time and expense involved in seeking patent protection.

The criteria that an invention must meet in order to justify the state granting a legal monopoly are then considered. This is followed by a description of the form which an application for patent must have and the patent office examination process that an application must undergo in order to be granted.

A final section details the events that can befall a patent in the period between its grant and its expiry twenty years after initial filing.

2.1 The Patent Bargain

The principle underlying the patent system is typically described as a 'bargain between the state and the inventor' in which an inventor is granted a limited-term monopoly on his invention in return for full disclosure of the invention to the state. In the words of the World Intellectual Property Organisation (WIPO)[1]:

[1] www.wipo.int/about-ip/en/about_patents

Patents provide incentives to individuals by offering them recognition for their creativity and material reward for their marketable inventions. These incentives encourage innovation, which ensures that the quality of human life is continuously enhanced.

All patent owners are obliged, in return for patent protection, to publicly disclose information on their invention in order to enrich the total body of technical knowledge in the world. Such an ever-increasing body of public knowledge promotes further creativity and innovation in others. In this way, patents provide not only protection for the owner but valuable information and inspiration for future generations of researchers and inventors.

2.2 The Patent Monopoly

Of the two sides of the 'bargain', the monopoly is clearly the most important to the addressee of the present research. It is important to understand that the right is <u>purely exclusionary</u> and restricted to the jurisdiction (or more usually jurisdictions) in which the patent is granted. In the UK, the right is set out in section 60(1) of the Patents Act 1977 which states that:

Subject to the provisions of this section, a person infringes a patent for an invention if, but only if, while the patent is in force, he does any of the following things in the United Kingdom in relation to the invention <u>without the consent of the proprietor</u> of the patent, that is to say -

(a) where the invention is a product, he makes, disposes of, offers to dispose of, uses or imports the product or keeps it whether for disposal or otherwise;
(b) where the invention is a process, he uses the process or he offers it for use in the United Kingdom ...;
(c) where the invention is a process, he disposes of, offers to dispose of, uses or imports any product obtained directly by means of that process or keeps any such product whether for disposal or otherwise.

These provisions are typical of patent law across the world. The sanctions for infringing a patent are set out in section 61(1) of the Patents Act, viz:

> *... civil proceedings may be brought in the court by the proprietor of a patent in respect of any act alleged to infringe the patent and ... in those proceedings a claim may be made –*
>
> *(a) for an injunction or interdict restraining the defendant ... from any apprehended act of infringement;*
> *(b) for an order for him to deliver up or destroy any patented product in relation to which the patent is infringed or any article in which that product is inextricably comprised;*
> *(c) for damages in respect of the infringement;*
> *(d) for an account of the profits derived by him from the infringement;*
> *(e) for a declaration ... that the patent is valid and has been infringed by him*

It should be noted that these sanctions are not automatic. Rather, they can only be realised by the patent owner first instituting court proceedings against the alleged infringer.

Furthermore, it is important to understand that although a patent gives its owner the 'negative' right to <u>exclude</u> others from practising an invention, it does not give the owner any 'positive' right to practice the invention himself. Accordingly, having obtained a patent to a development, a patentee may still be precluded from exploiting that development if happens to fall within an earlier patent right belonging to a third party. In such circumstances, it is not uncommon for the third party to grant a licence to the earlier patent in return for a licence to the later patent. Indeed, this is the principle underlying the 'Picket Fence' strategy discussed in the next chapter.

2.3 The Patented Invention

2.3.1 Definition of 'Invention'

As will have been seen, the term 'invention' is used frequently in the context of patents. The dictionary[2] definition of this term as follows:

> *1 The act of inventing. 2 the production of something new. 3 the faculty or power of inventing, inventiveness. 4 something which is invented; a contrivance. 5 a fabrication, a fiction*

where 'inventive' is defined as:

> *1 able to invent. 2 ingenious; imaginative. 3 characterised by creative skill.*

Particularly on the basis of the latter definition, the layman might assume that patent protection should only be sought for ideas that are ingenious, imaginative and creative. However, with a few exceptions, it is actually the case that <u>any</u> subject-matter may be considered for patenting. US patent law in particular contains no exclusions, simply stating that a patent may be obtained for:

> *<u>any</u> new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof*[3]

and that:

> *Patentability shall not be negatived by the manner in which the invention was made.*[4]

This mismatch between what the layman perceives as an 'invention' and the subject-matter which is actually patentable according to the patent statutes often results in

[2] Cassel's English Dictionary, 2000

[3] 35 USC para. 101

[4] 35 USC para. 103

patentable material being overlooked. For this reason, this thesis uses the term 'development' to describe any subject-matter for which a company might wish to consider – although not necessarily pursue – protection.

2.3.2 Criteria for Patentability

Regardless of how it comes about, a development still has to meet certain criteria if it is to justify the granting of a potentially valuable legal monopoly. These are:

The Development must be New / Novel

This means that the development must not have already been made public. This includes disclosures by the developer himself as well as earlier disclosures of the same development by a third party.

Under the patent law of most countries, this also means that the development must not already be the subject of another patent application having an earlier filing date. If it is, then the patent right is granted to the earlier applicant under the so-called 'first to file' principle. A different rule applies in the US, however, where the patent right is granted to the applicant able to prove the earlier invention date. This is the so-called 'first to invent' principle.

The Development must be Non-Obvious / Involve an Inventive Step

Given what is already in the public domain, the invention must not be obvious to a person skilled in the technical field of the invention.

The Development must be Industrially Applicable

The patent law of most territories also requires that an invention be 'industrially applicable'. Not only does this avoid overlap with other legal rights (e.g. copyright), it also provides a mechanism whereby certain subject-matter (e.g. methods for treatment of the human or animal body by surgery) can be excluded from patentability by excluding it from the definition of 'industrially applicable'.

The above criteria are discussed in more detail in chapter 8: Investigation of Patent Invalidity Factors.

2.4 The Patent Document

The patent bargain is implemented by means of the patent document which sets out the extent of the patent owner's monopoly on the one hand and discloses the invention to the public on the other. Such a document comprises a core 'claims' section and a supporting, technically-detailed 'description' section. Broadly speaking, the claims define the extent of the monopoly and the description discloses the invention. These are discussed in further detail below with reference to the website of the European Patent Office (EPO)[5].

2.4.1 Claims

The claims are a hierarchical set of statements which define the matter for which protection is sought. The first claim defines the development in the most general terms and is called an 'independent' claim to distinguish it from subsequent 'dependent' claims which specify further features of the development and thereby define the development in less general, more specific terms. Thus an independent claim to a car might read:

1. Conveying apparatus comprising a platform having wheels and a motor for driving the wheels.

whilst dependent claims might read:

2. Conveying apparatus according to claim 1, wherein the apparatus has four wheels.
3. Conveying apparatus according to claim 1 or 2, wherein the motor is an internal combustion engine.

[5] www.european-patent-office.org

Choosing the features to be included in the claims is arguably the most important task in drafting the patent application. It is considered by many to be an art rather than a science and as such is open to many different approaches which may be passed down from attorney to attorney within a patent attorney firm or company IP department.

One approach to claim drafting is put forward – together with dissenting comments from other patent attorneys – by Micklethwaite (1946). It was republished as recently as 2003 in the journal of the British Chartered Institute of Patent Agents where it was described as 'seminal'. Micklethwaite summarises the underlying purpose of any independent claim as:

> *mak[ing] it as difficult as possible for a potential infringer to get the advantages of the invention without infringing the claim*

and proposes that a claim 'include the features from which the advantages of the invention follow' Such an approach is hereinafter referred to as <u>'advantage-based'</u>.

However, a different approach is put forward in the discussion section of the same article where another attorney states that:

> *In the drafting of chemical claims, he [the attorney] would suggest that it was sometimes well to select from a long synthesis what was considered to be the essential step and to claim that separately [from the rest of the synthesis steps].*

It will be appreciated that were the attorney to include inessential steps in the claim, a third party could avoid infringement of that claim simply by omitting those inessential steps. The above approach is hereinafter referred to as <u>'feature-based'</u>.

With particular reference to chemical claims, the discussion further quotes the other attorney as stating that:

the claim should be too narrow rather than too broad, even if that sometimes enabled a few infringers, who were getting some of the benefits of the invention, to escape

This does of course run counter to Micklethwaite's statement that a claim should make it as difficult as possible for an infringer to get the benefit of the invention. However, by not making the claim 'too broad', the situation is avoided where the claim encompasses arrangements - typically chemical formulations - that do not provide the advantages of the invention. As discussed subsequently with regard to the description and the question of when to file a patent, such a 'too broad' claim will be considered invalid by the patent authorities.

Feature-based claiming is more likely in empirical fields such as chemistry, pharmaceuticals or biotechnology where the mechanism giving rise to an advantage may be difficult to determine. Such a situation is acknowledged by Knight (1996) who observes that:

... many inventors never truly understand how their invention works. Many know little more than if they add component A to component B, a new component C results which has very useful characteristics.

The present author has experience of both forms of claiming. Automotive suspensions lend themselves to an advantage-based approach, as do inkjet printheads, light-emitting display architectures and loudspeaker designs. However, the inks used in printheads and the polymers used in light-emitting displays are generally empirical developments that require feature-based claims.

2.4.2 Categories of Independent Claim

The EPO website notes that:

a European patent application may contain independent claims in different categories (e.g. product and process)

Article 64 of the European Patent Convention also specifies that protection extends to the direct product of a process claim. With a view to maximising protection, it is common practice to claim an invention both in terms of a product and in terms of a process. Where an inventive product has an associated inventive manufacturing process, a patent attorney will also draft a claim to that.

2.4.3 Claims to Intermediate and Final Product

The EPO website also notes that:

> *a European patent application may contain ... more than one independent claim in the same category, e.g. products fulfilling the same function or otherwise, or intermediate and final product.*

This reflects the common practice of drafting a claim to protect the simplest saleable group of features so as to provide a basis for action against component manufacturers as well as those further down the product chain. Micklethwaite (1946) refers to such a group as a 'subordinate integer'. The reason for this practice is that, although a claim to a final product may be asserted against a component manufacturer, this is only possible under so-called 'indirect' infringement provisions relating to the sale of an 'essential element' and is harder to prove.

Another common practice is to include not only a claim to an apparatus but also a claim to a device incorporating that apparatus, e.g. a claim to an engine and also a claim to a car incorporating the engine of the first claim.

2.4.4 Two-part Form of Claims

The EPO website also states that:

> *Wherever appropriate, the claims must comprise two parts : a first ("prior art") portion and a characterising portion. The first claim and any further independent claims must contain, in the first part, the designation of the subject-matter of the*

invention and the technical features necessary to define it but which, in combination, are part of the prior art. The characterising portion designates the technical features which, in combination with the features in the first part of the claim, it is desired to protect.

The first 'prior art' portion is typically referred to as the 'preamble', the two portions generally being delimited by the phrase 'characterised in that' in the case of a product claim, or 'characterised by the steps of' in the case of a process claim.

2.4.5 Dependent Claims

Dependent claims have already been discussed above. The EPO website states that:

Any independent claim can be followed by one or more "dependent" claims concerning particular embodiments of the invention. Dependent claims contain all the features of the claim to which they belong. They must contain, if possible at the beginning, a reference to this other claim (which can also be a dependent one) and then state the additional features it is desired to protect.

Knight (1996) explains the purpose of dependent claims as:

if the main independent claim is found for some reason to be invalid, the dependent claims may not, and still provide the patent owner with a measure of protection.

On the question of exactly which features to include in the dependent claims, Micklethwaite (1946) states that:

a nicely-graded series of [dependent] claims can be drafted each of which introduces some perhaps minor but definitely advantageous feature as compared with earlier claims. ... One may check for too great or too small a gap between claims by asking ... 'if [independent] claim 1 were found to lack novelty or

> *patentable subject-matter [i.e. be invalid] is there any chance of [dependent] claim 2 being upheld ?'*

2.4.6 Description of Background to Invention

As with the claims, there are established rules for the structure of the description and figures of a patent document. Under the heading 'description of background to invention' the EPO website states that the description should contain:

> *an account of the background art [i.e. publicly-available material] which, as far as is known to the applicant, can be regarded as useful for understanding the invention.*
>
> *The documents reflecting that art should also be cited wherever possible; this particularly applies to the background art according to the "prior art" portion of the independent claim or claims.*
>
> *The indication of the aforementioned documents must be sufficiently complete to enable them to be consulted: i.e. in the case of patent specifications, giving the country and number, in the case of books, the author, title, publisher, edition, place and year of publication, plus the page numbers and, in the case of periodicals, the title, year, issue and page numbers;*

However, these requirements are secondary to the requirements of novelty and inventive step and are not strictly enforced by the patent offices, resulting in wide variations in practice: some attorneys include many pages of discussion of the relative advantages and disadvantages of known technology so as to make the merits of the claimed invention completely clear. Other attorneys eschew any discussion of the prior art for fear that it might give a patent office basis for objections that might not otherwise have been raised. The significance of this practice to the present project will become more evident later.

2.4.7 Description of Invention

The EPO website states that the description must also contain:

> *disclosure of the invention as claimed; This disclosure must be such that the technical problem (even if not expressly stated as such) and its solution can be understood.*
>
> *Any advantageous effects of the invention vis- à -vis the background art should be stated, taking care, however, not to disparage a particular earlier product or process.*

Again, these requirements are not strictly enforced by the patent offices. Thus it is that the degree to which advantages are discussed in a patent document varies in dependence on the drafting attorney, some of whom prefer to claim subject-matter without any reference to why one might wish to practice such subject-matter.

However, all attorneys are obliged to ensure that a patent application meets its part of the 'bargain' by fully disclosing the invention to the state. To this end, the EPO website indicates that the patent document should contain:

> *a detailed account of at least one way of carrying out the invention claimed; This is usually done by means of examples explained by referring to any drawings, and by using the reference signs contained therein.*

US patent law goes further, requiring that the description disclose the best mode of carrying out the invention claimed.

In the case of empirical technologies and the resulting 'feature-based' claims discussed above, the description typically includes multiple examples to prove that the advantages of the invention are achieved over the entire scope of the invention as claimed. In both empirical and non-empirical fields, multiple examples are also used to illustrate that the broad invention of the independent claims may be carried out in a number of ways, some of which may have inventive merit in themselves. Such inventive embodiments can form the basis of dependent claims which in turn provide fall-back positions as discussed above.

2.5 Patent Lifecycle

2.5.1 Patent Examination Process

To ensure that a patent application meets the criteria for grant, a patent examination process is required. A patent office is generally set up to perform such examination, which it may carry out alongside the administration of other IP rights such as trademarks and designs. Although there are differences in detail between patent offices, the fundamental steps of patent examination remain the same, as will be evident from figure 2.1 comparing examination procedure between the European, Japanese and US Patent Offices.

Thus most patent offices allow for a patent application to be published eighteen months after first filing anywhere in the world. Such a publication may include a Search Report, which is a list of those earlier public disclosures considered by the examiner to be of most relevance to the claims of the application. The technical term for such earlier disclosures is 'prior art'.

Most patent offices also have a substantive examination phase in which a patent examiner compares the claims of an application with the prior art cited in the Search Report. If the claims do not meet the criteria for patentability (e.g. they define something that is already known in the prior art), then the examiner issues a corresponding examination report. It is then up to the patent applicant to submit claim amendments and/or explanation as to why the examiner's objections are incorrect. This process may go through several iterations before the application is either granted or rejected.

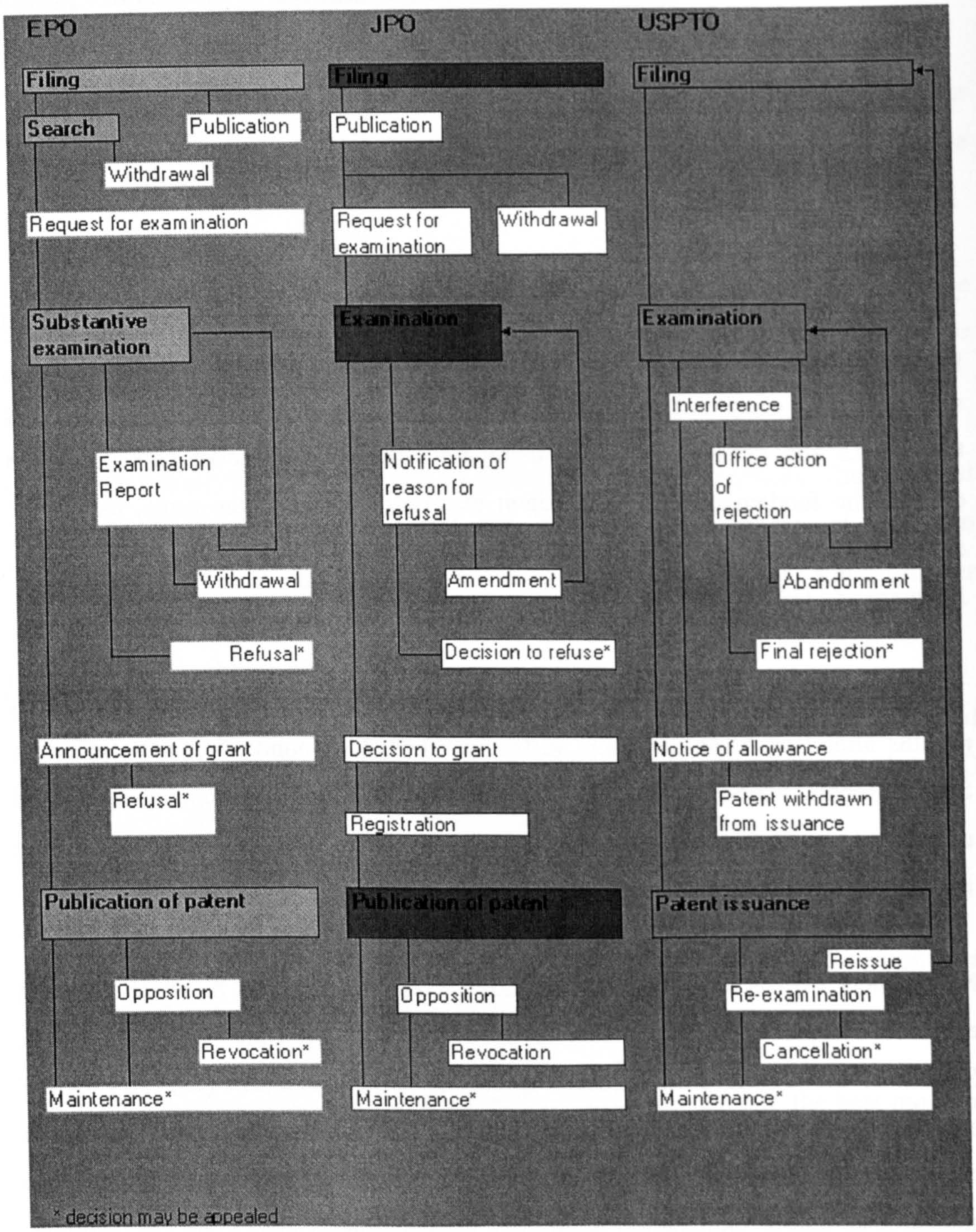

Figure 2.1:
Major Phases in the Examination Processes of the European Patent Office (EPO), Japanese Patent Office (JPO) and US Patent and Trademark Office (USPTO)
(Reproduced from the website of the USPTO)

2.5.2 Patent Grant

The time taken to get an application to grant depends on a number of factors. Certain patent offices have delayed examination: an applicant for a Japanese patent can defer requesting substantive examination by up to three years. Other patent offices such as the EPO have significant backlogs which can result in examination being postponed by several years. Common to all procedures are delays of several months between successive steps in the examination process.

However, once (and only once) grant has been achieved, a patent applicant can enforce the aforementioned rights of injunction, damages, etc. in the courts.

After grant, there may be a period within which third parties are allowed to submit evidence and arguments as to why the patent should not have been granted. At the EPO, there is a nine-month period for filing such 'opposition'. Where opposition is filed, examination is re-opened with both the third party and the patent applicant taking part in the proceedings which may result in the patent being revoked, being maintained in amended form or in the opposition being rejected and the patent being maintained unamended.

Finally, all patent offices share the requirement that renewal or maintenance fees be paid after grant of a patent in order to keep that patent in force. Another common feature is a twenty-year duration of the patent monopoly.

2.5.3 Patent Prosecution Treaties

Although the enforcement of granted patents remains very much a matter for individual national courts, a number of treaties have been signed over the years with the aim of facilitating the patent prosecution process.

The first of these is the Paris Convention whereby the date of filing a patent application in a first country belonging to the convention is accepted as the effective filing date of an application in a second country belonging to the convention on condition that the second application is filed within twelve months of the first application. Practically all the countries of the world belong to this convention, which allows an applicant to make a first filing to a development, to publish that development and then make further filings overseas without fear of the earlier publication prejudicing the validity of those further filings. The concept of claiming benefit of the earlier filing date is known as 'claiming priority' and the twelve month period as 'the priority year'.

A second treaty which can be used in conjunction with the Paris Convention is the Patent Cooperation Treaty (PCT). Administered by the World Intellectual Property Organisation, this provides for an International patent application which is searched by an International Search Authority (actually one of the patent offices) and subject to preliminary examination by an International Preliminary Examination Authority (again, one of the patent offices). Such an application cannot be granted – it must enter the various national patent systems in order to do this – but nevertheless provides the opportunity for an application to be searched and partially examined before the decision to commit to the expense of individual national patent applications is taken. Many examples of such PCT applications - which have a patent number prefixed by the letters 'WO' – are referred to later in the thesis.

Working on a similar principle is the European Patent Convention. This provides a single patent application for over twenty European countries which is not only searched and examined but also granted before being passed to the individual countries for enforcement. This system similarly simplifies examination and postpones the date at which expensive translations into the languages of the various nations must be made. Furthermore, it can be preceded by the search and preliminary examination of the PCT system. European patent applications are prefixed by the letters 'EP'.

2.6 Conclusions

Although this chapter was simply intended to be a primer on patent principles, it cannot help but highlight the complexity of patent systems. Not only is the law itself complex, with many exceptions and additions to the rules, there are also wide differences in the patent documents themselves. These are determined by differences in attorney practice on the one hand and by the specific nature of the technology to be protected on the other.

This complexity begs the question of whether patents are so complicated and so situation-specific that it can never be possible to determine the generally applicable guidelines which are the objectives of the research. The chapters that follow detail the author's attempts to answer this question.

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CHAPTER 3

Literature Review

3.0 Introduction

This chapter presents the literature considered relevant to the four research objectives identified in the Introduction chapter, building on the principles explained in the preceding Patent Fundamentals chapter.

It should be noted that for the objectives to 'investigate structure and logic of patent portfolios' and particularly the objective to 'investigate optimal patent portfolio structure for single technology companies', straightforward 'why?', 'what?', 'how?', etc. section headings have not been used: although this was tried initially, difficulty was experienced in classifying patent behaviour under such headings.

For example, 'when?' covers both time (as in 'once a decision to make a filing on an invention has been made, when should that filing take place?') and situations (as in 'a filing should only be made when commercial circumstances warrant'). 'What?' reads onto both the commercial significance of an invention as well as the way in which an invention manifests itself (or not as the case may be).

Instead, the heading 'Patent Properties' covers the teaching of the literature on the core exclusionary property of a patent whilst 'Patenting Objectives' covers the various reasons for patenting per se. This is followed by subsections on alternatives to patenting, namely trade secret or publication, and the timing of patent filing once the decision to patent has been made.

Next, 'Portfolio Strategies' covers the ways in which the exclusionary properties of a number of patents can be harnessed to achieve certain goals and this is followed by sections on the techniques used to depict portfolios and measure their properties. Since a patent portfolio also typically includes patents in a number of countries, it has been considered necessary to include a section on the literature regarding Patent Geography.

It is noted that such a division between 'patent' and 'portfolio' finds support in Knight (1996) who distinguishes between patent strategy for a technology area and strategy for a specific patent application.

A final section on 'Patent Risks' considers the teaching of the literature as it pertains to the objective of 'investigating a risk management approach to patents'.

3.1 Literature Review Methodology

A number of approaches to the literature were employed:

3.1.1 Personal Collection

At the time of starting the research, the author already had a significant collection of non-academic literature relating to patent strategy issues. This included newspaper articles that had appeared in the EPO's regular press watch during the five years that the researcher was at the EPO, as well as articles from the patent trade journals 'Managing Intellectual Property' and 'Patent World' to which the researcher had subsequently subscribed in his capacity as IP Manager. As a member of the Licensing Executives Society (LES), the researcher also had access to that society's journal, 'les Nouvelles'.

3.1.2 Databases

At the start of the research proper, Cranfield University library were commissioned to carry out searches on the ABI/Inform database that had been suggested by them as being most likely to contain references of relevance. Given the acknowledged body of literature on the economic and legal aspects of the intellectual property rights (IPR) system, a search based on single key words such as 'intellectual property' and 'patent' was rejected as being likely to throw up an unacceptably high number of citations. Instead, combinations of terms from the following two groups were used:

- patent
- IP
- intellectual property
- management
- strategy
- risk

Furthermore, with a view to gaining an understanding of approaches to risk in related fields that might shed light on the research objective of 'investigating a risk management approach' to patents', the term 'risk' was searched in combination with the terms:

- R&D
- research
- innovation
- development

As is usual, the searches yielded abstracts which were reviewed so as to identify those items worthy of analysis in full.

3.1.3 Journals

In addition to the journals mentioned above, the contents lists of the journals 'Research Technology Management' and 'Risk Management' were obtained via Cranfield library and reviewed.

Furthermore, the 'Patents and Licensing' section of a specialised 'Science and Technology Management Bibliography' compiled by Clarke and Reavley in 1995 was reviewed. This contained over 11,000 references to articles, books, conference papers and journals including:

- Research-Technology Management
- R&D Management
- IEEE Transactions on Engineering Management
- Journal of Product Innovation Management
- International Journal of Technology Management

- Les Nouvelles
- SRA Journal
- Journal of Technology Transfer
- Economics of Innovation and New Technology
- Journal of Engineering and Technology Management
- Research Policy
- Technovation
- Long Rang Planning
- Harvard Business Review
- RAND Journal of Economics

3.1.4 Libraries

An alternative search resource was the collection of IP-related books and journals held by the Science Reference Information Service of the British Library. This was for many years kept at the old Patent Office at Southampton Buildings, London but has more recently transferred to the new British Library building at King's Cross.

In researching risk aspects, the collection of the Centre for Risk Research, School of Management, Southampton University, was also visited.

3.1.5 DTI / ESRC / IPI 'Intellectual Property Initiative'

Via the Licensing Executives Society mentioned above, the researcher learnt of a report by the UK Government Inter-departmental Committee on Intellectual Property entitled 'Use and Exploitation of Intellectual Property by Small Firms'. Published informally in 1995, around a year before the present research commenced, it noted that:

> *Although there is a considerable body of literature on the economic and legal aspects of the intellectual property rights (IPR) system, and a comprehensive survey of research on the economic and legal aspects of IPR can be found in a report prepared for the Economic and Social Research Council (ESRC) (Hayward*

& Greenhalgh, 1994), very few studies relating to the particular issues facing small firms and their use of IPR have been published.

This was followed in 1996 by the 'Intellectual Property Initiative', a two-year research programme jointly funded by the UK Department of Industry (DTI), Economic and Social Research Council (ESRC) and the Intellectual Property Institute (IPI). The eleven projects making up the programme were as follows:

1. R Blackburn, J Curran
   Intellectual Property and the Small and Medium Enterprise (SME)
   School of Business, Kingston University

2. D Bosworth, P Stoneman, P Hayward, C Greenhalgh
   Company Performance and the Valuation of Intellectual Property
   School of Management, UMIST / Warwick / Oxford University

3. C Choi, C Baden-Fuller, R Wallis
   Knowledge Transfer and Protection in Multimedia Industries
   Business School, City University

4. K Dickson, A Woods
   Design Protection Practices in the UK Textiles Industry
   Department of Management Studies, Brunel University

5. S MacDonald
   Protection or Dissemination? The Contribution of the Patent System to Innovation in SME's
   Business School, Warwick University

6. S Massey, P Freakley, T Weyman-Jones, P Roberts, C McIntyre, J Seaton, R Fuscone, J Phillips
   Comparative Study of Systems for IP Management in HEIs in the UK,

USA, Canada, Japan, Germany and France
Faculty of Technology, Loughborough University

7. D Matthews, J F Pickering, J Kirkland
   Determinants of Intellectual Property Strategy in UK Companies
   National Institute for Economic and Social Research

8. I Miles, J Boden, N Kastrinos
   The Management of IP in Knowledge-Intensive Business Service Firms
   Policy Research on Engineering, Science and Technology (PREST), Manchester University

9. C Oppenheim, M Sheen, I Lloyd
   Barriers to the Use of Patents Information in British SME's
   Department of Information Studies, Strathclyde University

10. S Thomas, P Tang
    Managing Intellectual Property: Electronic Publishing and Biotechnology SME's
    Science Policy Research Unit (SPRU), University of Sussex

11. A Webster, B Rappert, D Charles
    University Spin-offs; SME's and the Science Base: The Effective Use of IP
    Anglia Polytechnic University / Newcastle University

It will be noted that - consistent with earlier observations regarding the nature of the literature on intellectual property - the projects covered a wide range of issues, most of which (nos. 2,3,4,5,6,8,9,10,11) did not appear to be relevant to the specific objectives of the present research. This was confirmed when the results of the various projects were presented at a conference held at the DTI Conference Centre, London in March 1998 to which the researcher was invited.

Summaries of the remaining two projects, 1 and 7, are included in Annex 1, from which it will be seen that project 1 (Intellectual Property and the Small and Medium Enterprise) was based on telephone surveys of the principals of 400 SME's, resulting in a picture of SME attitudes to patenting but shedding no light on the patent strategy questions of the present research. Project 7 (Determinants of Intellectual Property Strategy in UK Companies) did investigate patent strategy albeit in the context of large multinational companies and universities rather than the STC target of the present research. Project 7 is discussed in more detail in the body of the literature review below.

3.1.6 IVA / SPO / Chalmers University Studies

A similar study of patenting and IP matters was commissioned by the Royal Swedish Academy of Engineering Sciences (IVA), initiated by the Swedish Patent Office and carried out by Prof. O Granstrand of Chalmers University in 1992-93. The results of this research together with subsequent studies of Japanese corporations were summarised in a book *'The Economics and Management of Intellectual Property: Towards Intellectual Capitalism'* published in 1999. This comprehensive work provided welcome confirmation of much of the initial literature analysis but - like many books before it - did not provide answers to the specific questions underlying the present research.

3.1.7 Chronology of the References

Although the formal literature search only covered sources published before the research was started, i.e. pre-1996, it will be noted that the present review also includes further sources published during the course of the research. This has ensured that the results of the research are relevant to recent thinking in IP management, which has undergone a significant increase in profile over the years of the research project. In this regard, Granstrand (1999) notes that:

> *The literature in economics and management on patent strategies is generally very thin, as was the case for technology strategies until that area grew popular in*

the 1980s. The popularity of the strategy concept has also started to grow in the IP community.

Monitoring and analysis of literature developments also proved beneficial in that the researcher was provided with quasi-regular confirmation (a) that the results of the earlier literature review were correct and (b) that there was still a need for answers to the STC-specific questions that originally prompted the research.

3.2 Patent Properties

On the fundamental question of 'what makes a good patent?', the literature presents several answers:

3.2.1 Broad Scope of Protection

Knight (1996) notes that certain business goals require 'broad' patents, whereby:

> *A 'broad patent' is a subjective descriptor of a patent which typically has claim language which excludes others, or could be interpreted to exclude others, from a large chunk of a technology area.*

This is to be contrasted with his observation that:

> *A 'narrow patent' is typically used to describe a patent which has claim language which excludes others from a more specific piece of a technology area.*

Davis and Harrison (2001) note that:

> *... factors such as narrow vs. broad claims require a brief reading of the patent – a factor that software as yet cannot determine.*

Notwithstanding this, others have sought to express patent scope using numbers. Both Granstrand (1999) and Schankerman (1999) refer to Lerner (1994) as proposing the number of patent classes to which a patent is assigned as a measure of patent scope. (A patent classification is a patent office system for categorising technological documentation for retrieval purposes - it is discussed in more detail in the Investigation of Patent Invalidity Factors chapter 8). Other measures of patent scope used in the academic literature are mentioned by Granstrand (1999) as a patentor's ability to raise price, the impact on close product substitutes and the invent-around costs. It is noted that these latter measures are less directly linked to the legal definition of protection (which refers to technical features – see section 2.4.1 of the Patent Fundamentals chapter) than the two mentioned above.

3.2.2 Strategic Significance

A patent 'necessary for doing business within a specific product area' is defined by Granstrand (1999) as being 'strategic'. He notes that such patents exhibit large blocking power, i.e. they have deterringly high or insurmountable invent-around costs.

This is consistent with Rivette and Kline (2000) who quote the IP director of Hitachi (one of the Japanese companies that Granstrand interviewed) as defining 'strategic' patents as 'market-dominating' and as 'patents which competitors cannot get around'.

At the other end of the scale, Granstrand (1999) suggests that 'minor' patents 'can be used as nuisance patents to slow down competitors.

3.2.3 Quality of technology

Referring to the classification table reproduced in figure 3.1, Aoyama (1991) indicates that the level of the technology of an invention, namely 'noble/high' or 'conventional/low' influences the patent filing decision at Toyota, the other factor being the likely patentability of the invention.

Judgment by Intellectual Property Div.

Patentability / Technology	Yes	Doubt	None
Noble or High	Application for a patent		Rejection
Low or Conventional	Laid open to public		Rejection

Figure 3.1: Classification of Inventions (from Aoyama, 1991)

Murakami and Nakata (1994) describe a similar technology-based classification system, namely:

- Revolutionary: extremely original invention
- Innovative: creative and fundamentally different from existing technologies
- Improvement: a large improvement over existing technology
- Small improvement: an incremental improvement on existing technology

3.2.4 Key advantage(s)

This is the property identified by Micklethwaite (1946) and discussed in the Patent Fundamentals chapter, namely:

> *... it is [the purpose of a claim] to make it as difficult as possible for a potential infringer to get the advantages of the invention without infringing the claim*

This is supported by Rivette and Kline (2000) who propose that you 'protect your core technology advantage', as well as by Exxon Chemical (1996) who state that:

> *The scientist and patent attorney together can ensure that the claims ... are of appropriate scope to cover commercially realistic alternatives of achieving the technical advantage of the invention.*

3.2.5 Key Methods and Processes

As a follow-up step to the protection of core advantages described in the previous paragraph, Rivette and Kline (2000) recommend the filing of patent applications to:

> *the key methods and processes – whether these are manufacturing, distribution, or even business methods – that are absolutely essential to the building, marketing or selling of the product.*

This is supported by Crespi (1982) who cites the "7-ACA" patent for cephalosporins as an example of *a key intermediate-product patent .. with its promise of being crucial to new chemical routes to future cephalosporins.*

For their part, Rivette and Kline cite as an example the patenting of a $20 million vacuum chamber used to apply diamond-like carbon coatings to the blades of Gillette's Mach3 shaver. However, Knight notes that:

> *patents on machines which are developed by a company to be used in their proprietary processes but are not to be sold, have the least value. ... these types of apparatus patents are the least easy to detect – most companies will not show their proprietary equipment – and the easiest to engineer around.*

3.2.6 Lowest Cost Process

An exception to the previous observation is identified by Knight (1996) as:

> *when one patents the lowest cost process: obviously, patenting the lowest cost process gives the owner a better position than his competitors.*

This is again supported by Crespi (1982) who, in his review of the patents in the field of cephalosporins, describes how:

The main thrust of the research had now moved into the industrial sector and into a highly competitive search for new final products and methods of producing 7-ACA effectively on a commercial scale.

The significance of the cost associated with alternatives is also reflected in the comment by Chisholm (1972) that:

It is of little value to patent one embodiment of a discovery if third parties are free to practice alternate embodiments at equal or lower cost.

3.2.7 Applicability

Another quality of a 'truly powerful invention' is identified by Pike (2001) as:

whether the invention is capable of giving rise to further spinoff inventions. Think about different uses, or perhaps applications in other commercial areas.

Baillie (1986) calls this 'by-product value'.

3.2.8 Alignment with Business Plans

That a patent should support business objectives would seem to be an obvious point. However, it would appear from Manfroy and Gwinnel (1998) and Rivette and Kline (2000) that this cannot be taken as read, even (or perhaps particularly) in large companies.

Thus it is that Manfroy describes the formation of intellectual property management teams at Eastman Kodak, a $5billion dollar chemicals company, tasked *inter alia* with ensuring that the organisation's patent strategy matched the organisation's business strategy. Rivette and Kline go further, presenting an IP Audit Map (reproduced in figure 3.2) in which patents are classified according to their alignment with current and future business plans and the growth rate of the business unit to which they relate.

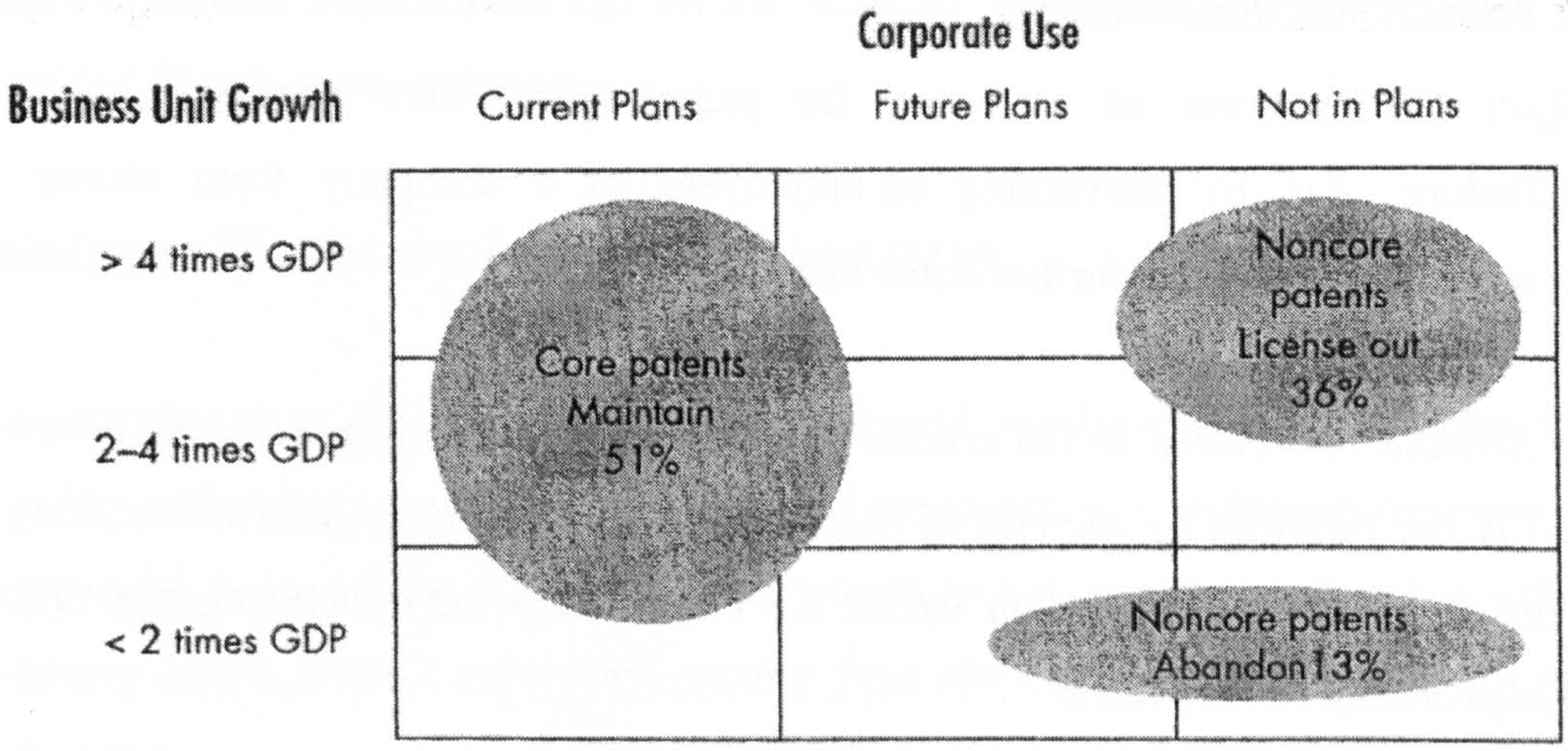

Figure 3.2: Dow Chemical IP Audit Map (from Rivette and Kline, 2000)

Rivette and Kline describe how such a map was used by Dow Chemical to drastically overhaul their patent portfolio: patents relevant to current plans were denoted 'core' and were maintained, whilst patents not relevant to current plans but relating to high-growth business units were marked for licensing. Patents not relevant to current plans and relating to low-growth business units were abandoned.

3.3 Patenting Objectives

The literature identifies many reasons for filing a patent, some of which are obvious, others less so. They are listed below in approximate order of complexity.

3.3.1 Maintain freedom to operate by publishing, not patenting

Reflecting the basic tenet of patent law, mentioned in the Patent Fundamentals chapter, that a patent shall not be granted for subject-matter that is already in the public domain, Knight (1996) states that '*at the very minimum, a company should maintain its freedom to operate by simply publishing ideas.*'

3.3.2 Protect local manufacture

Helfgott (1992) gives as a reason for patent filing the 'protection of local manufacture', e.g. by preventing ex-employees of a company from setting up competing businesses. He further notes that:

if an invention is related to the creator's unique manufacturing process or business, which is not followed by the rest of the industry, foreign filing [that is the filing of patents in territories other than where the creator has manufacturing operations] should probably be restricted

3.3.3 Preventing competitors from selling copycat product

As another reason for patent filing, Helfgott (1992) gives 'when patents primarily cover the patentee's own products, especially for single-patent products'. The 'single patent' reference suggests that protection will be limited to direct copies of the product, which is the simplest kind of competition. This is supported by Knight's comment that *'product patents are patents which claim the exact item which is sold, whether it be a bulk chemical or a machine'*, that is the simplest kind of patent coverage.

3.3.4 Protect Markets

Many commentators, including Norris (1991), Murakami (1994) and Gibson (1990), speak of protecting markets and market-share but do not specify any particular means by which this might be achieved.

3.3.5 Creating an exclusive marketing point

Pike (2001) describes a development of the previous concept which he calls a 'value-added' strategy and which involves protecting:

> *key value-adding features of the product or a service. The objective is to block competitive access to those value-adding features, which can then be used as exclusive marketing points to support premium-priced offerings. Companies*

operating this model often sell on the basis of 'new, improved X' or 'now with added Y' value propositions.

According to Pike, the corollary of this strategy is that:

companies must keep developing new, improved, market-relevant and protectable value-added features to stay ahead of the competition. Continuous innovation is required, because the barrier to entry posed by value-added features is only as strong as the market advantage arising from the exclusive presentation of those features.

A practical example of this strategy is described by Rivette and Kline (2000). Referring to Gillette's Mach3 shaver, they describe how

the next step was to determine which among the product's key features best communicate the shaver's branded personality and performance advantages to the consumer – and then patent-protect these features. This was an effort that blended engineering, aesthetics, design, marketing and, of course, patent law.

3.3.6 Slow down competitors

Granstrand (1999) states that *'minor patents can be used as nuisance patents to slow down competitors'.*

Knight (1996) clarifies the meaning of 'slow down' in this context. Referring to process patents, he notes that:

... it is not wise for companies to ignore and willfully infringe any patent. Most companies will attempt to develop a legally supportable position which will allow them to practice. However, the development of this position ... takes time and resources to complete. Therefore, at a minimum, process patents can have definite nuisance value.

3.3.7 Prevent competitors from acting in future markets

Glazier (1995) describes the filing of a 'toll gate' patent wherein:

> *the entire body of prior art, not just that of your competitor, is reviewed and generally conceptionalized to identify the direction in which it is developing. You then project the trend to anticipate future developments. Finally you leap-frog into the future and file the first patent application (with very broad claims) for the next generation of improvements, even when you may have only a vague concept of the best products to implement these improvements. When issued, this patent can act as a toll gate standing in the way of competitors when their actual products develop to that level of advancement.*

Davis and Harrison (2001) also acknowledge such patents that 'position the company in the path of industry evolution', albeit under the name of 'strategic' patents.

3.3.8 As a basis for licensing

As is often the case with STCs, a patent is not worked by the patent owner but instead licensed to third parties who are better placed to manufacture. Pike (2001) describes a 'hub monopoly model' based on:

> *... a well-defined 'hub' platform (e.g. a technology platform) that has many potential applications and that many companies will want to use in their own products or services. ... The technology is primarily protected by patents, but other rights such as copyright for software aspects, mask right for chip design aspects ... may be relevant. Hub access is offered, by way of licensing, to all comers, although key industry players may be offered preferential terms to encourage early adoption.*

Helfgott (1992) also mentions licensing as a way of earning revenue from markets that are not served by the patent owner and as:

a means of balancing the playing field between companies that make significant R&D investment and those companies that imitate the products of others

noting that:

a patent license is complementary to other intellectual property licenses (e.g. know-how) and may be an effective measure of control in the event of a breach [i.e. the know-how becoming public knowledge].

This is supported by Pitkethly (2001) who notes that:

The benefits of IPRs are thus not just in conventional direct monopolisation but in their more general use as control mechanisms ... patents and other forms of IP are not just closed barriers to entry but more fundamentally a means of control, a barrier that can be opened or closed as required.

Perhaps not surprisingly, a survey of US licensing executives carried out by McGavock and Lasinski (1998) also ranked 'create licensing opportunities' as the third most important reason for obtaining patents after 'obtaining a proprietary position in new markets' (corresponding to 3.3.7 above) 'protecting current markets' (corresponding to 3.3.4 above).

3.3.9 Define and support a business that is to be created / transferred

Helfgott (1992) also states that *'patents define and support a business that is to be created / transferred'*, giving the example of a joint venture. This was another of the reasons identified in a survey of US licensing executives carried out by McGavock and Lasinski (1998).

3.3.10 Indirect Patenting Reasons

Granstrand (1999) suggests that 'not all patents are economically motivated'. Certainly, it is true that the literature mentions several reasons for filing that do not directly relate to obtaining an economic monopoly. Helfgott (1992) cites:

the business opportunities that may be attracted by the published patent documents identifying the patent applicant as a technology resource.

He also suggests that a patent filing in a foreign country can generate goodwill in that country, viz:

a patent filing in the national language of that country not only demonstrates an investment in that country's infrastructure but also adds to the technical information database available for study in that country

and that a patent filing can serve as:

an indicator of technical leadership that is readily understood by the government, business and the public and consequently of use in forging relationships with these parties.

The latter is supported by Granstrand, who notes that 'patents can also be used as a marketing tool, signalling technical superiority to prospective customers', and by Hofinger (1996) who found that patents were filed 'to enhance the reputation of an organisation and thereby increase sales'. Gibson (1990) quotes an account supervisor for suitcase manufacturer Samsonite, explaining 'if we have a patent or patent pending, we want to flag that in our advertising'.

Hofinger's survey of Austrian patent-filing organisations also found that patents were filed to motivate employee inventors – a seemingly trite reason but supported by Knight (1996) who observes that:

If a researcher obtains a patent ... his marketability ... may be increased

Patent filings can similarly be used as a measure of the effectiveness of an entire R&D department, as noted e.g. by McGavock and Lasinski (1998) in their survey of members of the Licensing Executives Society in the US.

3.4 Secrecy vs Patenting (and Publication)

As already explained in the Patent Fundamentals chapter, patenting results in the publication of an invention. Accordingly, any comparison of the relative merits of protection by secrecy and protection by patenting must take account of the effects of patent publication. In this regard, Irish (1994) notes that:

> *Engineers and engineering companies always need to bear in mind the fact that publication occurs, and balance the possible disadvantages of this disclosure of the invention to competitors against the advantages of obtaining a patent*

Knight (1996) similarly observes that

> *The decision of whether or not to file a patent application requires a consideration of the business need and the impact a patent will provide. Also, there is a need to determine whether the protection obtained from having a patent is worth the disclosure of the technology. To some extent, the value of the patent will depend on the type of invention and the effort required to detect infringement and to eventually enforce the claims.*

The first sentence of the above paragraph alludes to the commercial and technological significance of an invention, characteristics that are discussed under the heading 'patent properties' above. As regards the issues raised in the second and third sentences, these are reviewed in more detail below.

3.4.1 Detection

Knight (1996) usefully summarises the amount of effort required to prove infringement of different types of patent claim as follows:

> *infringing product will, no doubt, be on sale and can be purchased and analyzed in secret to determine whether the product, in fact, does infringe ...*

> *Patents on processes which leave the equivalent of a fingerprint on the product are more useful as offensive tools than those process patents that do not. The fingerprint allows the detection of infringement of the process by analysis of the product.*
>
> *Some patent professionals question whether or not process patents which do not leave fingerprints in the products are of any value at all. The thinking is that the patents probably disclose more technology than the amount of protection which is obtained, and competitors who do not respect patents may practice the invention in secret and will never be caught.*

The latter paragraph is reflected in comments in Davis and Harrison regarding policeability, namely:

> *... how would you detect infringement? If it's not policeable, then is it really worth the time and money to file a patent application?*

Nevertheless, Knight (1996) notes that process patents can and have been enforced, although 'the effort required to detect infringement and develop a legal case against an infringer ... is much more involved than with a product patent.' Another situation where patenting may be appropriate is covered by section 100 of the UK Patents Act (see White (1995)), namely:

> *where a patent is granted for a process for making a new product, the onus is placed on the defendant to prove that such product has not been made by the patented process, the legal presumption being that it has been so made [because, being new, no other way of making the product is known]*

3.4.2 Disclosure

It will be appreciated that detection and disclosure are two sides of the same coin. Thus, with regard to the statement made by Knight in the previous section, a patent covering a product that is on sale and that can be purchased and analysed is not only easy to police, the product itself also represents a ready disclosure of the invention of the patent to third parties. Accordingly, there is less of a risk that a patent document will disclose anything that is not already publicly available from the product.

Where there is a risk of disclosure by a patent application when it is published, Knight (1996) notes that

> *Since patents play such a major role in the development of technology, companies must monitor the patent art to make sure they are aware of current developments. Because companies will be reading and studying patents one should try to avoid disclosing any more information in one's patents than is absolutely necessary*

In particular, Noone (1978) suggests that a patent can:

> *... give valuable information that would enable competitors to readily design around the patent such that the modified invention would undermine any competitive advantages derived from the basic patented invention.*

It should be noted that both Knight and Noone are chemists, Knight being an IP manager at US chemical multinational DuPont. However, Cookson (1991) quotes a representative of the UK Patent Office as stating that other industries such as engineering and electronics have not followed the lead of chemicals and pharmaceutical industries in utilising patents for competitor intelligence purposes. Similarly, Oppenheim (1998, as part of the Intellectual Property Initiative discussed above) found that small and medium-sized enterprises (SMEs) make insignificant use of patent information for technical knowledge purposes.

3.4.3 Publication

Knight notes a further alternative to secrecy and patenting, whereby '*at the very minimum, a company should maintain its freedom to operate by simply publishing ideas.*' The above figure 3.1 from Aoyama (1991) shows this principle in practice at Toyota, with publication taking place in Toyota's own magazine.

Driks (1998) describes how such 'defensive' publication can also be achieved by means of patent applications that are allowed to proceed to publication and then abandoned. Note that in most territories, the law provides that such patent applications also have 'prior art' effect against any later patent applications claiming identical subject-matter, even though they may not have been published at the time the later application is filed. As such they have some (and in the US, all) of the advantages of publication whilst keeping the invention secret from competitors for longer. The downside of such approach is the cost of filing and prosecuting such 'defensive' applications to publication.

Writing from the German perspective, Dolder (1991) identifies other factors in the secrecy / patent decision as:

3.4.4 Life of the Invention

If the invention is likely to be commercially significant for longer than the typical 20 year term of a patent, then secrecy should be considered. Obviously, this only applies to inventions that are not disclosed in the item that is sold – cf. 3.4.2 above.

Noone (1978) suggests that secrecy may also be appropriate for products having short lifetimes where:

> *... the market for the product or process is limited, or if the invention is in an area where there is rapid obsolescence, such that the return on investment may be insufficient to justify the costs and risks of patenting.*

3.4.5 Containment of the Invention

The effectiveness of secrecy depends on the extent to which the technology allows the invention to be kept privy to a small circle of workers. Such containment is clearly difficult when the invention is licensed to third parties.

3.4.6 Likelihood of Independent Invention

Unlike the protection of a patent, secrecy cannot prevent a third party from making and practising the invention independently.

3.4.7 Availability of 'Prior Use' Defence

Dolder notes that should a third party subsequently obtain a patent to the invention, the original inventor will only be able to continue use under certain restrictions which may vary from territory to territory. Thus in the UK, the right of the original inventor to continue use under section 64 of the Patents Act does not extend to licensees of the invention.

Noone (1978) further notes that:

> *There are risks associated with both patents and trade secrets and it is impossible to formulate a general rule as to which option presents the greater risk. Each case has to be considered individually and the advantages and disadvantages of each option compared.*

Furthermore, in their survey of the patent departments of large UK companies, Pickering et al. (1998) found that 'most companies seem well able to judge the risks of relying upon secrecy'.

3.5 Patent Timing

The Patent Fundamentals chapter makes clear that patent rights are granted to the first person to make an invention (in the US) or to file a patent application on the invention (outside of the US). Further considerations as regards the timing of patent filings are identified in the literature as follows:

3.5.1 Speed important in fast-moving fields

Knight (1996) gives the recommendation that, where there is much activity in a particular technology area, speed in developing inventions and filing patent applications becomes a real asset and may become a deciding factor in obtaining real exclusivity.

According to Rabino and Enyati (1995), seeking patent protection as early as possible is also the prescribed tactic when a technological field is closed, with competitors recognizing the patent positions of current segment participants.

3.5.2 Once an invention has been made

Crespi (1982), writing about patenting strategies in the biological sciences, notes that 'patents must lie in the wake of the discoveries that actually occur rather than constitute the object of research'. In contrast, Glazier (1995) suggests that a corporation can invent on demand, arguing that the most valuable patents involve no great scientific discovery, usually represent only a modest advance in fundamental technology, and are made by ordinary educated people working in a corporate environment.

However, Jorda (2003) argues that such a 'patent factory' approach with invention disclosure output 'on demand' is not possible, particularly for start-ups and middle-sized companies and the biotech, chemical and pharmaceutical industries that are rooted in the empirical sciences. He notes that months and years of experimental work may be required in these industries.

3.5.3 When there is sufficient information

As explained in the Patent Fundamentals chapter, the description of a patent application typically includes multiple examples to prove that the advantages of the invention are achieved over the entire scope of the invention as claimed. In practice, Knight notes that a researcher / research manager must balance the amount of experimental work required to obtain such examples against the requirement for a *'modest but acceptable'* exclusionary position. Driks (1998) further suggests that:

> *a time line is then established for completion of additional research and filing of a patent application directed to the basic invention and whatever applications of the invention have sufficient data to support desirable patent claims*

3.5.4 Before publication of earlier filings

In the Patent Fundamentals chapter 2, it was noted that an unpublished patent application may have 'prior art' effect against subsequent patent applications. In most territories, however, the law (e.g. Articles 54(3), (4) and 56 of the European Patent Convention) provides that this effect is limited to subject-matter that is identical between the two applications. Whilst this will prevent an applicant from getting a second patent to identical subject-matter, it will not prevent two patents to differing subject-matter, even if the difference is obvious and thus non-patentable had the earlier patent application been published.

Accordingly, where an invention is closely related to that of an earlier patent application, it may be desirable to file a further patent application to that invention before the publication of the earlier patent application. This is reflected in the comment by Driks (1998) that:

> *Because filing the patent application starts certain clocks running, additional patent applications ... must be filed. Preferably this will occur ... no later than the publication date (usually about 18 months after the patent application filing date) of the original patent application.*

3.6 Portfolio Strategies

The term 'strategy' has been used here to describe the ways in which the assembly of patents in a portfolio can be used together to achieve certain ends. Various strategies to various ends are identified in the literature:

3.6.1 'Wall' Strategy

Described by Knight (1996), this strategy addresses the problem that some of a company's patents will:

> *eventually be bypassed by competitors, and that the true value of the patent is the time delay caused by the need for extra work by a determined competitor which wants to get around the 'wall' of the patent.*

Knight's diagram illustrating the strategy is reproduced in figure 3.3. According to Knight:

> *A company wishing to implement the wall strategy files one or more patents on a technology or a part of the desired technology. After the filing of the patent(s), research by the company continues at a high rate*
>
> *The result of this strategy is that by the time the original patent applications have been published and digested by competitors, additional patents have been filed which build on the original patents. The original patent filer has already developed new technology that will make the old technology obsolete.*
>
> *In this manner, the competitor is always behind the originator and at least theoretically a company's patent monopoly can be continued indefinitely.*

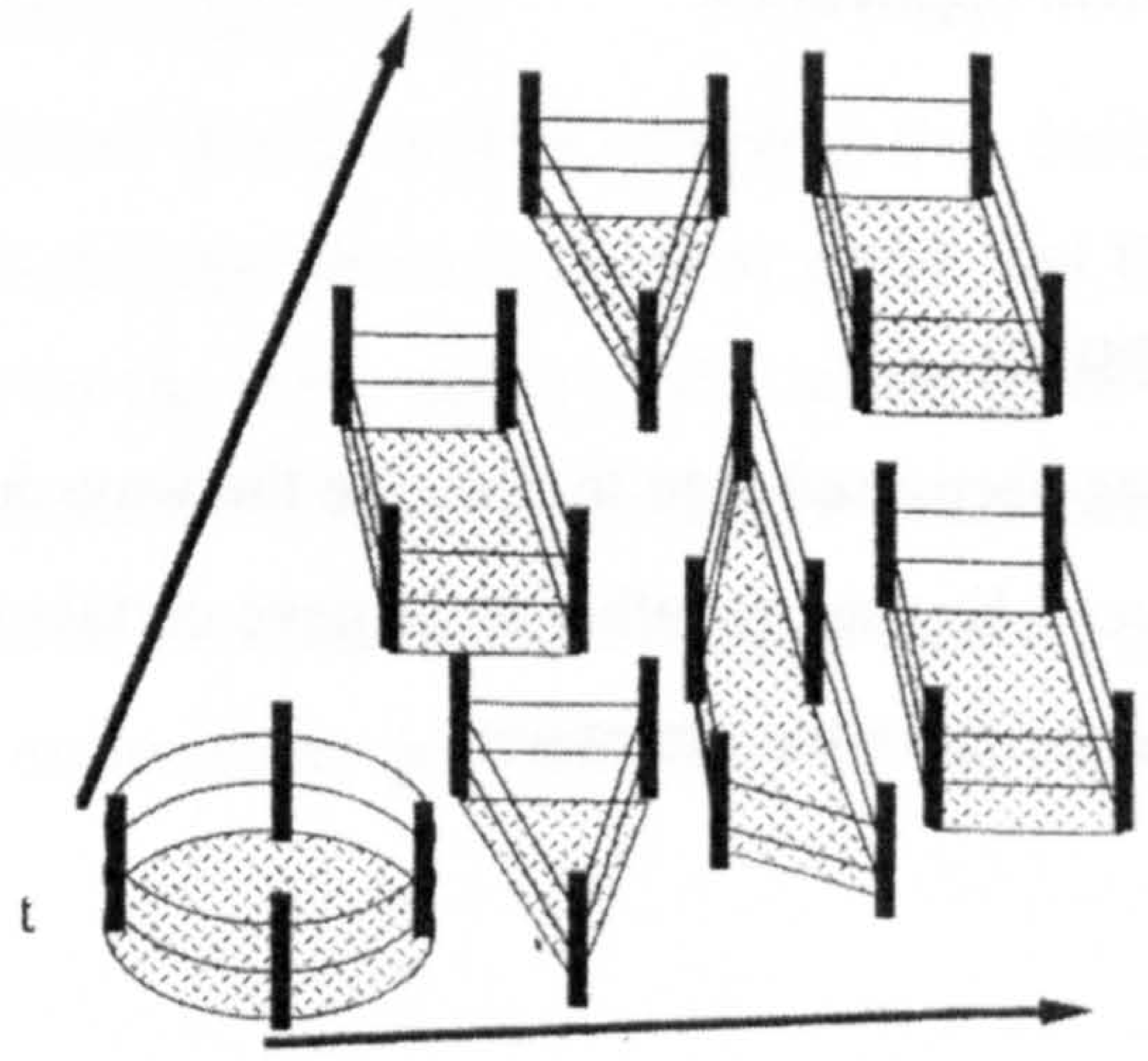

Figure 3.3: Illustration of 'Wall' Strategy (from Knight (1996))

3.6.2 'Multiple Barrier' Strategy

This is described by Norris (1991) with reference to the diagram reproduced in figure 3.4 and in the context of inkjet printing technology. He states:

> *There are four different sets of possible patent barriers which may be established to prevent a trespass on the patented technology. The first set is directed to the ink jet device itself with a broad concept patent complemented by more focused, specifically-directed patents to alternative embodiments for practicing the broad concept.*
>
> *The scope of the broad concept patent is broad, but because of its breadth, it may be subject to attack from a validity standpoint. For this reason, more narrow patents directed to the specific embodiments are provided which may be more likely to withstand a validity attack*
>
> *It is important, however, that each specific patented embodiment pick up where the other one left off so as to leave no holes in the barrier. In other words, the claims covering an embodiment have as their outer limits the claims for alternative embodiments.*

It is noted that this strategy mirrors conventional patent claim structure as described by Micklethwaite (1946) in the Patent Fundamentals chapter.

As well as illustrating the principle discussed above, figure 3.4 also shows multiple sets of barriers relating to other aspects of inkjet printing, namely methods of operating the inkjet device, methods of fabricating the inkjet devices and the ink used in the devices. Norris suggests that this potentially establishes 'eight different barriers through which a trespasser would have to pass in order to invade the proprietary technology'. To the rear of the diagram he also shows a further barrier corresponding to trade secrets.

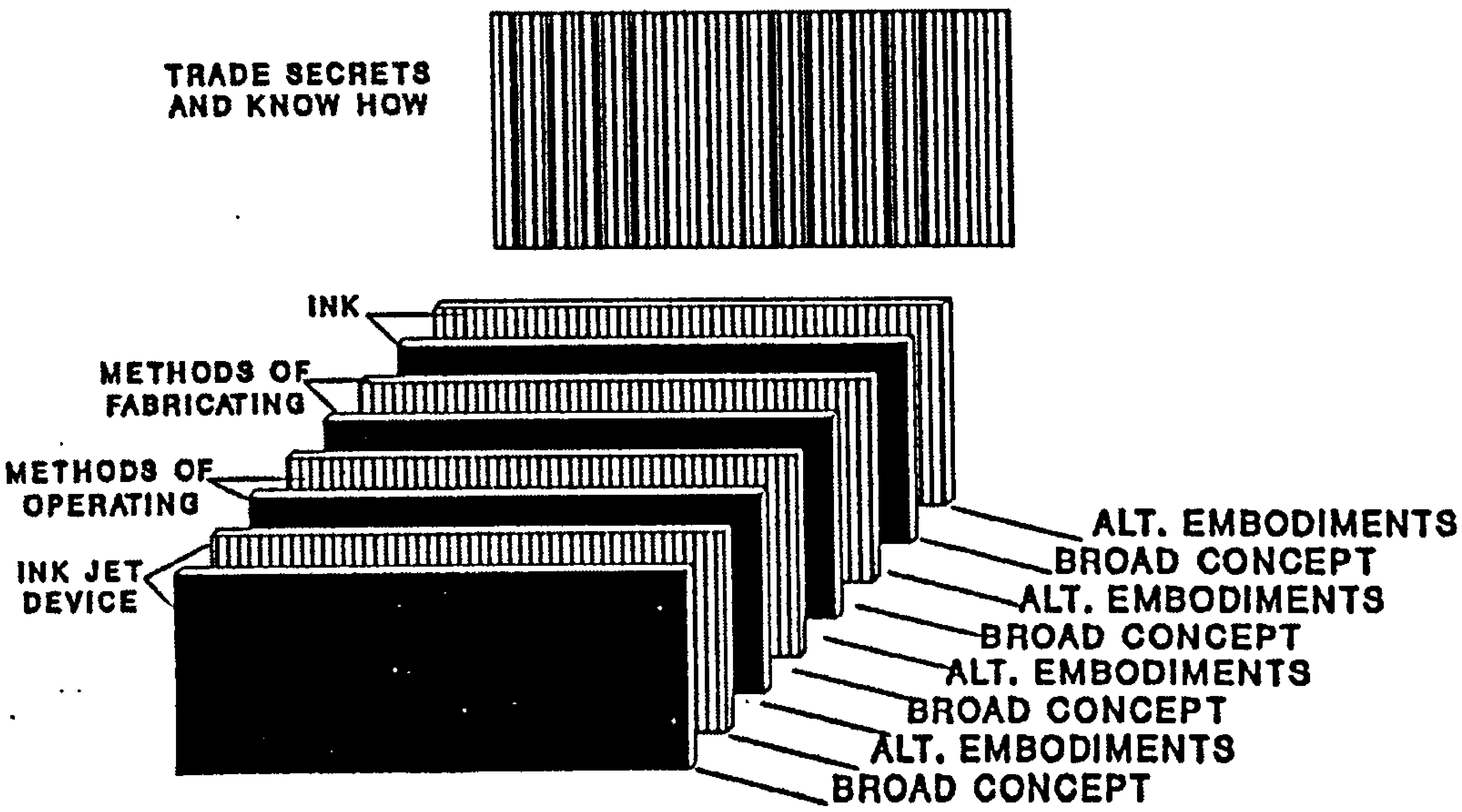

Figure 3.4: Illustration of 'Multiple Barrier' Strategy (from Norris (1991))

Norris also explains the typical flaws in patent portfolios. Referring to the diagram reproduced in figure 3.5, he notes that whilst considerable effort may be expended on obtaining patent protection on specific embodiments of the device as well as particular inks, there are nevertheless 'large gaps between the patent and subject-matter which would allow the infringer to bypass the patent protection on his way to trespassing the patentee's technology'. This is similar to a comment made by Chisholm (1972) that:

> *It is of little value to patent one embodiment of a discovery if third parties are free to practice alternate embodiments*

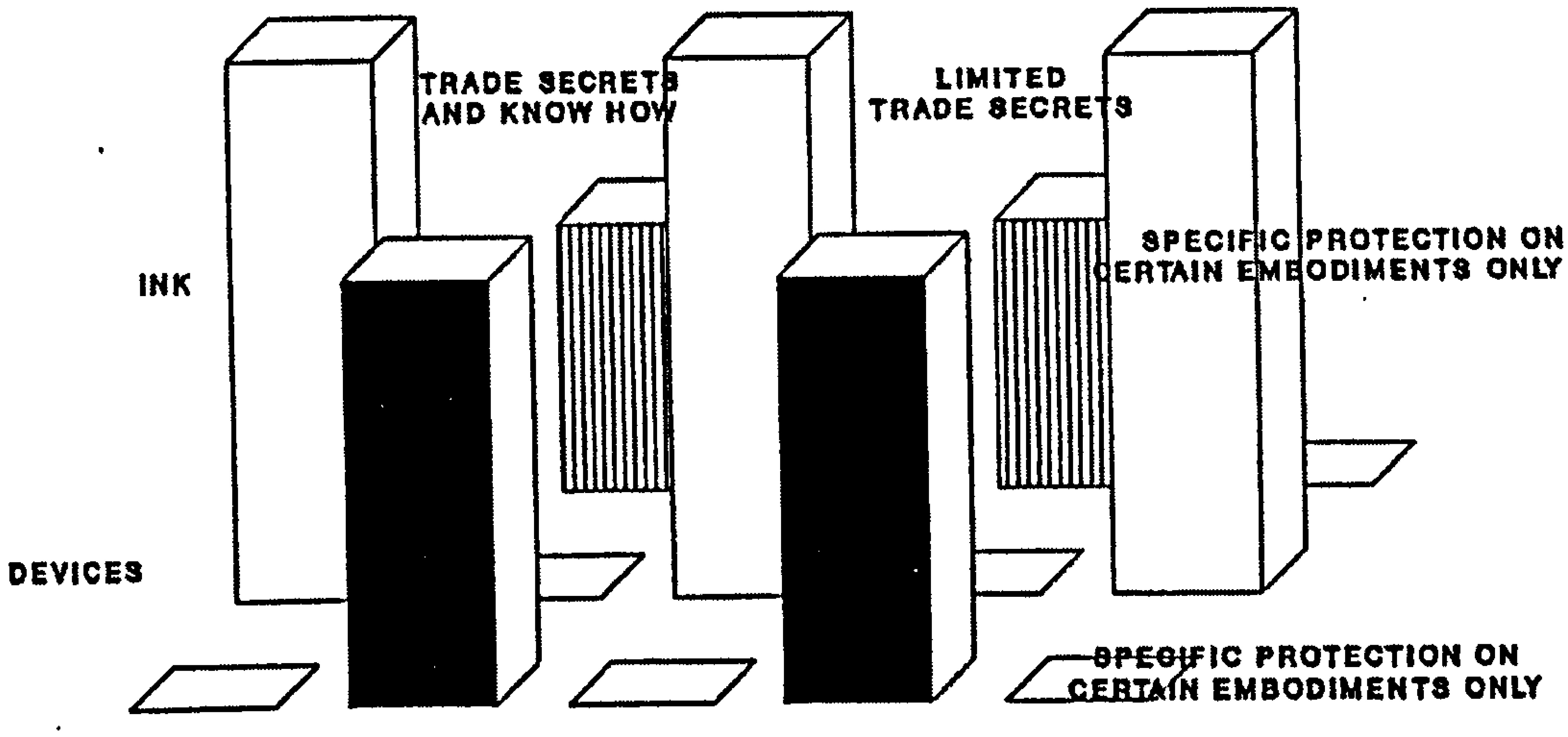

Figure 3.5: Flawed 'Multiple Barrier' Strategy – Case 1
(from Norris (1991))

With reference to another diagram (reproduced in figure 3.6), he notes that:

> *Here, an effort has been made to patent a broad device concept but that effort has failed since the breadth as claimed is insufficient to provide a full and complete barrier. This would-be barrier protecting alternative embodiments is in itself insufficient since there are large holes of unpatented embodiments provided for a would-be infringer to pass through.*

In a final diagram, reproduced in figure 3.7, Norris uses a barrier of reduced height to depict a weak patent, i.e. one that is subject to a validity attack.

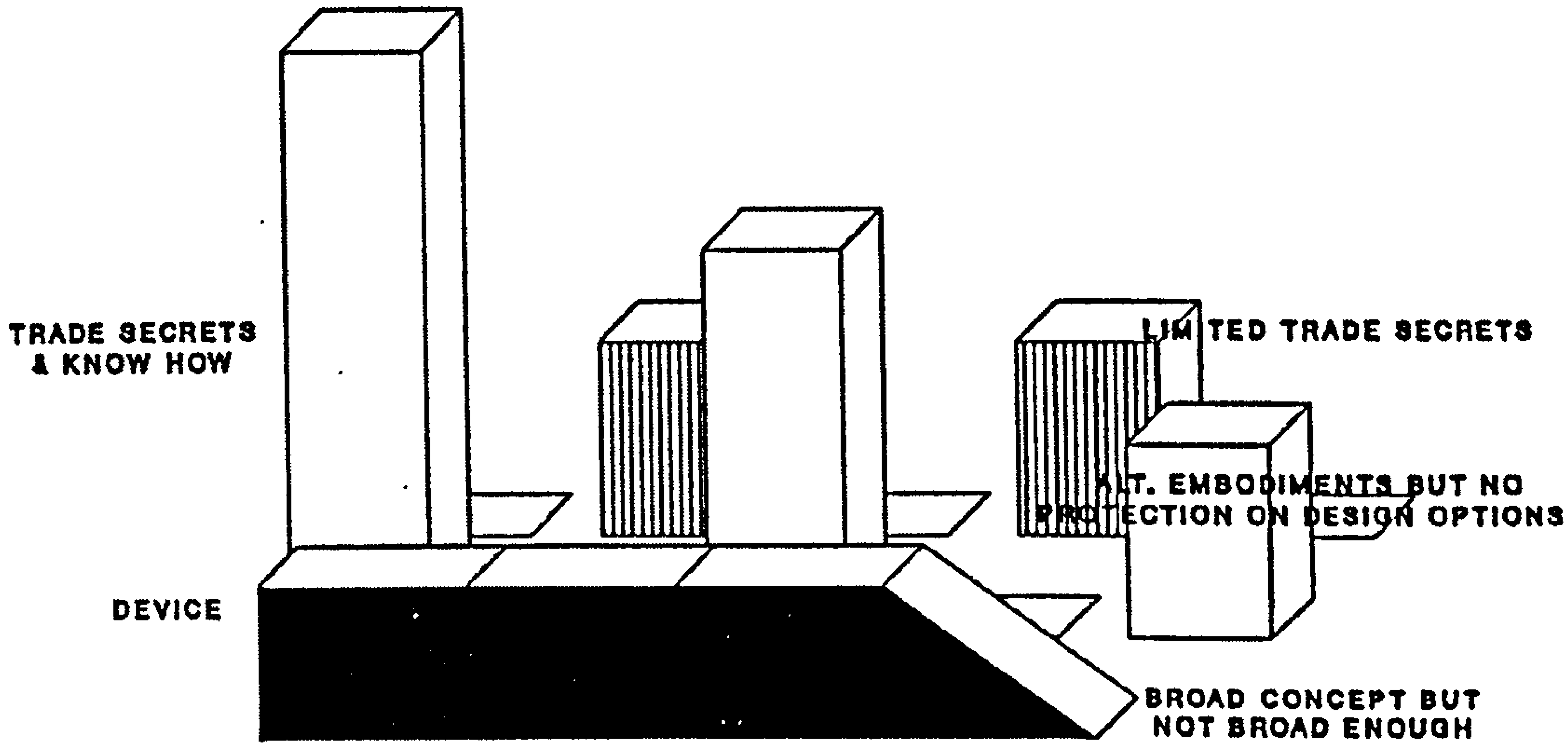

Figure 3.6: Flawed 'Multiple Barrier' Strategy – Case 2 (from Norris (1991))

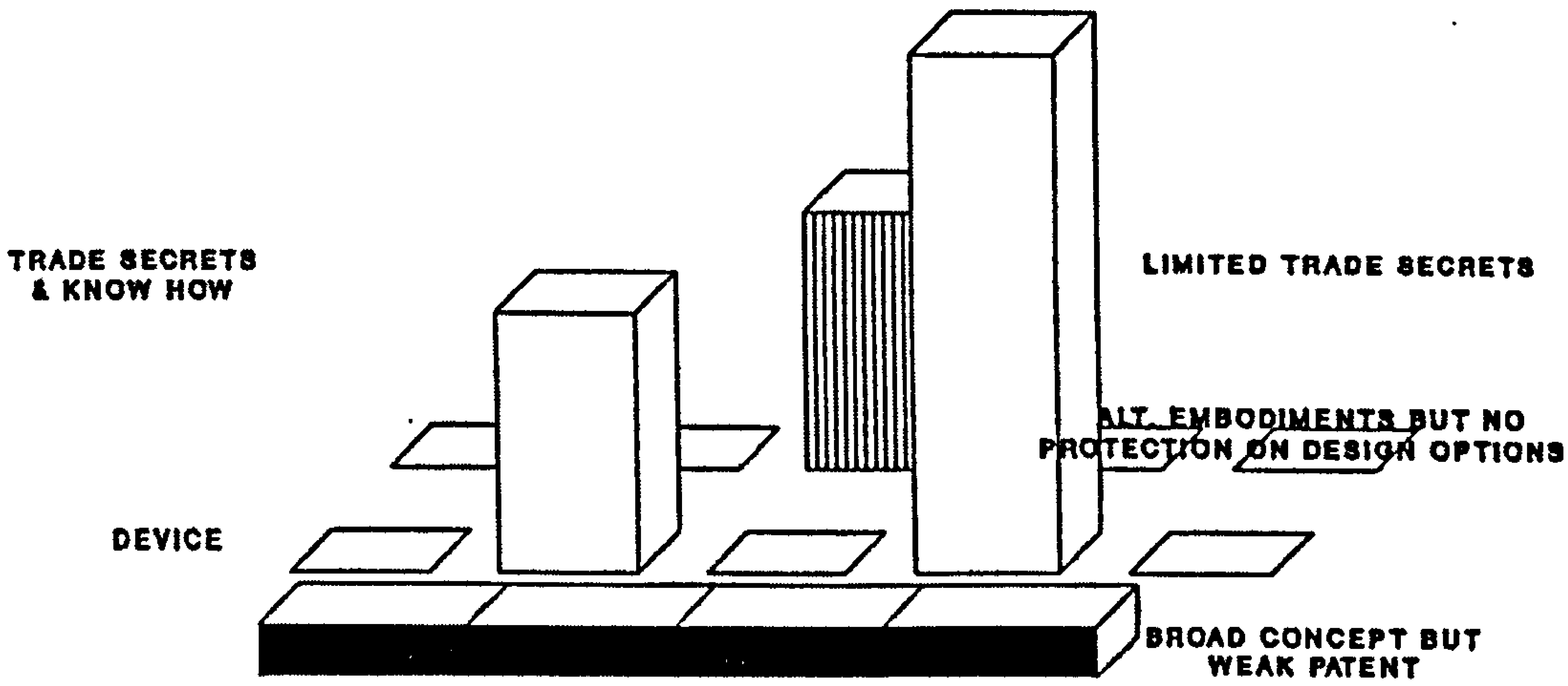

Figure 3.7: Flawed 'Multiple Barrier' Strategy – Case 3 (from Norris (1991))

3.6.3 'Improvement' Strategy

This strategy addresses the problem of patent expiry, explained by Gibson (1990) as:

> *In exchange for exclusive rights, patent holders must publicly disclose details about their products, processes or designs. Then, after a set period of time ... those details aren't just there for all the world to see but to take as well.*

An example of this strategy is mentioned by Gourlay (1990) who cites McMurtry's plan to counter the effect of patent expiry, namely:

> *... to patent as we go along. Even if competitors are able to make our earlier [products] ... these would not now be accepted in the market because we have better products which remain covered by patents.*

Gourlay goes on to explain the strategy using the following analogy:

> *It is as if boots had been patented before the invention of laces. By the time the patent expired, laces would have appeared and been patented. A newcomer would be able to make boots but who would buy them without laces ?*

Gibson describes the same strategy at US company Polaroid, noting that although the company's original patents to instant photography were originally issued in 1940:

> *Polaroid has managed to protect its hold on the instant camera market by continually upgrading its products ... They're still receiving improvement patents on innovations over fifty years old.*

In another example, Gibson describes how US agrochemical company Monsanto dealt with the expiry of the patent to the active ingredient of their 'Lasso' herbicide product by

> *tailoring new performance characteristics for Lasso – breaking up a large generalised product into targeted, value-added segments that command premiums in the market place.*

3.6.4 'Flooding' or 'Blanketing' Strategy

Under the heading 'patent flooding' or 'patent blanketing' Knight (1996) indicates that:

> *This type of strategy can be thought of as being composed of a series of individual fences, very quickly erected around a technology area, with each fenced-in area being a separate patent application enclosing a separate invention.*
>
> *The object of blanketing a technology area is ... to patent ... as much of the technology area as possible in an attempt to have an exclusive position*

This is supported by Murakami and Nakata (1994) who cite:

> *the application for and acquisition of patents as a way to discourage the entry of others into a specific area ... The intention is to cause other firms to think 'Company X is filing lots of patent applications in technical field Y, so it would be difficult for us to move in that area'.*

Certain commentators seek to make a distinction between 'blanketing' and 'flooding' According to Knight:

> *Blanketing an area of technology is normally the result of a deliberate effort to examine each and every facet of a technology area. To accomplish this, normally a team of researchers is required.*

whereas, according to Granstrand (1999):

Flooding refers to a less structured way of taking out multiple patents, major as well as minor, in a field and may result from patent-reward schemes as much as from a conscious strategy.

The diagrams used by Knight and Granstrand to illustrate these strategies are reproduced in figures 3.8 and 3.9.

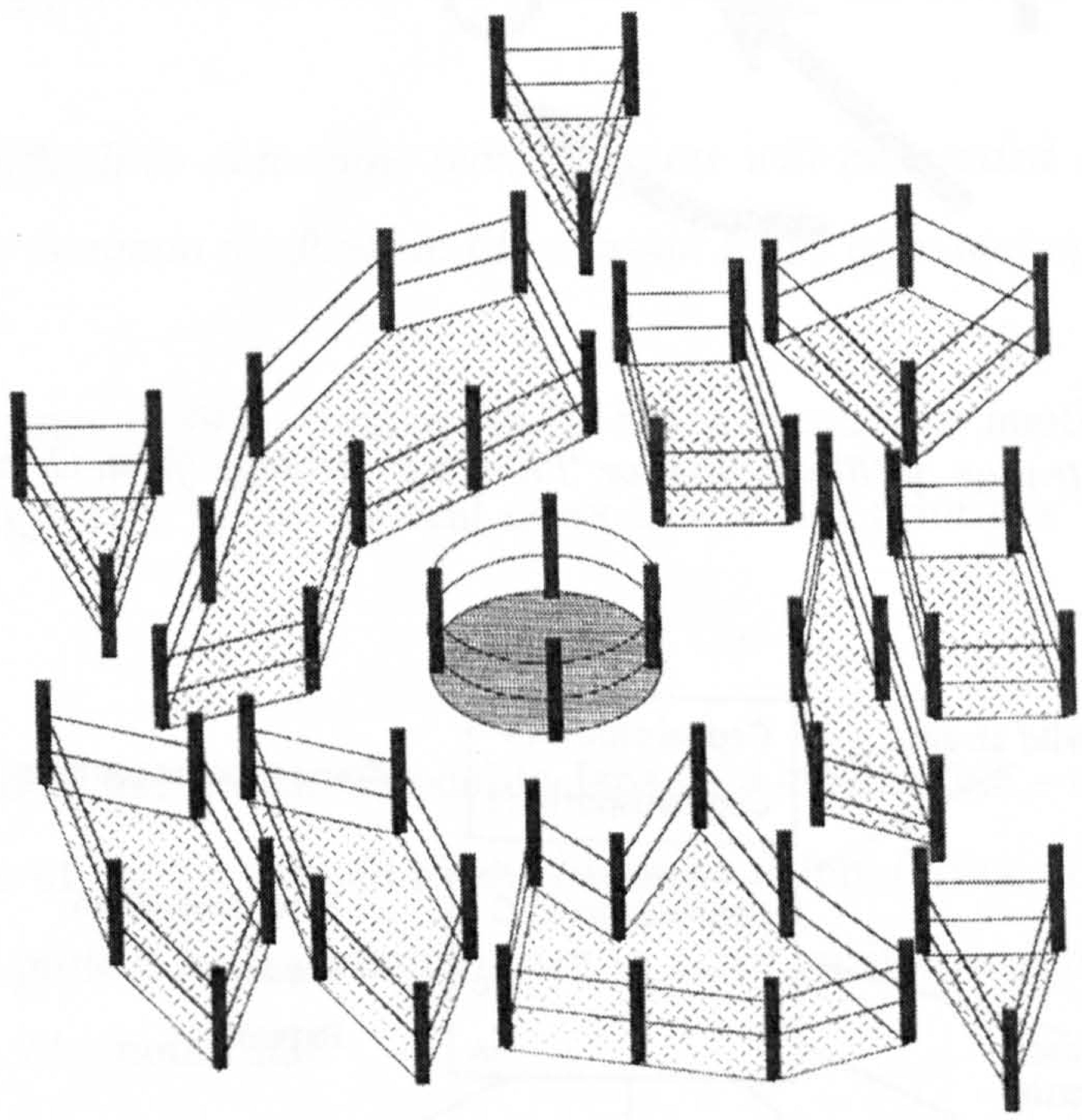

Figure 3.8: Illustration of 'Flooding' or 'Blanketing' Strategy (from Knight, 1996)

An example of this kind of strategy in the biological field of cephalosporins is given by Crespi (1982) who notes that:

patent strategy at this time was to protect any development that could conceivably be significant in the long term in a field which was still totally open but of uncertain future.

Figure 3.10 is Crespi's illustration of the corresponding patent structure.

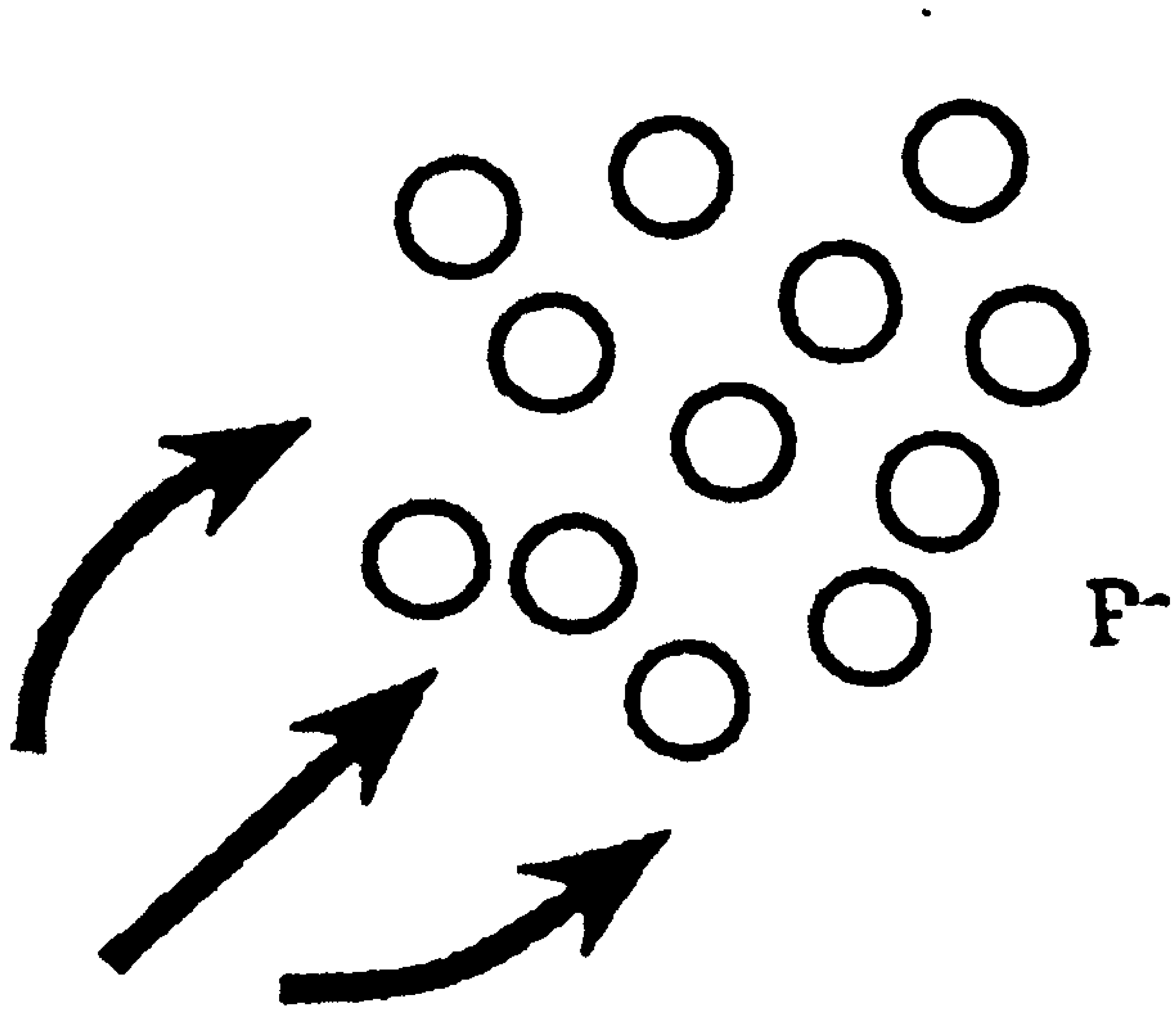

Figure 3.9: Illustration of 'Blanketing' or 'Flooding' Strategy (from Granstrand, 1999)

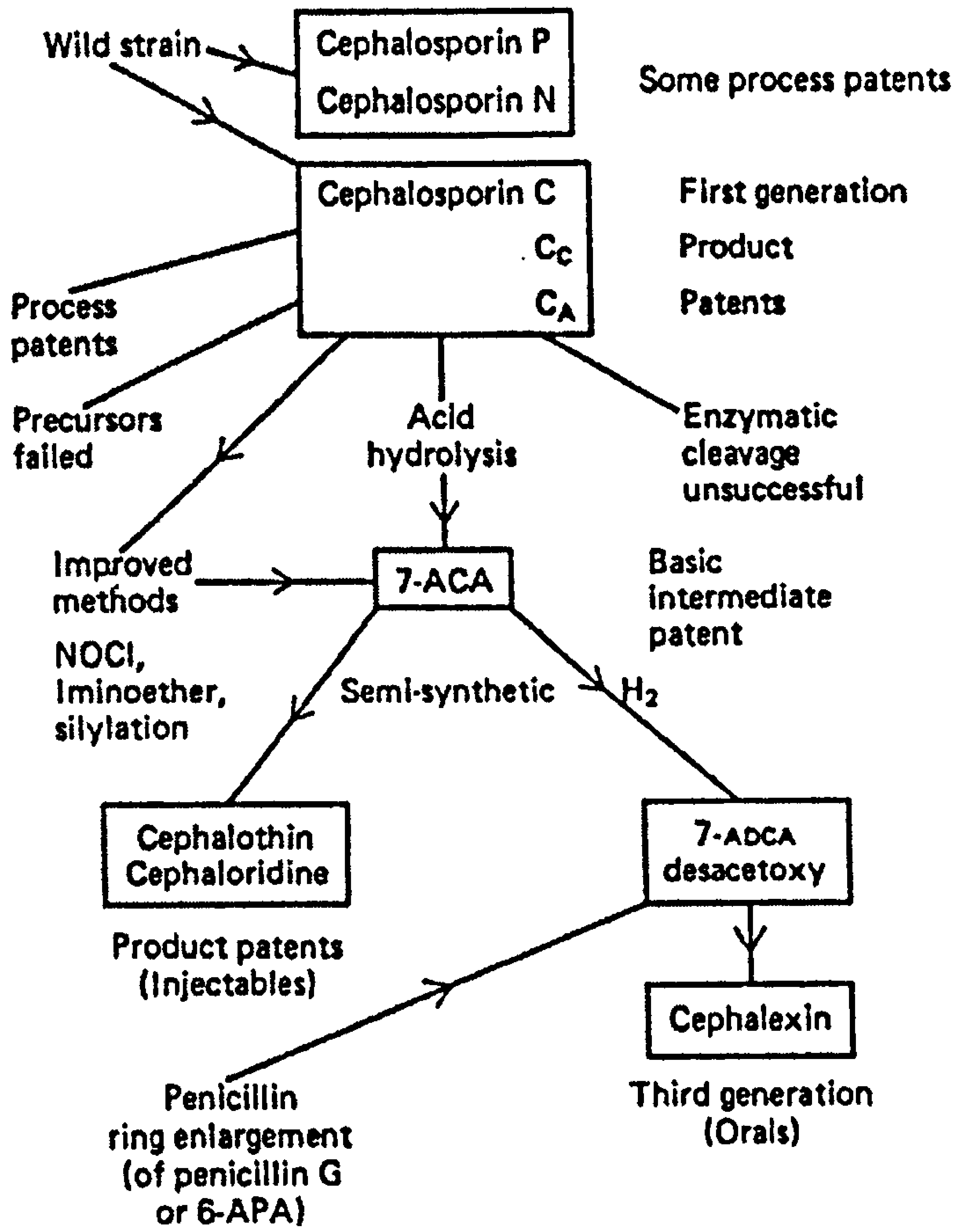

Figure 3.10: Illustration of Cephalosporins Patent Structure (from Crespi, 1982)

Granstrand further notes that:

> *Blanketing and flooding may be used as a strategy in emerging technologies when uncertainty is high regarding which R&D are fruitful or in situations with uncertainty about the economic importance of the scope of a patent.*

This also finds support in Murakami and Nakata (1994) who note that:

> *Since it is difficult to determine which patents will be needed as one's business develops, it is common for firms to file a broad scope of patent applications.*

Referring to Westney (1993), Granstrand (p163) suggests that another reason for the 'flooding' strategy may be to conceal one's true R&D priorities within the patent 'flood'.

Nurton (1996) notes that patent 'floods' in Japan are attributable – at least in part - to the narrow scope of claims granted by the Japanese Patent Office (JPO), necessitating more patents to protect each invention than in other territories. This consistent with Helfgott (1992), who notes that:

> *the JPO may demand the inclusion of a feature into the claims on the grounds that the description indicates this feature as being indispensable to the invention.*

Referring to the inkjet market, Bower (1994) suggests that whilst large companies may have the funds and often the patent staff to blanket an area of technology with patents, smaller firms do not. Rather, such firms are 'market driven, have few key patents and take some risk that other similar technologies may emerge'. Bower notes that they are also more manoeuvrable than the larger companies which require a more defensive patent posture if they are to survive.

3.6.5 'Fencing' Strategy

Granstrand (1999) uses the term 'fencing' to refer to the situation where:

a series of patents, ordered in some way, block certain lines or directions of R&D ... Fencing is typically used for a range of possibly quite different technical solutions for achieving a similar functional result.

Granstrand's illustration of this strategy is shown in figure 3.11.

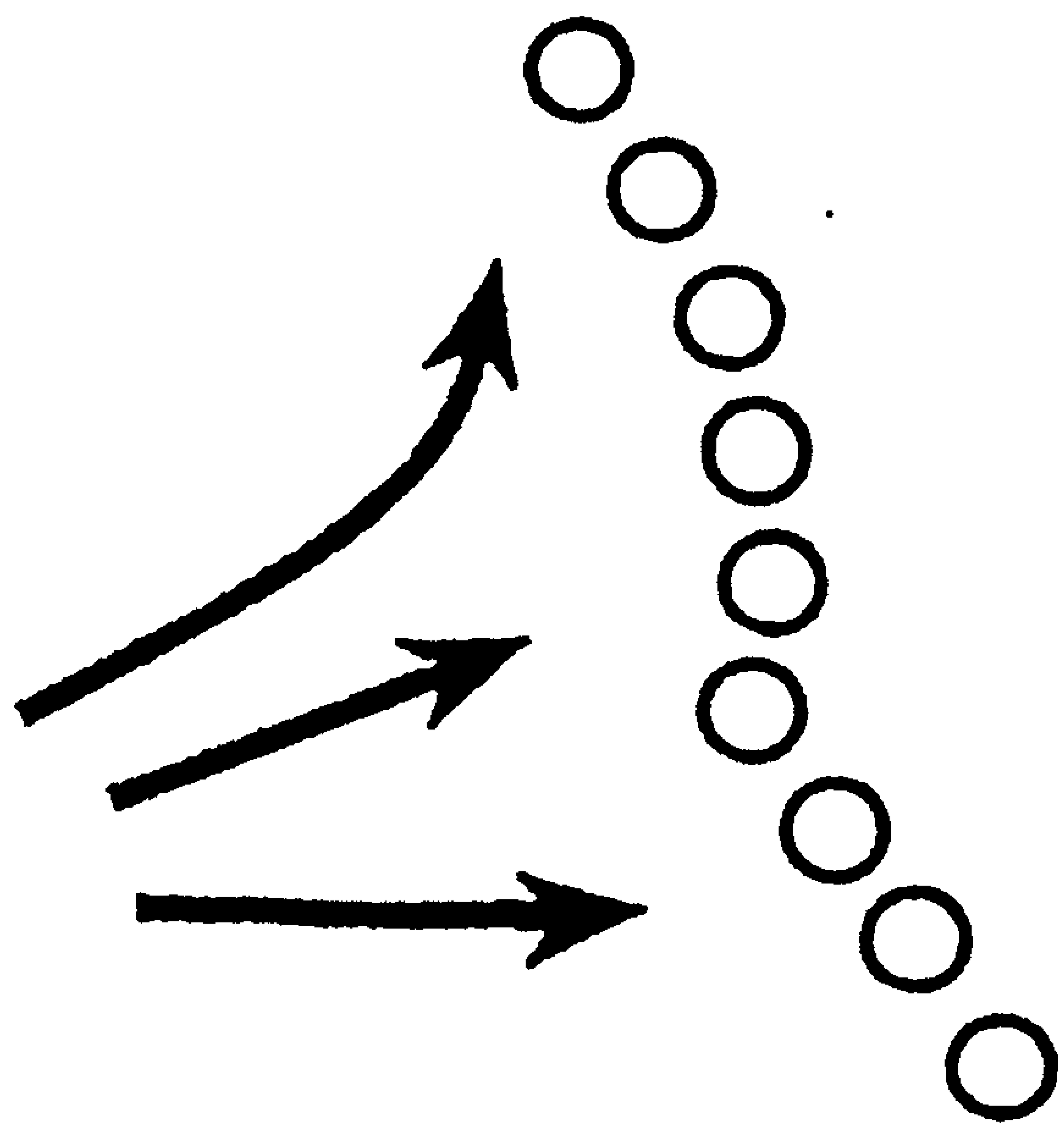

Figure 3.11: Illustration of 'Fencing' Strategy (from Granstrand, 1999)

3.6.6 'Picket Fence' Strategy

Called the 'picket fence' strategy by Glazier (1995), this involves:

inventing a series of patents that represent small incremental innovations around the core technology embodied in a competitor's key fundamental patent. The incremental innovations represent the preferred products in which the core technology may be used commercially. The idea is that they become a barrier to the owner's effective use of its original technology. The owner of the picket fence is then in a position to force a cross license of patents to acquire the core technology for its own use.

Knight (1996) also notes this strategy, albeit only as an aspect of the 'blanketing' strategy mentioned. Granstrand (1999) calls this strategy 'fencing-in or surrounding', illustrating it with the diagram reproduced in figure 3.12.

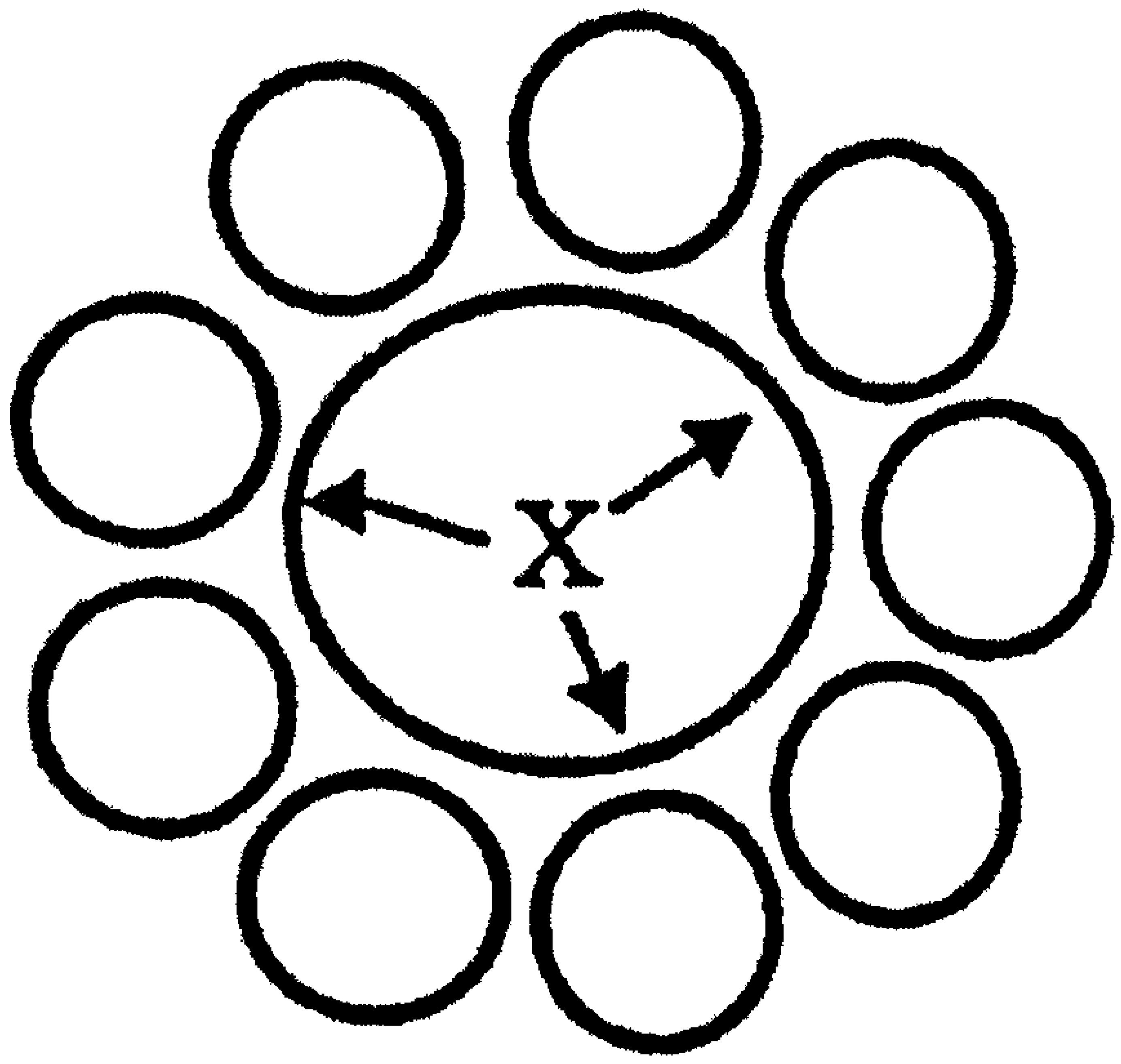

Figure 3.12: Illustration of 'Fencing-In' or 'Surrounding' Strategy (from Granstrand, 1999)

Rivette and Kline (2000) also give an example of this strategy, which they call 'bracketing':

> *imagine that your competitor has invented a new high-intensity light and has patented the filament. But, as it turns out, the filament requires a more durable glass bulb and socket housing to absorb the added heat, as well as more heat-resistant shade construction and electrical connectors. ... Your competitor may have patented the filament, but if you patent everything else, then the competitor is locked out of much of the market.*

The same strategy is also called 'patent flooding' in East Asian Executive Reports (1993) where it is asserted that:

Japanese companies use patent flooding as a tactic to force cross-licensing by obtaining patents on numerous and insignificant variations, holding another inventor's basic patent 'hostage' with the threat of bringing an infringement action based on the variations.

This is confirmed by Murakami and Nakata (1994) who found that just over 60% of Japanese companies surveyed pursued what the authors called a 'defensive' strategy, namely:

submitting large numbers of patent applications for applied technologies that relate to, or would be used to commercialize, a particular invention. This type of process limits the ability of the original inventor of a fundamental patent to exert his rights. This is because in many cases it is impossible to create a product without utilizing both the fundamental patent and the related peripheral patents.

Pitkethly (2001) considers the strategy from the perspective of the owner of the original technology, noting that:

If an initial inventor fails to follow up with subsequent inventions and fails to retain the technical lead, then subsequent developers may so swamp the initial invention with developments critical to commercial success that the balance of power may shift to the developers, not the initiator.

Driks (1998) further suggests a strategy that owners of original technology might use to counteract the picket-fencing strategy. Called 'patent mapping', it requires the marketing function of a company to identify promising new applications of a core technology and the patent function to file corresponding patent applications before the patent application on the core technology publishes.

3.6.7 'Mutually Assured Destruction' Strategy

Sharing broadly similar negotiating goals with 'Picket Fence' is the strategy named 'MAD' (Mutually Assured Destruction) by Rivette and Kline (2000) under which:

> *patents served as bargaining chips, to be traded off or cross-licensed between firms as a means of forestalling costly patent infringement lawsuits that often benefited no one (except the lawyers). The thinking was, if you sue me, then I'll sue you back and in the end we'll both just wind up with radioactive balance sheets.*

The same strategy is described by Glazier (1995) under the heading 'Bargaining Chip Strategy'. Helfgott (1992) also mentions 'the need to receive freedom of action for present products and future developments'. Hofinger (1996) similarly cites 'the fact that an organisation's competitors are filing patents' as a reason for making patent filings'. Pitkethly (2001) describes the implementation of the strategy in more detail. Referring to the figure shown at 3.13 below, he describes the scenario whereby

> *A and B produce innovations a1 and b1. ... A and B both produce improvements a2 and b2 ... in order for A to produce its preferred product (illustrated by vertical arrows in the technological advance/Techno-legal Scope graph) it requires a licence from B to b2. By obtaining a cross-licence to a2 in return for the licence to b2, both A and B can produce products involving a2 which is more technically advanced than competitor C's innovation c1. By cross-licensing both A and B are better off relative to C.*

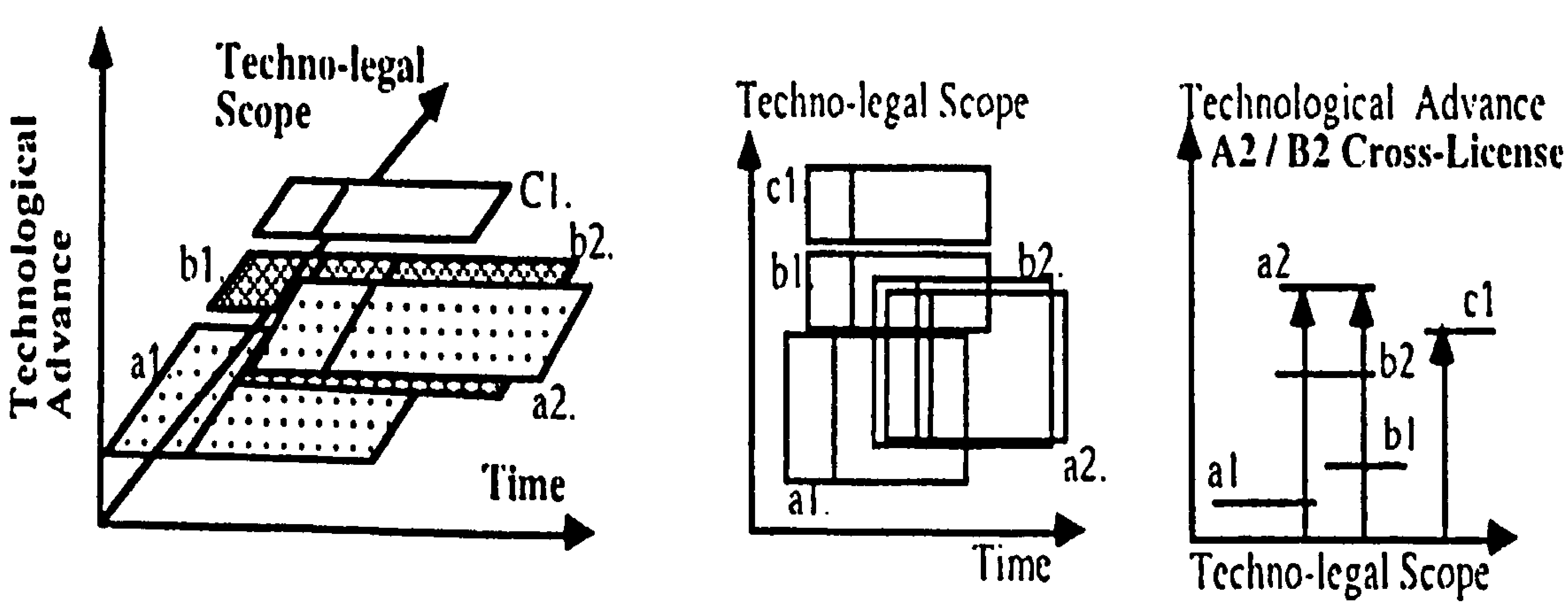

Figure 3.13: Depiction of Cross-licensing Scenario (from Pitkethly, 2001)

3.6.8 'Patent along the supply chain' Strategy

Davis and Harrison (2001) note that:

> *Oftentimes, your company exists in the middle of a supply chain where patented innovations can have either a positive or negative impact on your business. For example, you may have an exclusive arrangement with a supplier that has a superior product, in part protected as intellectual property. This gives your product [which incorporates the supplier's product] a competitive advantage in the marketplace.*

A corresponding diagram is reproduced at figure 3.14

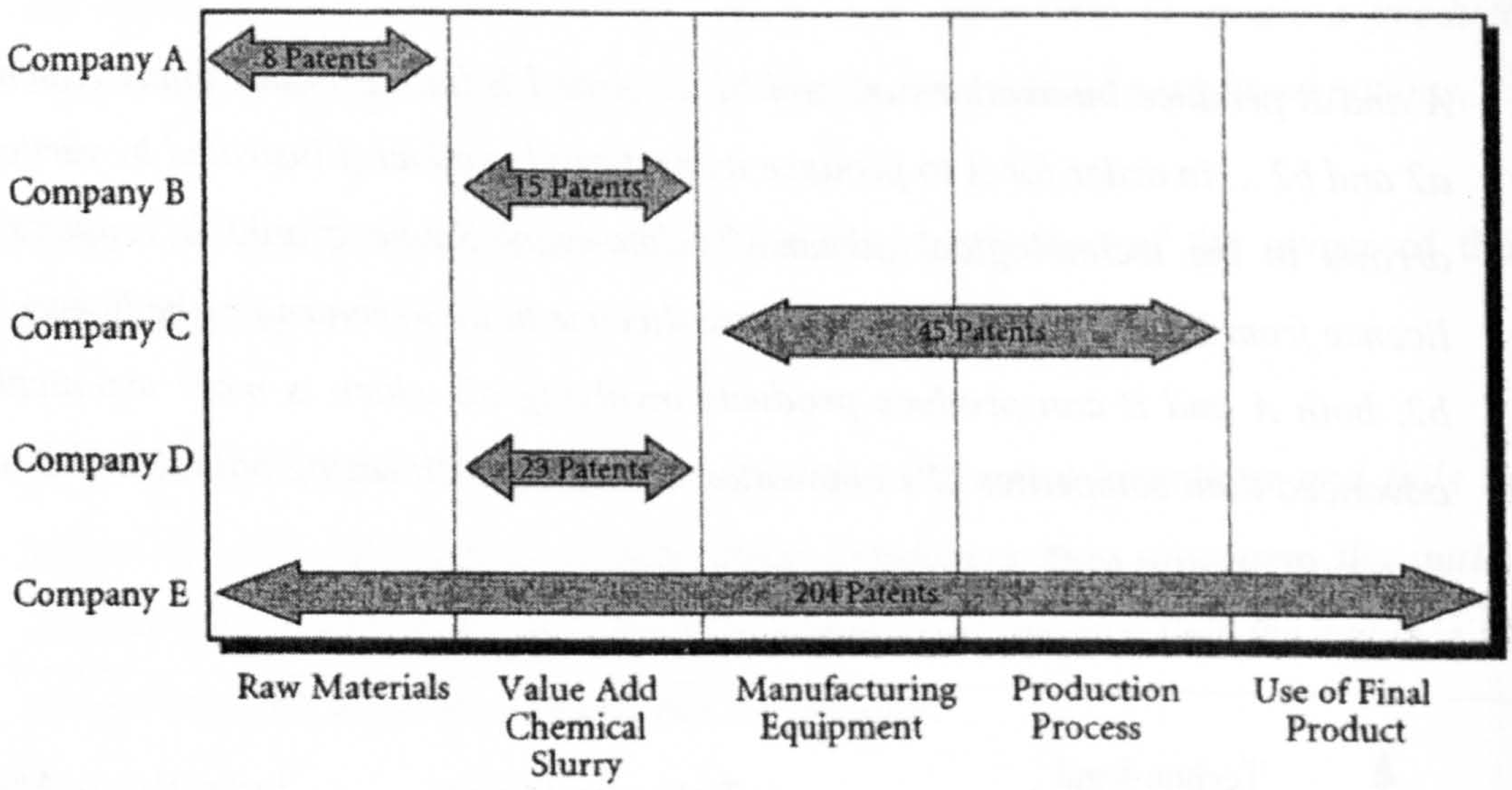

Figure 3.14: Patenting on the Supply Chain (from Davis and Harrison, 2001)

Buckley (2000) describes a similar 'cooperative' strategy involving patent filings 'for causing alliances with those who own critical points in the value chain'. Rabino and Enyati (1995) give a pharmaceutical example, noting that:

> *a patent for a method that treats someone with a particular disease by using a novel drug may potentially be infringed upon by ... doctors and nurses. By contrast, a patent for the novel drug itself may potentially be infringed upon by the*

manufacturer of the drug. ... From a long-range strategic perspective then, it is more 'desirable' to anticipate suing potential competitors rather than potential customers.

Filings at different points along the supply chain can also be made by the owner of a core technology as part of a different strategy to extract value at different points along the route to market. To use the analogy introduced above, the owner of the patent to boots may also seek patent protection for a spacesuit incorporating boots.

It should be noted that once the boots have been sold, either by the patent owner or under license, patent law generally considers the patent right in the boots to be 'exhausted'. As noted by White (1995):

Under English law, the sale of a right-protected product normally carries with it an implied license under that right for the purchaser to use or re-sell the product without fetter from it.

However, such exhaustion would generally not extend to any patent right in a spacesuit, allowing e.g. a royalty under that patent to be demanded of a spacesuit manufacturer, even though that manufacturer may have bought the boots to be used in the spacesuit.

3.6.9 'Maze' Strategy

Knight (1996) suggests that where only 'narrow' patents are available in a technology area (e.g. due to earlier prior art), it may be possible to obtain a degree of exclusivity in that area by means of a 'maze' of narrow patents. The diagram used by Knight to illustrate this point is reproduced at figure 3.15.

As similar point is made by Rabino and Enyati (1995) who note that:

when most patents in a particular field are improvement patents, this signals that the field is closed and that competitors, for the most part, recognize the patent *positions of current segment participants. The prescribed tactic in such a setting is to seek patent protection whenever possible*

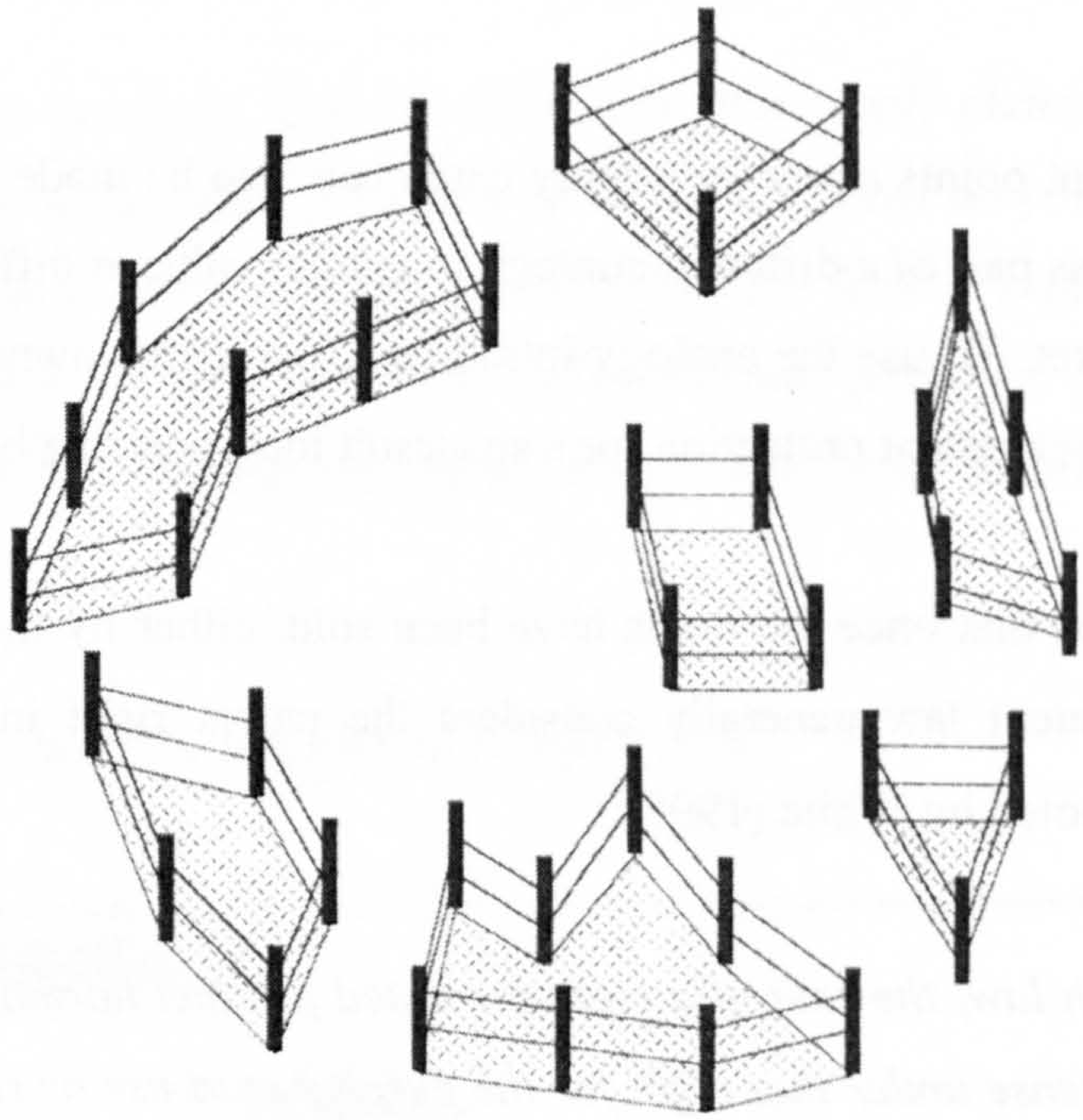

Figure 3.15: 'Maze' Strategy (from Knight, 1996)

3.7 Portfolio Depiction

As already shown in figure 3.15 above, Knight (1996) uses a fenced enclosure to depict patent scope. The greater the scope of the patent, the greater the size of the enclosure. Patent portfolios are depicted by multiple enclosures.

Granstrand (1999) employs a similar concept which he describes as 'technology space', using a circle to enclose the technical solutions in the claims of the patent. To this he adds arrows entitled 'R&D direction of competitors' – see figure 3.9 above.

The diagrams of Norris (1991) shown in figures 3.4 to 3.7 above use broad and narrow barriers to depict patents of broad and narrow scope, the height of the barrier representing the strength of the patent against validity attack.

The diagrams of Pitkethly (2001) shown in figure 3.13 above also employ barriers of width corresponding to patent scope. However, the 'height' of the barrier, rather than being used to depict the strength of the patent against validity attack, is used to depict the term of the patent relative to a time axis. Barriers corresponding to respective patents are also spaced along a third axis entitled 'Technological Advance'. Together, the three axes are said to define 'Intellectual Property Strategic Space'.

Germeraad (1999) describes 'patent landscape maps'. Originally developed by American company Cartia and subsequently acquired by Germeraad's company, Aurigin, these computer-generated diagrams depict each patent by means of a dot, with patents to similar technology being grouped together, groups being differentiated by means of shading and/or 'contour lines' which also lend the diagram an aesthetically-pleasing 3D effect. A screen dump of such a map is shown in figure 3.16: although lacking detail and colour, it is nevertheless demonstrates the map-like nature of such diagrams.

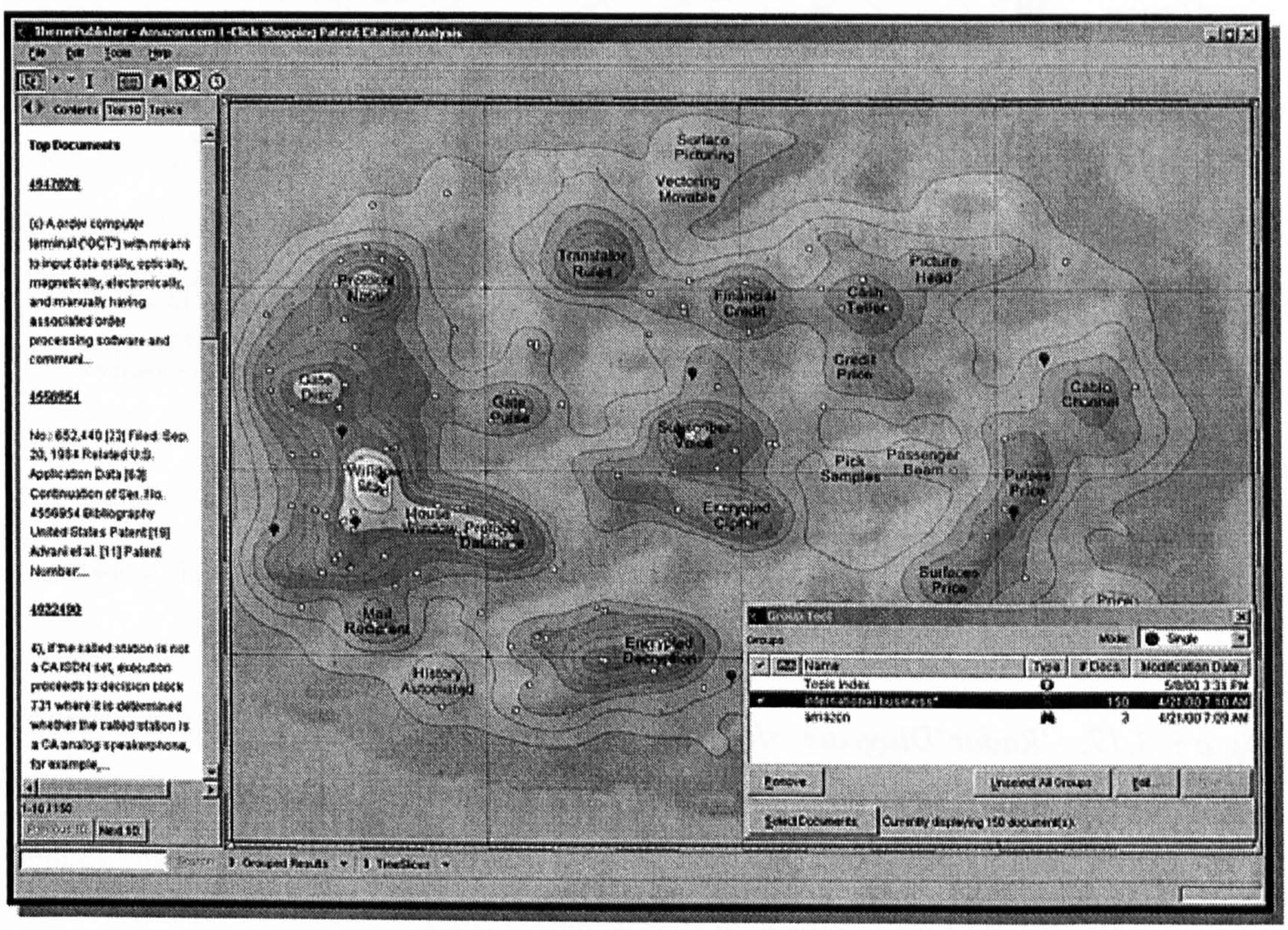

Figure 3.16: Patent Landscape Map (from www.micropatent.com)

Germeraad also shows how the 'similar technology group' approach can be implemented using a 'radar' diagram of the kind often found in conventional spreadsheet software (figure 3.17). A similarly conventional bar graph is also used by Germeraad to show the age distribution of the filings in a patent portfolio.

A final method of depicting patent relationships proposed by Germeraad is a so-called 'citation tree'. Computer generated from the results of patent office search reports (cf. section 2.5.1 of the Patent Fundamentals chapter 2), such a diagram shows the earlier patent documents that have been cited against a patent application during examination as well as the later patent documents against which that patent application has been cited.

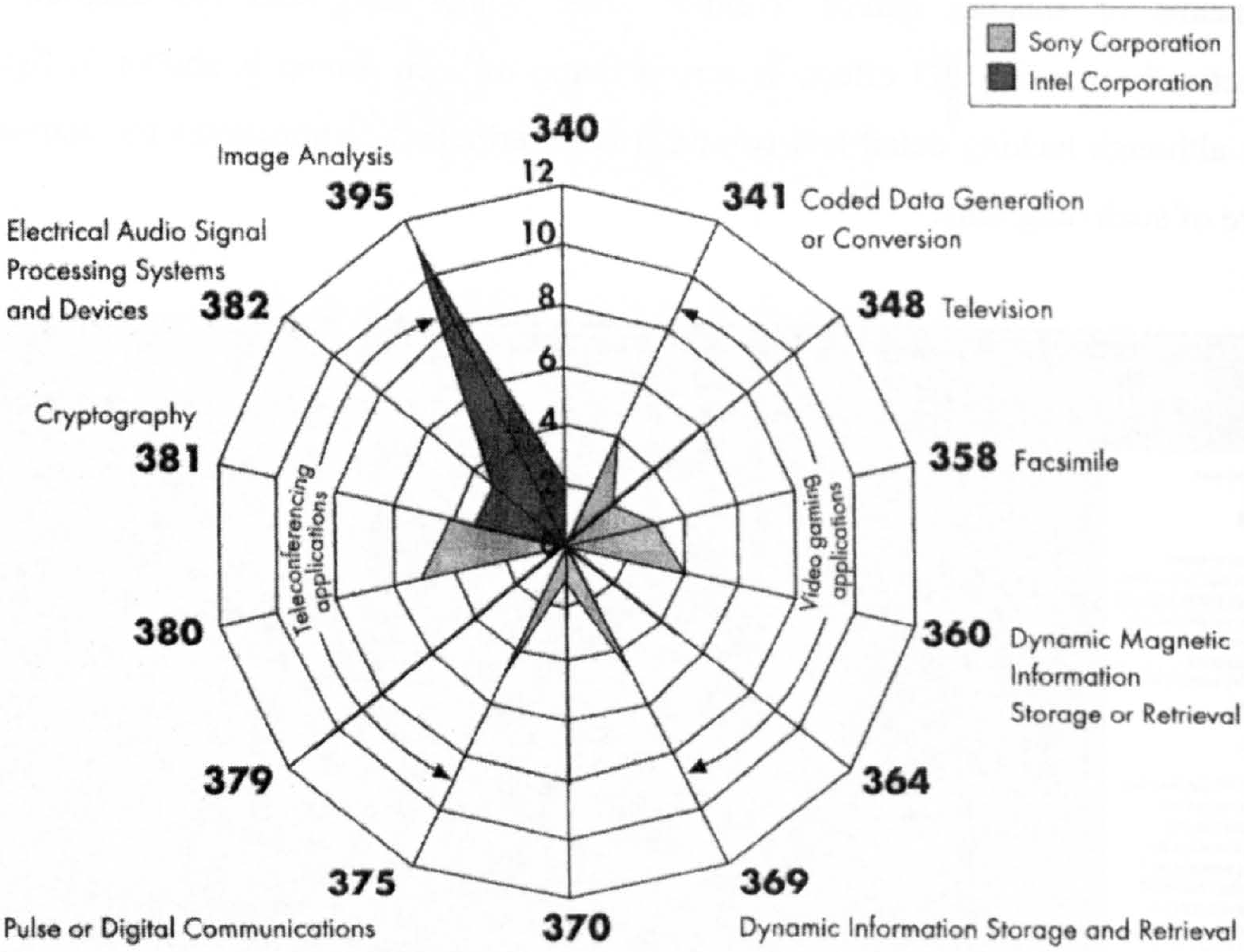

Figure 3.17: 'Radar'Diagram showing technical distribution of two companies' patent portfolios (from Germeraad (1999)) Each spoke of the diagram corresponds to a different technical area. The distance along each spoke corresponds to the number of patent filings held by a company in that technical area.

Granstrand (2000) devotes a whole section to 'Patent Mapping in Japan'. He notes that:

> *usually patent maps take the form of two- or three-dimensional diagraphs, graphs (for example, networks), tables or matrices. The common dimensions (or variables) in patent maps are as follows:*
>
> 1. *Time*
> 2. *Patent class, sub-class and so on*
> 3. *Function and sub-function*
> 4. *Application and sub-application*
> 5. *Product and sub-products*
> 6. *Actors (for example, inventors, firms, nations)*
> 7. *Industry class or characteristic*
> 8. *R&D resources*

Granstrand notes that there are numerous types and variants of patent maps, depending on the purpose, and gives five examples. For the sake of completeness, these are reproduced in figures 3.18 to 3.22 below together with an example of an invention-to-product matrix (figure 3.23). The latter is also reported by O'Connell (1992) as being one of the tools used by Japanese company Toshiba to pinpoint technological gaps which can be turned into patent protected markets.

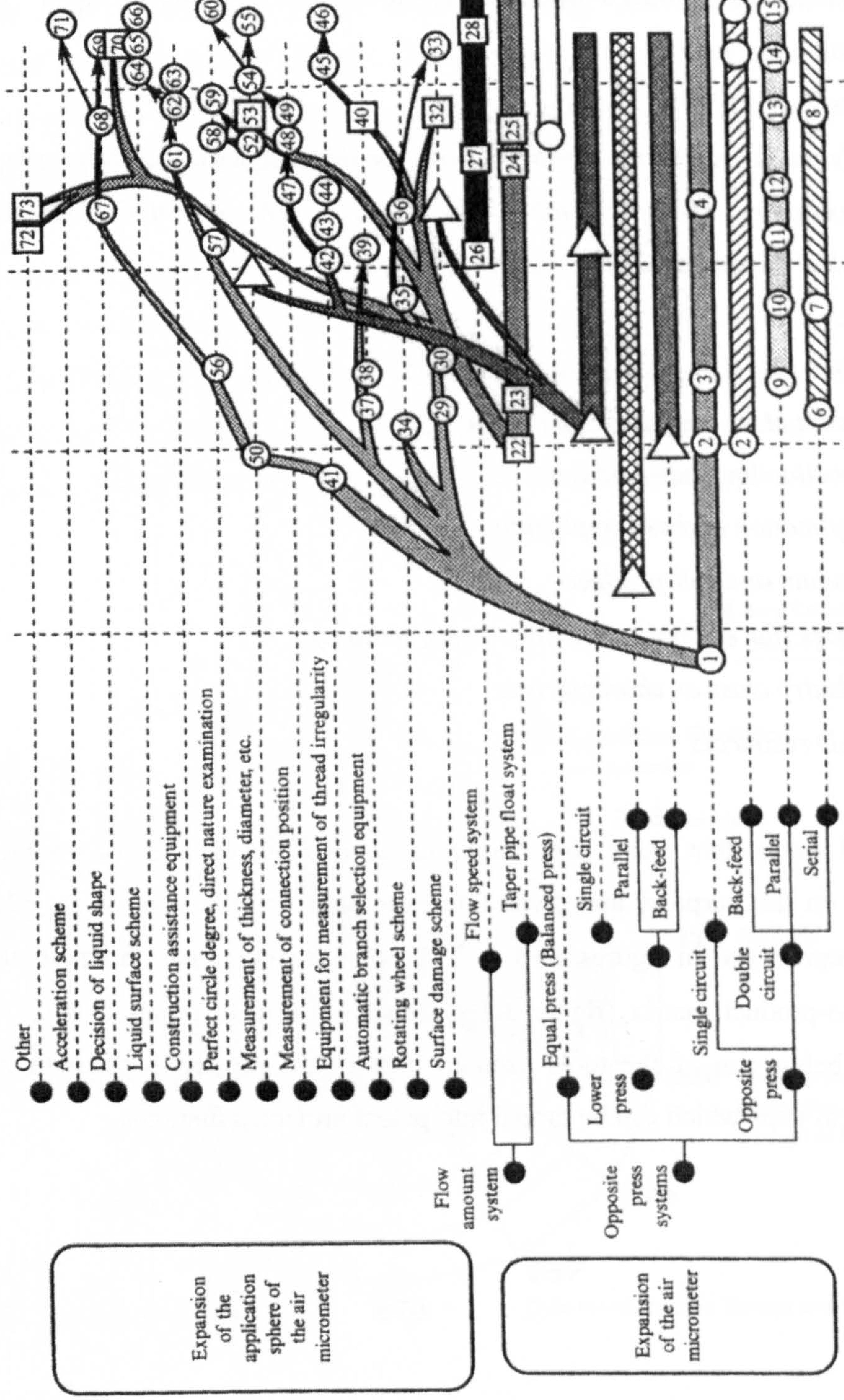

Figure 3.18: Patent Map published by Japanese Patent Office and showing the development of the air micrometer over time (from Granstrand (1999)). It would appear that numbers represent patent filings, the lower part of the diagram shows micrometer features and the upper part shows micrometer applications. The arrows seem to show how features are incorporated into new applications.

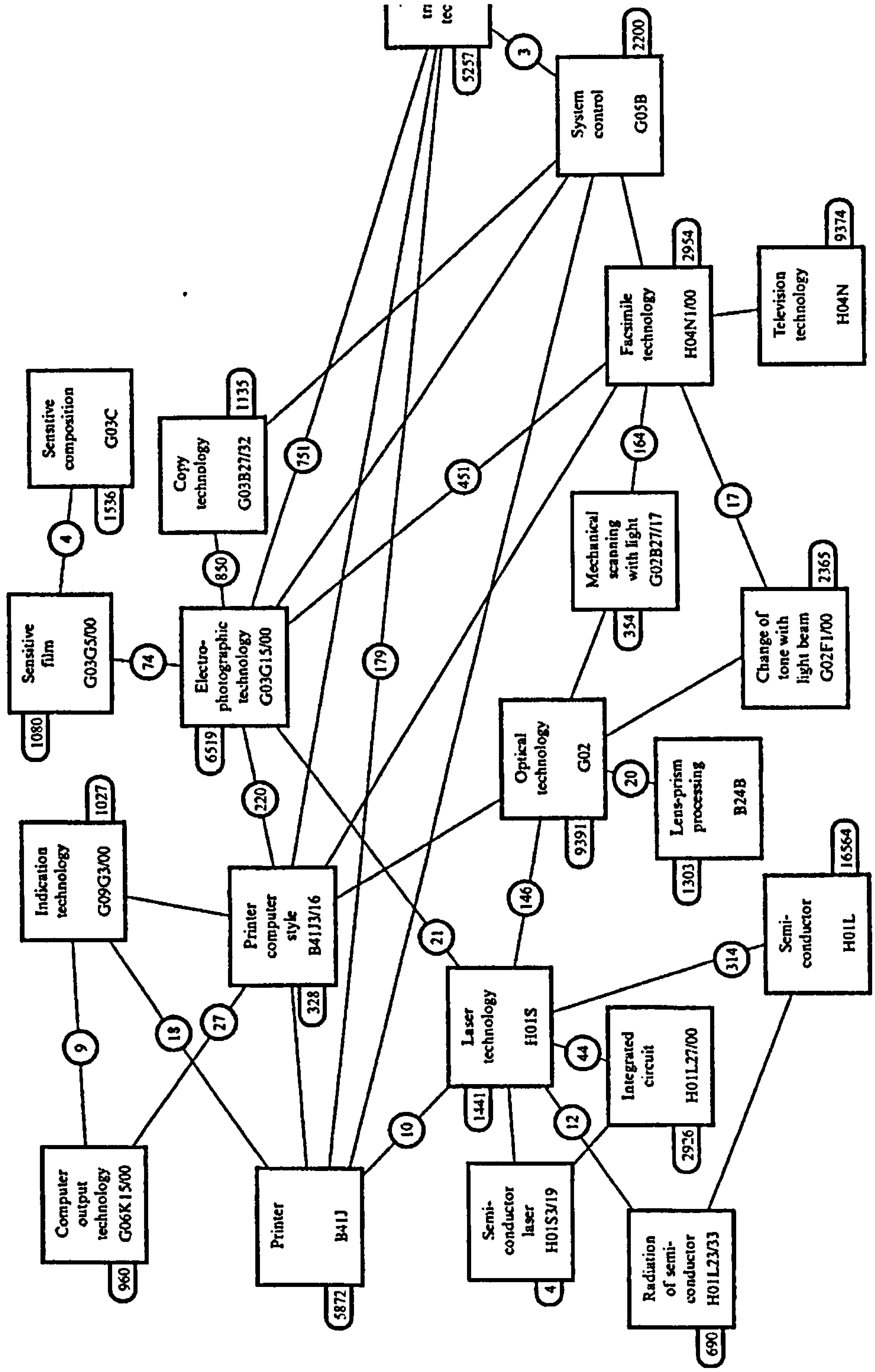

Figure 3.19: Example of Patent Network Map for 1983 (from Granstrand (1999)). Each box relates to a patent class (e.g. B41J – Ink Jet Printers). The ear on the side of the box indicates the number of JP patents granted in that class in 1983. The number in the circle linking two boxes indicates the number of JP patents granted in 1983 that fall into both patent classes of the two boxes.

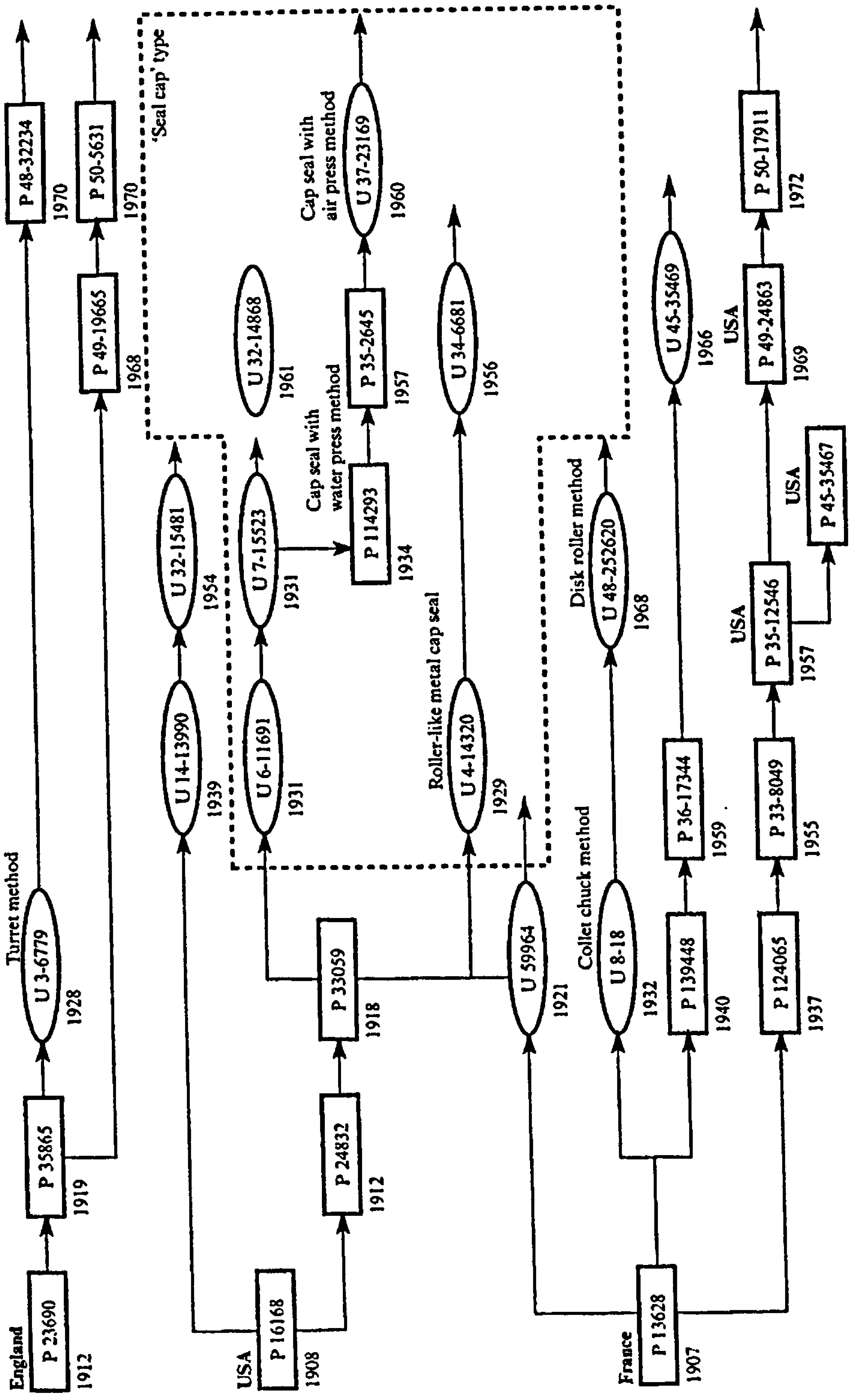

Figure 3.20: Example of Patent-by-Country Map (from Granstrand (1999)). For each of England, USA and France, the chronology of patent filings in a particular technical area is shown. Prefix 'P' indicates a standard patent, 'U' indicates a 'petty patent', also known as a ' utility model'.

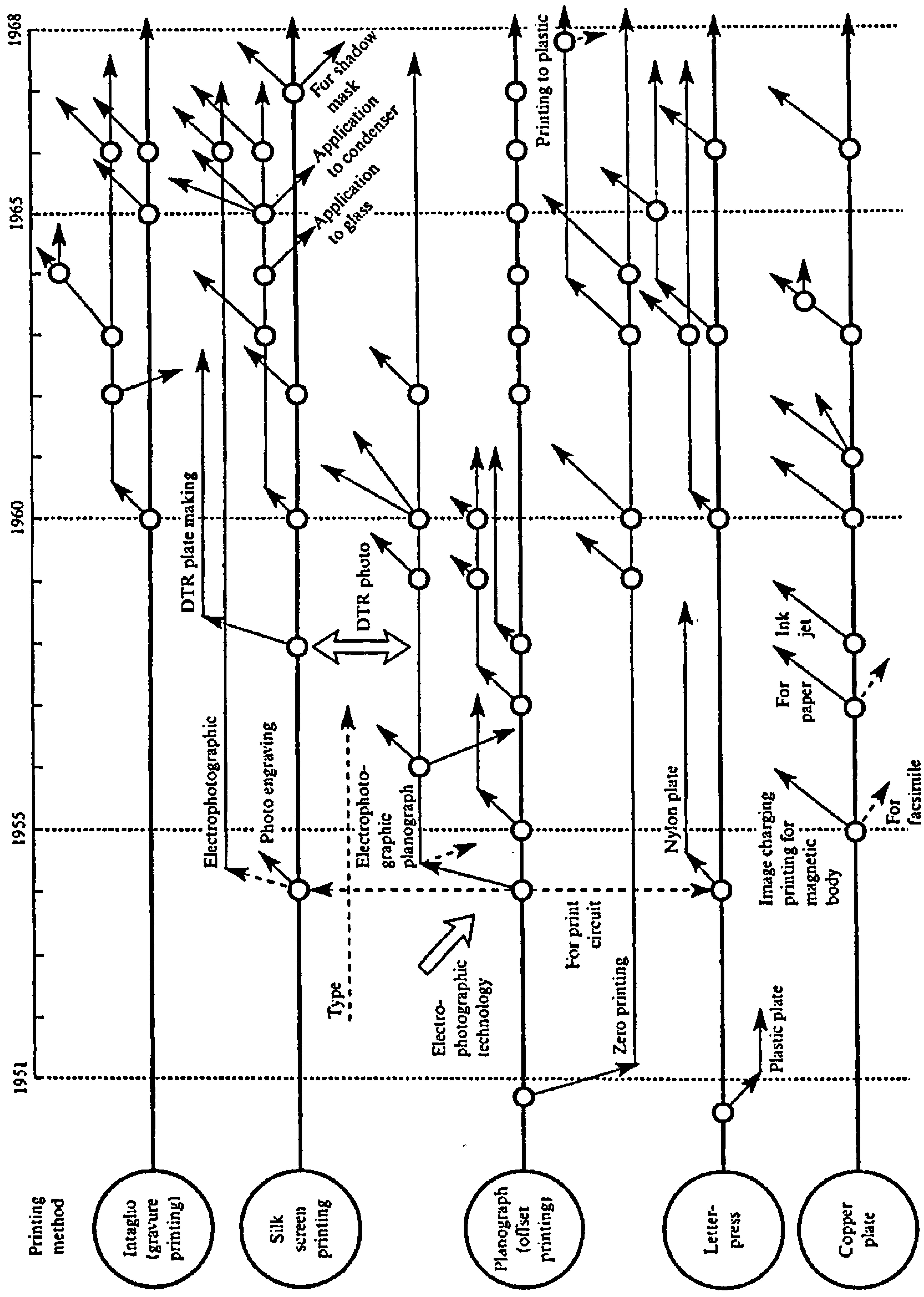

Figure 3.21: Example of Patent-by-Technology Map for the field of Printing (from Granstrand (1999)). Five printing methods are listed. The small arrows seem to indicate the new applications for each method that arise over time.

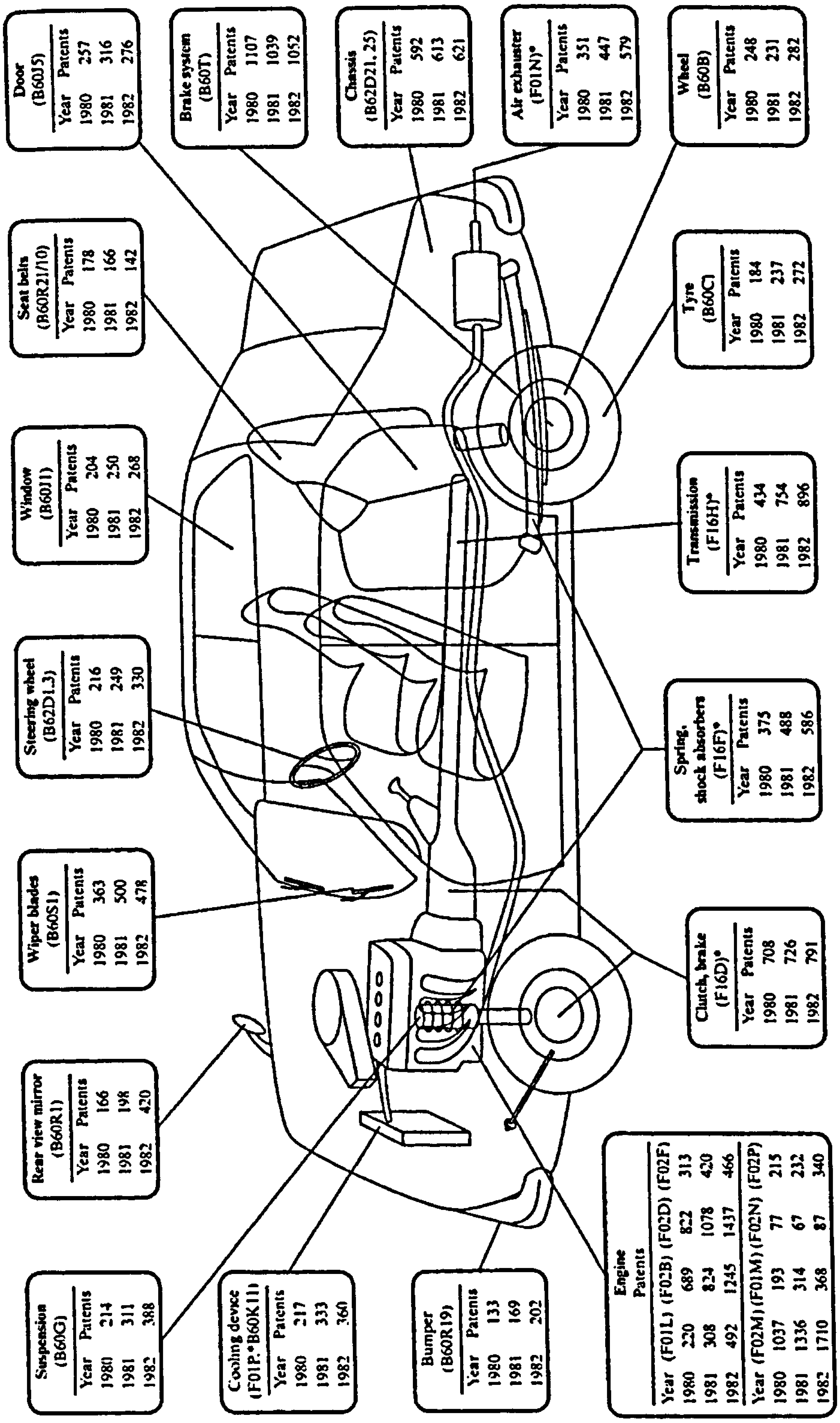

Figure 3.22: Example of Patent-to-Product Map (from Granstrand (1999)). Each box shows the number of patents relating to a particular aspect of a car for the years 1980, 1981 and 1982.

Date of application / No. of notification	Name of invention / *Applicant*	Composition																
		Material						Manufacturing method							Form			
		Core			Clad													
		Quartz and double quartz glass	Glass with other ingredients	Others	Quartz and double quartz glass	Glass with other ingredients	Others	Flame oxidation method	Method with two melting pots	Layer fusion method with indication powder	Ion exchange method	Pull-out method	Fibre bundle formation roll method	Dope material and dope method	Flood pattern	Distribution pattern	Multiple layer pattern	Others
62.5.25 48-30125	Glass formation technique *Owens-Corning (?) Fibre Glass Corporation*	•					•											
38.6.22 48-30126									•						•			
63.2.14 48-31734	??									•								
44.5.7 48-37696	??															•		
44.9.25 48-37731	??		•								•					•		
44.3.22 48-37852	Method for manufacturing plastic fibre optics plate *Fuji Photo Film*																•	
44.7.28 48-37854	*Matsushita*																	
44.9.25 48-28267	??		•											•		•		
44.12.23 48-38268	??																	
69.3.28 48-38269	??																	
69.6.9 48-33291	??											•			•			
41.4.14 49-212	??												•					
69.1.24 49-904	*Western Electric*																	
42.1.19 49-4344	Optical thin film Olympus Optical Co. Ltd	•				•										•		

Figure 3.23: Example of Invention-to-Product Matrix for the field of Glass Fibres (from Granstrand (1999)). For each patent application listed in the left-hand column, the presence of certain characteristics is indicated by a dot.

3.8 Portfolio Metrics

As acknowledged in the Introduction chapter, the use of patent filing data in the measurement of innovation is well known. Van Leuven (1996) gives a resume of the advantages and limitations of the different kinds of patent statistics. Results and Methods of Economic Patent Research are also presented in the proceedings of a workshop of the same name (ed. Taeger, 1992). An example of patent filing analysis in a particular technical field is given by Sangeetha et al (1999).

As regards metrics relating to patent portfolios, Davis and Harrison (2001) refer to work by the Canadian Institute of Chartered Accountants (CICA) identifying four different categories of metric:

3.8.1 Quantitative, Monetary

Under this heading CICA list typical financial measures such as '$ invested', '$ received', 'forecasted income', 'costs to date' and 'forecasted costs'. McGavock and Lasinski (1998) detail similar information on the average patent portfolio cost across various industries as well as the average distribution of those costs between filing maintenance (64%), Enforcement/Litigation (14%) and Licensing-related expenditures (20%).

3.8.2 Quantitative: Non-Monetary

Under this heading CICA list e.g. the number of patent disclosure evaluations carried out by a patent department and the number of staff in that department. Similar departmental productivity metrics are described by Ransley and Gaffney (1997) as tools to 'upgrade your patenting process'.

3.8.3 Qualitative: Vector Based:

The metrics listed by CICA under this heading seem to differ from those under the previous heading only by inclusion of a time element. It is assumed that 'vector based' refers to this time element. Thus they include 'rate of addition [to the portfolio]', 'rate of deletion' and 'backlog'.

The remaining metrics of 'market share forecast', 'coverage' and 'comprehensiveness' would seem to be better placed under the final heading, namely:

3.8.4 Qualitative: Value Based

This also includes 'value category', 'alignment with vision and strategy', 'satisfaction' and 'quality', although with no suggestion that these metrics are anything other than subjective assessments.

Another accounting organisation, Ernst and Young (2000), working for the Danish Patent and Trademark Office, have proposed a scoring system for individual patents which incorporates a number of the latter subjective metrics. Despite this, they note – as did Jorda (2003) referred to in the Introduction chapter – that 'some companies do not place their main focus on the individual rights, but rather on a portfolio.'

A more scientific approach is described by Narin (1993), who states that:

> *a crucial indicator of technological quality or impact [of a patent] is how frequently a patent is cited in later patents. ... The key idea behind patent citation analysis is that when a patent is very highly cited, i.e. cited in 5, 10, 20 or more subsequent patents, then that highly cited patent is likely to contain an important technological advance, an advance that many later patents are built upon. As a general rule, 70 percent of all patents are either never cited, or cited only one or two times, so that even five citations places a patent in the top few percent of cited patents.*

Mogee (1997) comes to a similar conclusion, making a distinction between 'citations' by later patents belonging to third parties and 'references' by later patents belonging to the same organisation. Referring to Campbell and Nieves (1979), she notes that:

> *Self references indicate that a company has seen enough value in an invention to follow up on it with more technological activity. The existence of a cluster of patents owned by a single company connected by a high level of inter-referencing,*

signals an attempt by the company to develop a tightly protected niche in technological space – probably a sign that it has what it thinks is an important core invention, which it has surrounded with multiple improvement inventions.

Interestingly, Mogee goes on to give an example involving patents belonging to Xaar – a company for which the present author has managed the IP.

A word of warning regarding citation data comes from EPO search specialists Michel and Bettels (2001) who point out that:

... the comprehensiveness and quality of a given search report may vary significantly as a function of the patent office drawing up the report. These differences imply consequences with respect to the safe use and interpretation of the data.

3.9 Portfolio Geography

As it has such a significant impact on the cost of a patent portfolio, the question of where, i.e. in which countries, to file patent applications is discussed in many references. The comment by Glazier (1995) is typical:

The essence of a global patenting strategy is the use of a benefit-cost analysis, on a country by country basis, to pick the proper national targets that will be profitable patent investments.

Such benefit-cost decisions are facilitated by analyses, e.g. Helfgott (1986), Bednarek (1996), of the relative value of a patent obtained in various territories, in particular the ratio of the GDP of a country - assumed to be representative of the potential market - to the cost of obtaining and maintaining a patent in that country.

Not surprisingly, the US comes out top in such analyses. Helfgott (1992) notes another advantage of a US filing, namely where:

there is a worldwide market for a product, and better yet, where worldwide product standards exist or are developing. For example, the US, Europe and Asia may specify a standard electrical part or connector. A US lawsuit could bar the Asian infringer from the large US market, and prevent adoption of the infringer's product worldwide

For similar analysis purposes, Knight (1996) presents a list of the countries expected to have the greatest population growth over the coming decades. The chief executive of British Technology Group, Ian Harvey (1992) similarly notes that:

country analyses of future GDP suggest that patent filing programmes should include more Far Eastern and Latin American countries. Relatively small changes in patent-filing programmes, at quite low cost, could affect the success of technology-based companies in 10 years' time

However, Nurton (1996) warns against filing in countries where the patent law is inadequate e.g. when it comes to enforcement or where inventions are subject to compulsory licensing if they are not worked. This finds support in Seltzer (1994) who cites an unidentified president of a large chemical firm as saying that:

The weaker we perceive a country's system for protecting intellectual property to be, the more likely we are not to transfer any leading-edge technology

3.10 Patent Risks

Sweeney (1997) identifies the fundamental steps that underlie intellectual property risk management. They are the same as the steps for any risk management, namely:

1. identifying the hazards;
2. analysing the hazards to determine the likelihood and potential impact data that together define 'a risk';

3. controlling the risks, either by risk reduction measures, transfer of risk to an insurance company or retention of risk within the organisation.

However, Sweeney does not go into detail regarding any of the risks, their likelihood or potential impact.

In an article entitled 'Intellectual Property and Managing Legal Risk', Smith (1997) approaches the subject from the point of view of the solicitor. He details various measures that might be taken to reduce the risks of potential loss of rights (including educating staff, checking employment contracts), the risk of infringing third party patent rights (including ensuring that the necessary licenses from third parties are in place) and the risk of losing revenue through non-enforcement of rights (again, ensuring the necessary licenses to third parties are in place). An intellectual property audit, advantageously by an external firm of solicitors, is suggested as the solution.

Samuel and Berry (2000) approach the subject from the insurance perspective. In addition to the risk of patent infringement mentioned above, they also identify the risk of a challenge to the validity of a patent, citing the then recent decision of the UK Patents Court that Pfizer's UK patent to Viagra was invalid. Insurance policies are suggested as the solution. Interestingly, the authors make a similar observation to that of Jorda (2003) mentioned in the Introduction chapter, namely the difficulty of apportioning value to a particular patent when a product is effectively supported by a bundle of patents. 'How may patents have to be declared invalid before the IP insurance kicks in?' they ask, noting that the situation becomes even more complex if the patent is a process patent.

Pickering et al (1998) discuss the risks associated with the US 'first to invent' system. They noted that whilst all companies seem to recognize the importance of keeping well-documented laboratory books as proof of invention:

> *... in a couple of cases companies stated that they doubted whether the risks of losing a patent and the attendant costs of this were sufficiently high as to justify the additional costs which rigorous maintenance of laboratory books imposed.*

Prestia (1994) and Glazier (1995) both describe the use of decision trees as a tool in communicating patent-related risks, e.g. between a lawyer and a client about to undertake a new business venture involving possible patent infringement. In addition to infringement and invalidity risks, Prestia mentions the risk under US law of infringement being deemed 'wilful' and thus liable to triple the normal amount of damages. For his part, Glazier (1995) notes that:

> *It is ... probably never possible to know if one's estimates of the probabilities of events were accurate ... [but] ... the quantification of estimated probabilities ... for such a decision tree, even though imperfect, can improve everyone's understanding of the situation*

Deboys (2003) again describes the use of decision trees but this time to assess the particular risks associated with prior art searching. On this topic, Simmons (1985) notes that:

> *Patentability searching is, by its nature, a paradox. To be patentable, a new product or process must never have been described or suggested in the prior art. The searcher charged with confirming the patentability of an invention is thus presented with three dilemmas: how to design an exhaustive search for a reference that is believed not to exist, how to recognize a reference describing the invention in a different context or vocabulary, and, if no relevant references are found, how to tell if the search is complete.*

Although Simmons identifies many of the difficulties inherent in patent searching, she sheds no light on the probabilities of a search being complete (and thus a patent valid) other than to note that 'one can never know with absolute certainty that no pertinent prior art exists'.

Similarly, although the UK Patent Office (Haselden, 1996 and 1998) has published data on the quality of its searches, this is only relative to search results generated by the European Patent Office and sheds no light on the actual probabilities.

Nevertheless, the literature does contain a few suggestions as to the factors that might influence patent validity. Knight (1996), in particular, suggests that, in a very general sense, the degree of exclusivity a patent can provide is inversely proportional to the number of prior inventions previously disclosed in the technology area. He also observes that if there is a lot of activity in a particular technology area, speed in developing inventions and filing patent applications may become the deciding factor in obtaining exclusivity.

The report from Ernst and Young (2000) also suggests that the position of a patent in its lifecycle will affect validity, making the obvious point that a patent application may be restricted in scope or even rejected during examination. They also note that:

> *As far as more mature patents are concerned, legal proceedings may be instigated, and the validity of the patent itself may be subjected to close scrutiny. If patents have survived such attacks and won them, they may be considered more tenable, and hence more valuable.*

3.11 Conclusions

This chapter has pulled together that teaching of the literature which is considered to be relevant to the research objectives.

The problem identified in the Introduction chapter regarding lack of guidance in the literature has been confirmed. In particular, there is a lack of consistency in the use of concepts and terminology which makes it difficult to establish exactly where there is agreement.

For example, Knight's 'blanketing' strategy covers both the 'blanketing' and 'surrounding' strategies of Granstrand. Davis and Harrison use the term 'strategic' for a patent described by Glazier as 'tollgate'. There is even confusion over the exact meaning of the term 'strategy', which is defined by Cassel's English Dictionary (2000) as 'a long term plan aimed at achieving a specific goal': Knight suggests three different interpretations of the term whilst Granstrand describes the apparent oxymoron of a 'sporadic patenting strategy'.

Accordingly, before practical research can begin, it is necessary to distil out exactly what principles are being taught by the literature. This not insignificant piece of analysis is the subject of the next chapter.

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CHAPTER 4

Literature Critique

4.0 Introduction

This chapter seeks to reconcile the various disparate teachings in the literature and distil out the actual knowledge in this area. A certain amount of distillation has already taken place in the Literature Review chapter where a distinction was made between teaching relating to patents and teaching relating to portfolios. A distinction was also made between patent properties and patent objectives.

In line with the research objective to investigate a risk management approach, this chapter also seeks to identify who, i.e. which department/function within an organisation, might be responsible for various aspects.

4.1 Secrecy vs Patenting (and Publication)

This issue is dealt with first simply because a decision to keep subject-matter secret removes the need for any further discussion regarding patenting. Furthermore, this is one issue where the teaching of the literature does seem to be complete, with several articles listing the many factors that need to be taken into account.

This is not to say that there are no contradictions: rather, the various articles acknowledge that 'each case has to be considered individually and the advantages and disadvantages of each option compared' (Noone, 1978). Furthermore, the various factors will demand input from more than just the IP function: table 4.1 suggests the company function most likely to be in a position to advise on each of the factors identified in the previous chapter. Note that these are only the author's suggestions - the distribution of responsibilities between departments within a particular company may of course be different.

FACTORS AGAINST PROTECTION BY SECRECY	
FACTOR	RESPONSIBLE COMPANY FUNCTION(S)
invention can be detected in sold product	**Technology** function – to judge whether the invention will be detectable in the sold product. **IP** function – to know what constitutes disclosure according to patent law.
sold product is new and can only be made in one known way	**Technology** function – to know whether the product is new and whether there is only one way known of making it
knowledge of invention difficult to contain	**Technology** function – to judge the extent to which the technology allows the invention to be kept privy to a small circle of workers
invention likely to be made independently by third party	**Marketing** function – to judge the likelihood of a third party wishing to invest resources to come up with invention independently
business model depends on licensing	**Marketing** function – to know the business model
FACTORS FOR PROTECTION BY SECRECY	
FACTOR	RESPONSIBLE COMPANY FUNCTION(S)
competitors are known to analyse patent information	**Marketing** function – to know the extent to which patent information is used by competitors
commercial life of the invention longer than typical patent term of 20 years	**Marketing** and **Technology** functions – to estimate the long-term commercial viability of the invention
commercial life of the invention much shorter than typical patent term of 20 years	**Marketing** and **Technology** functions – to estimate the likely rate of obsolescence of the invention

Table 4.1: Factors and Responsible Company Functions in the Decision to Protect by Secrecy

4.2 Patent Properties

Once the decision has been made not to protect by secrecy, the question is whether to patent or to publish.

Whilst the Literature Review chapter has identified various desirable properties of a patent, it provides no guidance on the patent/publish decision. For example, is it necessary to pursue patents having all types of property - i.e. to key advantages, key methods and processes, lowest cost processes, etc. - or will just some of these suffice? As explained in the Introduction chapter, a 'patent everything' strategy can have a significant impact on the financial viability of a start-up STC.

Nevertheless, there are certain observations to be made regarding the apparent inapplicability to the STC of some of the Patent Properties listed in the Literature Review chapter.

4.2.1 Properties based on value

As mentioned in the Introduction chapter, it takes on average eight years for a technology to move from conception to significant sales, making it difficult to put a value on the technology during its early stages. In contrast, a large company will have an income stream reliant on certain patents. It follows that value-based measures such as Granstrand's 'strategic' characteristic referring to invent-around costs cannot be considered in the patent filing decisions of STCs, at least not in the early years.

More fundamentally, where individual patents all relate to a single technology which is commercialised as a whole, it is difficult if not impossible to establish what proportion of the overall value is attributable to a single filing. This very point was made in the Introduction chapter with reference to Jorda (2003). Such is the case with STCs.

4.2.2 Properties that reflect Market/Technology Uncertainty

Glazier's 'Toll-Gate' property is arguably the same as Granstrand's 'strategic' property, albeit with even greater uncertainty regarding the market and/or the technology at the time of filing. As such, it too provides no guidance to the STC on the patent filing decision.

4.2.3 Properties and objectives that emphasise a protected feature or product

Patents protecting a product or a feature that is used as an exclusive marketing point for a product are arguably the preserve of organisations that already have a product on the market. As explained above, this is typically not the case for the STC of the present research.

4.2.4 Properties relating to the nature of the core technology rather than the patent

Such a property is 'applicability'. For the STC of the present research, the core technology is a given. The question is rather how best to protect that technology.

4.3 Patenting Objectives

Unfortunately, like the Patent Properties, the Patenting Objectives detailed in the previous chapter provide little guidance to the STC as to exactly how to file patents. It is certainly possible to separate out two groups, namely:

- Indirect Patenting Objectives as detailed in subsection 3.3.10;
- Objectives relating to the modus operandi of the business, namely 'as a basis for licensing' (3.3.8) and 'define and support a business that is to be created / transferred' (3.3.9)

However, the remaining objectives are simply obvious business desiderata: for example, every business desires freedom to operate (3.3.1); no business will not wish to protect its market (3.3.4) or slow down its competitors (3.3.6); an exclusive marketing point (3.3.5) is clearly a desirable attribute of any product. They provide no guidance as to how a STC should actually configure its portfolio to achieve these objectives. To return to the earlier question, 'are these desirable objectives achieved by patenting everything – which clearly has major implications for the financial health of the STC – or is there another way?'

Similarly, although indirect patenting objectives such as impressing investors or motivating employee inventors are important, even for STCs, they do not provide any guidance on the fundamental question of what to patent and what not to patent. Nor is it clear how licensing or the creating / transferring of a business should actually influence patent portfolio structure, if at all.

4.4 Portfolio Structure

Although the literature does not provide guidance on what to patent and what not to patent, it does contain suggestions as to how later patents should relate to earlier patents. Indeed, among the many portfolio strategies, there would appear to be certain fundamental relationships:

4.4.1 Filings to developments that supersede earlier patents ('Superseding' relationship)

This relationship would seem to underlie both the 'Wall' and 'Improvement' strategies. The former specifies 'additional patents ... which build on the original patents' and which relate to 'new technology that will make the old technology obsolete'. The latter describes the obsolescence of earlier products which 'would not now be accepted in the market because we have better products which remain covered by patents.'

4.4.2 Filings to new areas of technology ('New' relationship)

This relationship would seem to underlie the 'blanketing' / 'flooding' strategies, the objective of which is described by Knight as being 'to patent ... as much of the technology area as possible'. Having patents that cover a wide technology area would also seem to be important for a company wishing to defend itself against patent infringement suits from third parties by means of the 'Mutually Assured Destruction' strategy. The 'Maze' strategy illustrated in the previous chapter also shows the use of many patents to cover a technology area.

4.4.3 Filings to different technical solutions for achieving a similar functional result ('Similar Function' relationship)

This relationship underlies the 'fencing' strategy identified by Granstrand and illustrated in figure TBC, namely the protection of a range of possibly quite different technical solutions for achieving a similar functional result.

4.4.4 Filings to products in which a patented technology may be used ('Application' relationship)

This relationship is clearly fundamental to the 'patent along the supply chain' strategy and would also seem to underlie the 'picket fence' type of strategy which specifies filings to 'preferred products in which the core technology may be used commercially'.

4.4.5 Filings to developments that fall within earlier patents ('Nesting' relationship)

This relationship underlies the 'Multiple Barrier' strategy which specifies 'more focused, specifically directed patents to alternative embodiments for practising the broad concept [of an earlier patent]'. The term 'nesting' has been chosen for this relationship to reflect the way in which, in the manner of Russian dolls, the claims of a specific patent can be considered as nesting within the claims of a broader patent

4.4.6 Filings to key manufacturing methods for patented technology ('Manufacturing' relationship)

The advantages of patents to key methods and processes are fully discussed in section 3.6.10 of the Literature Review chapter.

4.5 Portfolio Factors

In addition to the six relationships listed above, there are further factors that differentiate those portfolio strategies that share the same underlying relationship. Moreover, responsibility for assessing those factors does not lie solely with the IP function.

4.5.1 Bypass Risk and Expiry Risk

Considering the two strategies based on the 'Superseding' relationship, it is noted that Knight's 'Wall' strategy is based on the premise that some of a company's patents will eventually be bypassed by competitors, and that the true value for the patent is the time delay caused by the need for extra work by a determined competitor which wants to get around the 'wall' of the patent. Gibson's 'Improvement' strategy, in contrast, does not acknowledge this 'bypass' risk but rather addresses the problem of loss of market following patent expiry.

Whether 'patent expiry' risk is actually a significant problem for a company would appear to depend on the technological environment: where a technology field is developing rapidly, as in Knight's example, a patented technology is likely to be obsolete well before the end of the twenty year patent monopoly. A company's technology and/or marketing functions would seem to be best placed to make such an assessment.

As regards 'bypass' risk, the significance of this to a company would seem to depend on the competitive environment in which that company operates. In particular, it seems reasonable to assume that where a company's competitors are not technologically advanced, they are less likely to bypass a company's patented solution. Again, assessment of this risk would seem to be the job of the technology and/or marketing functions of a company.

It is noted that the 'bypass' risk would also seem to be addressed by two other patent relationships: firstly, the 'Similar Function' patent relationship that underlies the 'Fencing' strategy which seeks to block the development of machines which might be constructed for the same purpose using alternative means. Secondly, the 'New' patent relationship that underlies the 'Maze' strategy which is aimed at obtaining a degree of exclusivity in a technology area where there is much prior art.

4.5.2 Market / Technology Risk/Litigation Risk

As regards other strategies based on the 'New' relationship, 'Blanketing/flooding' is suggested by Granstrand as a strategy in emerging technologies when uncertainty is high regarding which directions are fruitful or in situations with uncertainty about the economic importance of the scope of a patent. In other words, where there is high market / technology risk. Such assessments would appear to be the responsibility of technology and marketing functions respectively.

The 'MAD' strategy is proposed as a means of forestalling costly patent infringement lawsuits, i.e. a large amount of money is spent on patenting so as to avoid spending an even greater amount of money on litigation. Determining the sums to be spent would seem to be an exercise for accountants working with data provided by the IP function. This strategy will not be given any further consideration, however, given that there are two clear reasons why it is not applicable to STCs. Firstly, as acknowledged by Bower (1994), small companies do not generally have the resources to pursue a large filing strategy. Secondly, STCs do not generally have a product which is likely to be the subject of infringement litigation, either because the technology is at an early stage and there is no product, or because any product is manufactured by licensees who bear the infringement risk themselves.

4.5.3 Technology-Access Objective and Income-maximising Objective

Unlike the strategies discussed above, the two strategies based on the 'filings to products in which a patented technology may be used' relationship differ not in the risk that they address but in the underlying objective. Thus Glazier's 'picket-fence' strategy has as an objective the establishment of a negotiating position that will allow access to a third party technology whereas the 'patent along the supply chain' strategy is intended to provide multiple sources of income.

It is noteworthy that, unlike the risks identified in previous subsections and which are outside of a company's control, a decision on whether to pursue the above objectives can be determined by the company itself – most probably by the commercial/marketing function rather than IP or technology. Hence the later designation of these objectives as 'internal'.

4.5.4 Invalidity Risk

For the sake of completeness, it is noted that there is one further risk of 'invalidity' that underlies the 'multiple barrier' strategy proposed by Norris (1991). For the purposes of this chapter, a general risk factor of 'significant likelihood of invalidity' is proposed. However, it should be noted that patent invalidity factors is in fact the subject of a later chapter.

4.5.5 Partial Guidance on Patent Filing

The analysis of this section does provide partial guidance on filing strategy in that it identifies certain external risks and internal company objectives that support patent filing, as well as patent relationships that address those risks and objectives.

Accordingly, once a company's departments have made their respective assessments of commercial objectives and external risks, it should be possible for a company to use this partial information to structure its patent portfolio using the various patent relationships. This could be done pro-actively by 'inventing on demand' per Glazier (1995) and/or by using the patent mechanisms as a template for selecting patentable ideas whenever new ideas arise in the course of day-to-day development activity. In the latter case, where none of the factors or objectives apply to a new idea, then the default position is arguably publication of that development. The various departmental responsibilities, factors/objectives and patent relationships are summarised in table 4.2.

Risk	Apparent Factor	Responsible Department	Relationship	Strategy
Bypass (4.5.1)	Significant technological capability of competition	Technology / Marketing	Superseding Similar Function New	Wall (3.6.1) Fencing (3.6.5) Maze (3.6.9)
Expiry (4.5.1)	Lifetime of technology greater than patent lifetime	Technology / Marketing	Superseding	Improvement (3.6.3)
Market / Technology (4.5.2)	Significant market / technology uncertainty	Technology / Marekting	New	Blanketing / Flooding (3.6.4)
Invalidity (4.5.4)	Significant likelihood of relevant prior art	IP	Nesting	Multiple Barrier (3.6.2)
Objective: Establish offensive negotiating position (4.5.3)		Marketing	Application	Picket Fence (3.6.6)
Objective: Extract value at multiple points along route to market (4.5.3)		Marketing	Application	Patent along supply chain (3.6.8)

Table 4.2: Responsible Company Functions, Factors / Objectives and corresponding Patent Relationships

4.6 Patent Timing

Having taken the decisions not to keep a development secret and to patent the development rather than publish, it only remains for a company to decide when to file the patent application.

As with the Secrecy vs Patenting (and Publication) decision, the issues to be taken into consideration – although sometimes in conflict – seem nevertheless to be well established in the literature. Similarly, the issues require input from across the company rather than just the IP function. They are summarised in table 4.3.

FACTORS THAT SPEED UP FILING	
FACTOR	RESPONSIBLE COMPANY FUNCTION(S)
significant activity in the technical field	**Technology, Marketing** and **IP** functions – will each have a different perspective on the pace of activity in a field based on technical literature, marketing intelligence and new patent documents respectively.
significant relationship of development to as yet unpublished earlier patent application belonging to the company	**Technology** and **IP** functions – to judge closeness of technology from both technical and patent viewpoint
FACTORS THAT SLOW DOWN FILING	
FACTOR	RESPONSIBLE COMPANY FUNCTION(S)
requirement for well-supported patent application	**Marketing** – to judge the commercial significance of the advantage(s) underlying the development, and **IP** – to judge the amount of experimental work required to support claims protecting those advantages.

Table 4.3: Factors and Responsible Company Functions in the Patent Filing Timing decision

4.7 Portfolio Geography

Choice of territory in which to pursue patent protection is another area in which the underlying principles seem to be well established. Basically, there is a cost / benefit judgement to be made for each territory, with discounts being made to allow for various risks which are again well documented. Accordingly, no further research in this area is considered necessary.

4.8 Portfolio Depiction

It will be evident from the discussions above that patent scope is a key parameter in portfolio strategy. However, only a few of the diagrams detailed in the Literature Review actually depict patent scope, namely Knight's 'fence' diagram (figure 3.3), Norris' 'barrier' diagram (figure 3.4), Granstrand's 'technology space' (figure 3.12) and Pitkethly's 'intellectual property strategic space' (figure 3.13). Moreover, all these diagrams depict scope only at an information-poor, conceptual level.

As regards the Knight and Granstrand diagrams, it is noted that these reflect a view of patents as 'territory' or 'real estate', a view which is consistent with the broader concept of intellectual 'property' and which may have also its origins in the feature-based chemical way of drafting mentioned in the Patent Fundamentals chapter. However, using two dimensions to define an area representative of patent scope does not seem to convey any more information than the single dimension of Norris' barrier.

Indeed, the Knight and Granstrand diagrams may even give a misleading impression of patent scope: as previously explained, the linear technology development path followed by many STCs involves refining a technological concept to a stage where it can be launched on the market. Accordingly, any technical developments that the STC may wish to patent will generally fall <u>within</u> a broad concept for which, per definition, the STC already has patent coverage. However, whilst the Knight and Granstrand diagrams include a single large fenced-in area corresponding to a broad concept, any developments are shown as smaller fenced-in areas <u>outside</u> of that single large fenced-in area. This in turn gives the impression that the additional filings expand the 'technology space' occupied by the portfolio (to use Granstrand's terminology) when in fact the patent owner's ability to exclude has not grown beyond the scope of the broad concept for which there is already patent coverage.

Like the Norris diagram, the Pitkethly diagram uses a single dimension to depict patent scope. Unlike Norris, Pitkethly does not show the 'nesting' relationship, referring instead to the 'overlapping' of patents. This latter relationship is depicted in the Techno-legal Scope/Time sub-diagram of figure 3.13 where (most recent) patent filing a2 is shown as partially overlapping (earliest) filing a1 on the Techno-legal scope axis and identically overlapping (intervening) patent filing b2. However, although the text of Pitkethly (cited in section 3.6.7 of the previous chapter) suggests that patent filings a2 and b2 relate to different improvements having different advantages, i.e. patent filings of different scope, this is not reflected in the diagram where both filings occupy identical positions on the Techno-legal scope axis.

In conclusion, the existing diagrams are of little guidance to the IP manager in building a patent portfolio.

4.9 Portofolio Metrics

As regards the metrics detailed in the Literature Review chapter, many of these relate to the mechanics of the patenting process rather than the patent portfolio itself. Others relate to patent value. As explained in subsection 4.2.1, these are also of little help in deciding which filings to include in a patent portfolio. The class of 'Qualitative, Value-based' metrics might have provided guidance were it not for the fact that they all appear to be merely subjective assessments.

Citation data is less subjective but is by definition only generated after a filing has been published, some 18 months after the initial filing date. Accordingly, it provides no help in the initial filing decision although it may be of use when subsequently deciding whether to maintain that filing or let it lapse in order to save prosecution and/or renewal fees.

4.10 Patent Risks

The literature does identify a number of different risks associated with patents, of which infringement of third party patents and invalidity of one's own patents feature the most.

As mentioned in subsection 4.4.2 above, whilst a patent portfolio can be used to address third party infringement risk by means of the 'MAD' strategy, this is not considered appropriate to the STC that is of interest in the present research. This leaves invalidity risk, which is indicated in table 4.2 above as being a factor in patent portfolio structure.

In spite of Sweeney's 1997 explanation of how the three standard risk management steps of risk identification, risk analysis and risk reduction/transfer/retention might be applied to patents, the literature does not seem to contain any comprehensive treatment of patent invalidity risk. Rather, there simply seems to be acknowledgement that the risk to patent validity exists and the suggestion that this risk be transferred to insurers. There does not seem to be any attempt to analyse the risk or to consider risk reduction and risk retention alternatives to risk transfer.

4.11 Conclusions and Proposals for Further Research

Returning to the research objectives identified in Introduction chapter, the above critique suggests the following conclusions:

4.11.1 Research Objective: Investigate structure and logic of patent portfolios

Even having distilled out certain common principles from the muddled literature, the fact remains that these principles are all abstract. There is no evidence of their having been used successfully in practice.

Furthermore, the distilled principles are still not entirely consistent. For example, table 4.2 above does not include a supporting factor for the 'manufacturing' relationship. Similarly, three different patent relationships are proposed to deal with the 'bypass' risk. Indeed, there may be other patent relationships that have not yet been identified, perhaps relating to some of those Patenting Objectives which currently just seem to be obvious desiderata.

Certainly, the known portfolio depiction methods provide very little guidance on patent portfolio strategy and indeed may even confuse matters.

4.11.2 Research Objective: Investigate optimal patent portfolio structure for STCs

Thus far, the research has mainly been successful in identifying strategies that would not seem to be appropriate to the STC. However, there remain questions regarding the applicability of the remaining strategies.

In particular, the protection of different ways of achieving the same function per Granstrand's 'Fencing' strategy would not seem to be appropriate given an STC's focus on a single technology. Similarly, an STC's commitment to a particular technology field would seem to preclude those strategies intended to address uncertainty surrounding the technology.

On the other hand, Norris' 'multiple barrier' strategy involving the 'nesting' patent relationship would seem to be consistent with the STC model which, per definition, is to develop a core patented technology to such a level that it is acceptable to the market. However, such an approach also results in patents of narrower scope which, as already discussed in the Introduction chapter, are arguably of lesser value and thus harder to justify pursuing. Indeed, it runs directly counter to the 'New' patent relationship.

4.11.3 Research Objective: Investigate a Risk Management Approach

Insofar as tables 4.1 to 4.3 above have identified both patent risks and corresponding preventative measures, this chapter can be said to have been successful in applying risk management principles to patent portfolio structure. It has also suggested which departments within a company should be responsible for the various risks – another of the research objectives.

However, as already discussed, there are still inconsistencies in table 4.2. Moreover, there is no analysis data that might otherwise allow an informed decision to be made on the appropriate amount of money to be spent on preventative measures.

4.11.4 Research Objective: Investigate Hard Data rather than Opinion.

As already highlighted above, the literature is strong on principles but low on hard data backing up those principles. Accordingly, the IP manager seeking to implement those principles still bears the burden of proving to others that they actually apply in practice.

More fundamentally, the literature does not seem to describe any methodology that might allow suitable data to be obtained. Rather it has confirmed the suspicions raised in the Introduction chapter that the existing data is based either on surveys of the assertions of practitioners or on superficial bibliometric data.

4.11.5 Proposed Initial Research Methodology

If there is one common theme to the above conclusions, it is that the literature is abstract and lacking hard data. It follows that to meet the research objectives, the research proper needed to look at real patent portfolios and at a level of detail that went deeper than the bibliometric. Furthermore, the patent portfolios needed to belong to STCs.

As the only diagram that appeared to properly reflect both patent scope and patent portfolio structure, the 'multiple barriers' diagram of Norris (1991), figure 3.4, was chosen to show the patent relationships within the portfolio. As previously explained, this diagram is particularly suited to illustrating the 'nesting' relationship which itself would appear to be appropriate to the technology strategy of the STC.

At this stage, no attempt was to be made to reflect the validity of each patent filing in the height of each barrier (if indeed this was actually possible). Accordingly, it would be possible to replace the barrier by a simple one-dimensional line of width reflecting patent scope. Nor was any attempt be made to make the dimensions of the line reflect the claim scope – the difficulty of measuring claim scope has already been discussed in detail above. However, by illustrating nesting relationships, the diagram should be able to show the relative scope of protection of the filings in the portfolio.

In accordance with the third research objective, namely the investigation of a risk management approach, it was also decided to obtain information on the background commercial and technical environment of the real-life patent portfolio to see if any of the risk factors or company objectives identified in table 4.2 could be identified. The thinking was that it might be possible to show that the links between risk factor and patent relationship proposed in table 4.2 did actually apply in practice.

4.12 Summary

Key results of this chapter are as follows:

- Three stages in the patenting decision process have been identified and the relevant factors, actions and departmental responsibilities tabulated for each stage;

- By identifying factors and proposing departmental responsibilities for assessing those factors, the research objective of a risk management approach to patent portfolio management has – at least in part – been achieved;

- Contradictions and inconsistencies in the literature have been reduced to the three fundamental concepts of external risk factors, internal objectives and patent mechanisms;

- Provisional links between risk factors / internal objectives and patent mechanisms have been suggested that should allow patent filing decisions on individual inventions to be made given an assessment of risk factors and a knowledge of company objectives. This is useful: a lot more is talked of portfolio strategy than of individual filing decisions, yet it is individual patents that incur costs and individual patents that are litigated.

- A preliminary research methodology has been formulated to address the gaps in the knowledge.

CHAPTER 5

First Portfolio Analysis

5.0 Introduction

This chapter describes the attempt to apply the patent portfolio depiction method proposed at the end of the previous chapter to a first Single Technology Company, Renishaw.

It starts with an explanation of the choice of company, the method used to identify the relevant patent documents and the manner in which each document was analysed. The construction of the portfolio diagram is then presented in the Results section together with background company environment information on the company. The characteristics of the portfolio diagram are then discussed and possible causal links with the background environment examined. This leads to conclusions and proposals for further research.

5.1 Methodology

5.1.1 Choice of Company

Renishaw plc was known from Gourlay (1990), mentioned in the Literature Review, and was chosen for analysis of its patent portfolio on the grounds that it had been founded on the basis of a single technology, that the company had been successful (it had grown into a substantial PLC) and that patents to the founding single technology had been vital to its growth, as evidenced by some high-profile litigation activity. Specifically, Renishaw was founded by an engineering manager in Rolls Royce, who invented the Touch Trigger Probe, a device having great use in the numerically controlled machining that was applied by Rolls Royce to manufacture its core product. He left Rolls Royce to found a Single Technology Company based upon the invention. The company was a considerable commercial success. It had to defend its patents against infringement in the US courts. A copy of the Gourlay article setting out this story is attached as Annex 2.

5.1.2 Identification of Filings

A list of Renishaw's patent filings was initially obtained by means of a search in the online Derwent World Patents Index database. Additional searches in the name of the inventor of the founding technology, David McMurtry, were carried out to identify the very earliest filings which - it will be gathered from the Gourlay article - were filed in the name of Rolls-Royce. Since it was Renishaw's patent filing strategy that was of interest, the searches focused on patent applications rather than granted patents. Figure 5.1 shows the chronological distribution of the over 200 patent applications identified by the online searches.

Given that it had yet to be established that the abstract barrier diagram of the literature (Norris (1991) – see figure 3.4) could indeed be fitted to real patent filing data, it did not seem appropriate to invest time in analysing all 200+ filings at this stage. However, it was obviously necessary to identify the fundamental initial patent filings, for which the first five years, 1972 to 1977, were chosen. In addition, the filings for 1986 were chosen on the grounds that there was a big jump in filings in that year (500%) - indicative, the author suspected, of a change in patent strategy. Finally, the filings for 1995 were chosen as being the most recent year for which data was available at the time the analysis was carried out.

5.1.3 Analysis of Filings

Full copies of the published documents for the chosen years were ordered from the Patent Unit of Leeds City Library. Obviously, no copies were available for those applications indicated in the search results as having been filed but which had been dropped before the publication stage. This accounted for some of the discrepancy between the number of filings indicated in figure 5.1 and the number of entries on the portfolio diagrams.

Another reason for the discrepancy was that filings made within a year of one another were sometimes combined into a single application at the end of the priority year of the earliest filing, as is standard patent practice. For example, three UK applications filed 21.09.72, 14.06.73 and 03.08.73 were combined into a single application filed 14.09.73 which went on to publish as the first Renishaw filing GB1 445 977.

It should be noted that Renishaw filings prior to 1977 were made under the old UK patent law that saw publication only once the application had been granted. However, later filings were published 18 months after the initial filing date as is now the norm.

The claims of each document were then reviewed and a brief summary of the scope of the broadest (i.e. independent) claim of each document recorded in a table together with the document publication number and initial filing date. Documents were reviewed in order of increasing initial filing date in order that any 'nesting' relationships, i.e. later filings that fall within the scope of earlier filings, might be identified. Once the review was complete, a diagram was constructed as described in section 5.2.2 below.

5.1.4 Environmental Information

A final stage of the methodology was to gather information on the commercial environment on the candidate company. This was done by reviewing the Renishaw website, obtaining the Renishaw Stock Market Floatation Prospectus from Companies House and reviewing the Annual Report for the year in question, 1997.

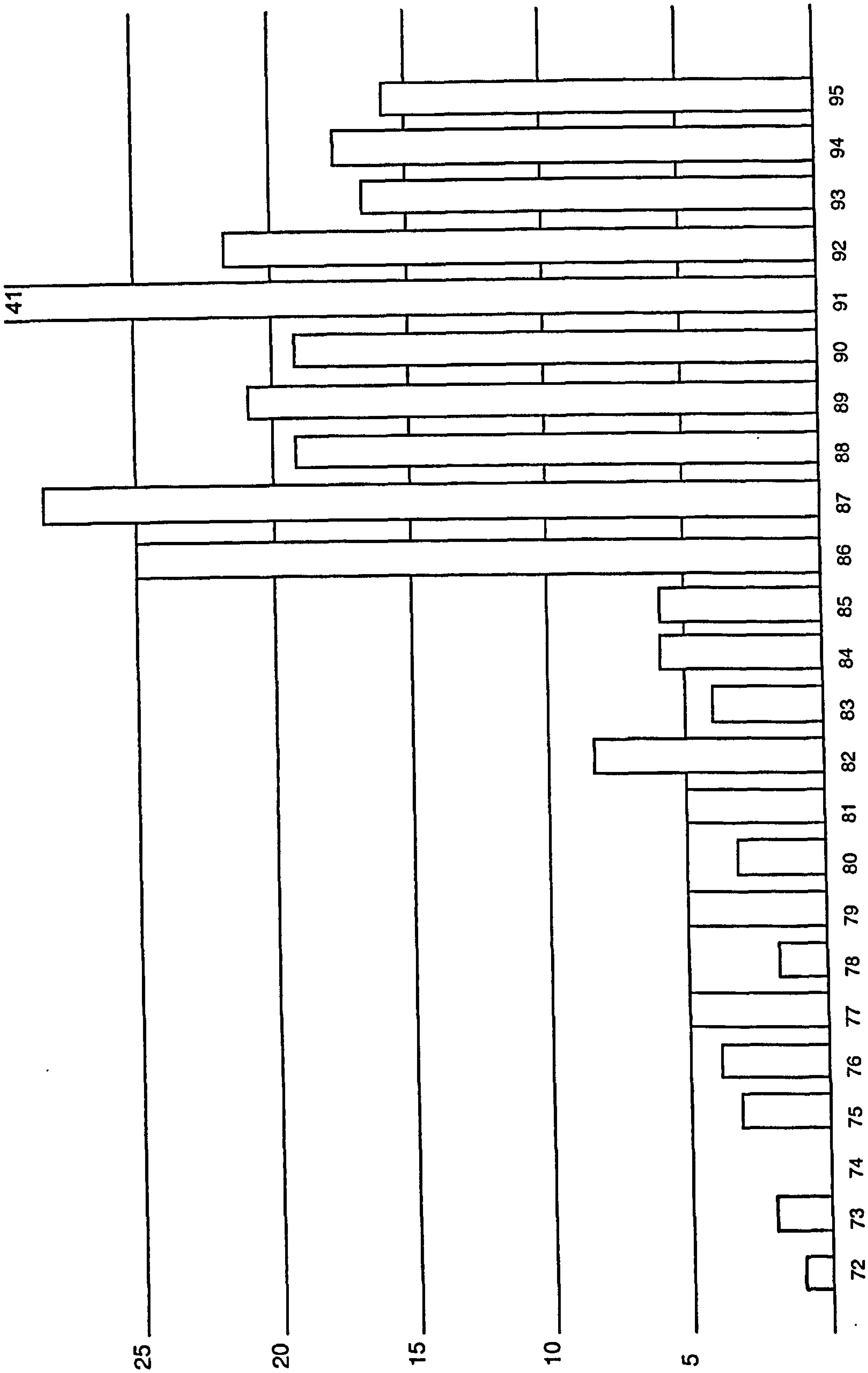

Figure 5.1: Number of Renishaw Initial Filings by Year, 1972 - 1995

5.2 Results

5.2.1 Initial Filing Analysis

The initial filing date and summary of the broadest claim for every Renishaw filing reviewed is given in tables 5.1 to 5.3 below. It will be immediately evident that many of the 1986 and 1995 filings bear no relationship at all to the probe technology developed in the early years of the company but instead cover new product lines based, for example, on Raman spectroscopy and laser interferometry. Such filings, which have been indicated by grey shading in tables 5.2 and 5.3, are clear evidence of a diversification strategy on the part of Renishaw but shed no light on single technology portfolio strategy per the research objectives. For this reason, no attempt was made to incorporate them into a diagram.

Initial Filing Date	Publication No.	Summary of the Broadest Claim
21.09.72	GB 1 445 977	probe with mutually convergent surfaces
13.05.75	GB 1 551 217	probe with sensors and sensor surfaces in three mutually-perpendicular directions
13.05.75	GB 1 551 218	leaf spring mount for probe
04.10.75	GB 1 568 053	probe with different convergent surfaces
24.03.76	GB 1 573 447	probe with linear and linear/pivotal motion sensors
30.09.76	GB 1 593 050	probe with additional support surfaces
24.12.76	GB 1 589 297	probe with upper and lower seats
20.01.77	GB 1 593 682	probe with two members in series, each with engagement seats
07.02.77	GB 1 597 842	head having plurality of covergent surfaces so as to allow head to be indexed
20.08.77	GB 2 021 990	rotary mounting with air bearings
22.10.77	GB 2 006 435	probe using vibration to sense contact

Table 5.1: Filings in the Renishaw Patent Portfolio 1972-1977

Intial Filing Date	Publication No.	Summary of the Broadest Claim
24.03.86	EP 0 239 337	probe link arrangements between fixed and moveable members
24.04.86	EP 0 242 747	circuitry for interconnecting probe and supporting machine
24.04.86	EP 0 243 766	probe using strain gauge sensing mechanism
14.06.86	WO87/07711	tool positioning system that allows for acceleration error
21.06.86	WO87/07943	position sensing algorithm for use with optical sensor
21.06.86	WO87/07945	optical position sensor
03.07.86	WO88/00331	flexible metrological scale
05.07.86	WO88/00327	laser measuring apparatus
25.07.86	EP 0 254 515	method of operating inspection machine incorporating probe
25.07.86	EP 0 482 672	movement control algorithm for probe
08.08.86	EP 0 255 977	processing of signals from a DC motor
30.08.86	WO88/01798	Pre-heat control system for a laser
30.08.86	WO88/01799	frequency stabilised laser
03.09.86	WO88/01726	signal processing circuit for probe
16.09.86	WO88/02139	method of calibration using a probe
08.10.86	EP 0 264 223	method of using an analogue probe
20.10.86	WO 88/02843	apparatus for determining surface position
20.10.86	WO 88/02845	optical probe
20.10.86	WO 88/02846	optical measuring probe
07.11.86	WO 88/03672	combined probe and cutter
08.11.86	WO88/03673	method of operating a co-ordinate positioning system
15.11.86	EP 0 269 286	stylus tip for 3D measurement
09.12.86	WO88/04401	stylus mount arrangement using links

Table 5.2: Filings in the Renishaw Patent Portfolio 1986

Intial Filing Date	Publication No.	Summary of the Broadest Claim
05.01.95	GB 2 296 766	laser interferometer for measuring displacement
02.03.95	GB 2 298 488	probe with indexable sections, releasable by lever/motor mechanism
01.04.95	WO96/31752	angular laser interferometer
25.04.95	WO96/34256	Raman spectroscopic apparatus
05.05.95	WO96/06346	apparatus for detecting an explosive material
07.06.95	EP 0 747 681	Raman microscope
12.06.95	EP 0 748 669	probe arm for a machine tool
13.07.95	EP 0 753 804	real-time compensation system for a laser interferometer measuring system
13.07.95	WO96/10737	method of scratch testing using Raman techniques
13.07.95	WO97/03346	probe for scratch testing using Raman techniques
02.08.95	EP 0 757 194	Seal for probe arm
23.08.95	EP 0 759 534	method of interpolating angular position of probe
02.09.95	GB 2 304 923	detector system for an interferometric measuring apparatus
02.11.95	WO97/16704	opto-electronic rotary encoder

Table 5.3: Filings in the Renishaw Patent Portfolio 1995

5.2.2 Basic Diagram Structure for Initial Filings

Turning to the construction of a portfolio diagram, the first page is shown in figure 5.2. Each horizontal line corresponds to the scope of a patent filing, as proposed at the end of the last chapter. However, in a departure from the abstract Norris diagram, the relative spacing between 'multiple barriers' down the diagram was chosen to correspond to the respective filing date. The diagram can therefore be described as a scope/time diagram.

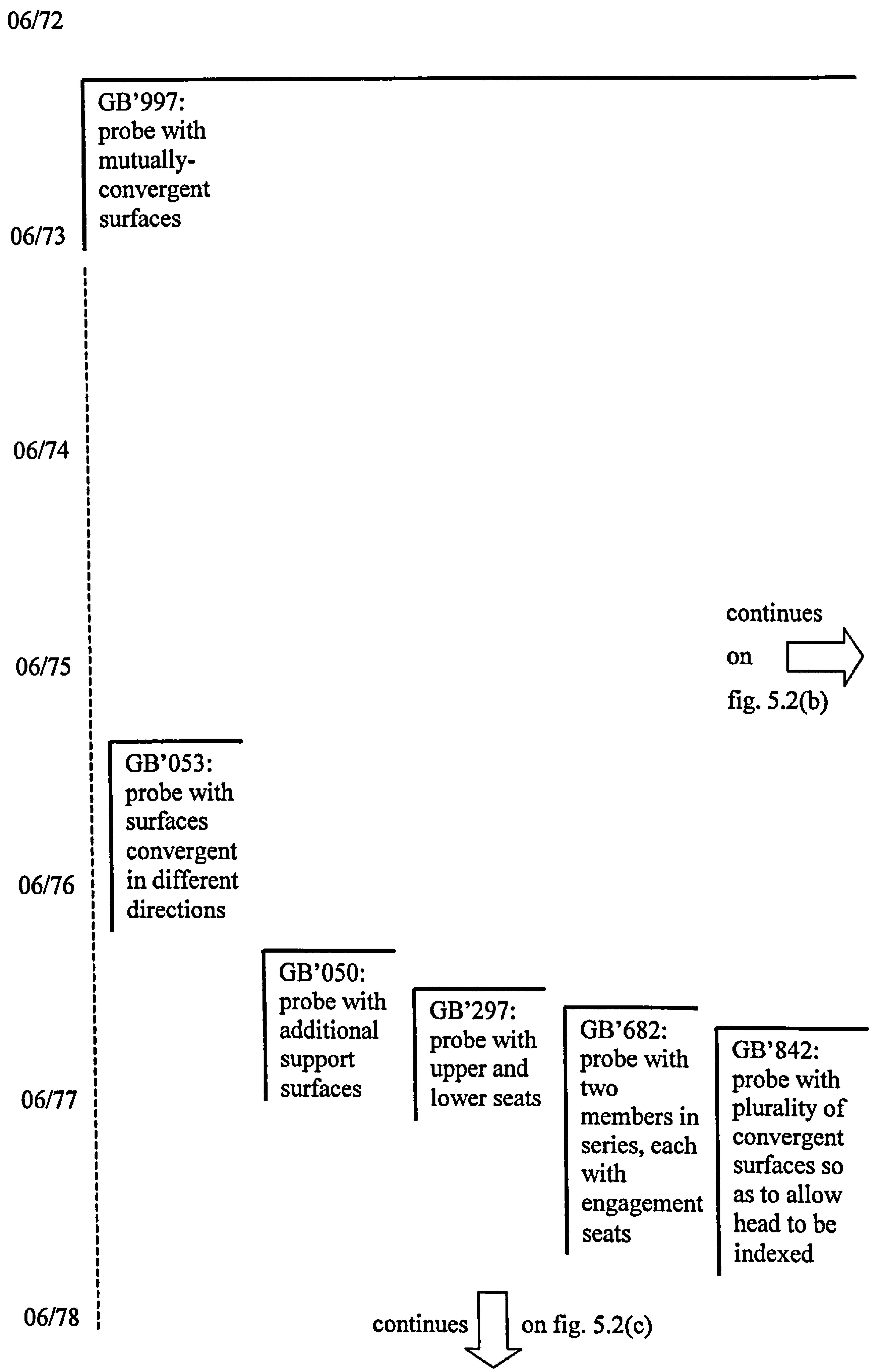

Figure 5.2(a): Scope/Time Diagram for Renishaw portfolio 1972-1975

Thus from the scale on the left-hand side of figure 5.2(a), it will be seen that the first Renishaw filing GB1 445 977 was made approximately three-quarters of the way through 1972, with the next filing GB 1 551 217 (see figure 5.2(b) overleaf) being made approximately mid-way through 1975.

Filings have been identified by an abbreviation of the filing publication number, i.e. GB'997 instead of GB 1,445,997, as is normal practice in patent attorney circles. The summary of claim scope was also kept brief to as to allow the diagram to remain legible yet relatively compact. This in turn allowed the relationships between successive filings to be better identified.

Where claim analysis revealed a 'nesting' relationship between an earlier and a later filing, as is the case with GB'997 and GB'053, the later filing was entered below the earlier filing at a position down the page corresponding to its later filing date. It was also entered slightly to the right of the earlier filing, the line of the earlier filing being extended to cover the later filing and thereby indicate its relatively broader scope.

Where several later filings fell within the scope of an earlier filing, as is the case with GB'050, GB'842, GB'297 and GB'682 falling within GB'997, these were also entered in the diagram at the appropriate position down the page. In the example just given, these filings do not nest within one another. Accordingly, their diagram entries were positioned successively across the page, the line corresponding to GB'997 being further extended to encompass all four entries and thereby indicate the significant relative breadth of this particular filing.

Later filings that did not fall within the scope of any earlier filing, for example GB'217, were placed far enough to the right so as not to fall under the lines of any earlier filings. In the present example, this necessitated extending the diagram on to a further page -see figure 5.2(b) below.

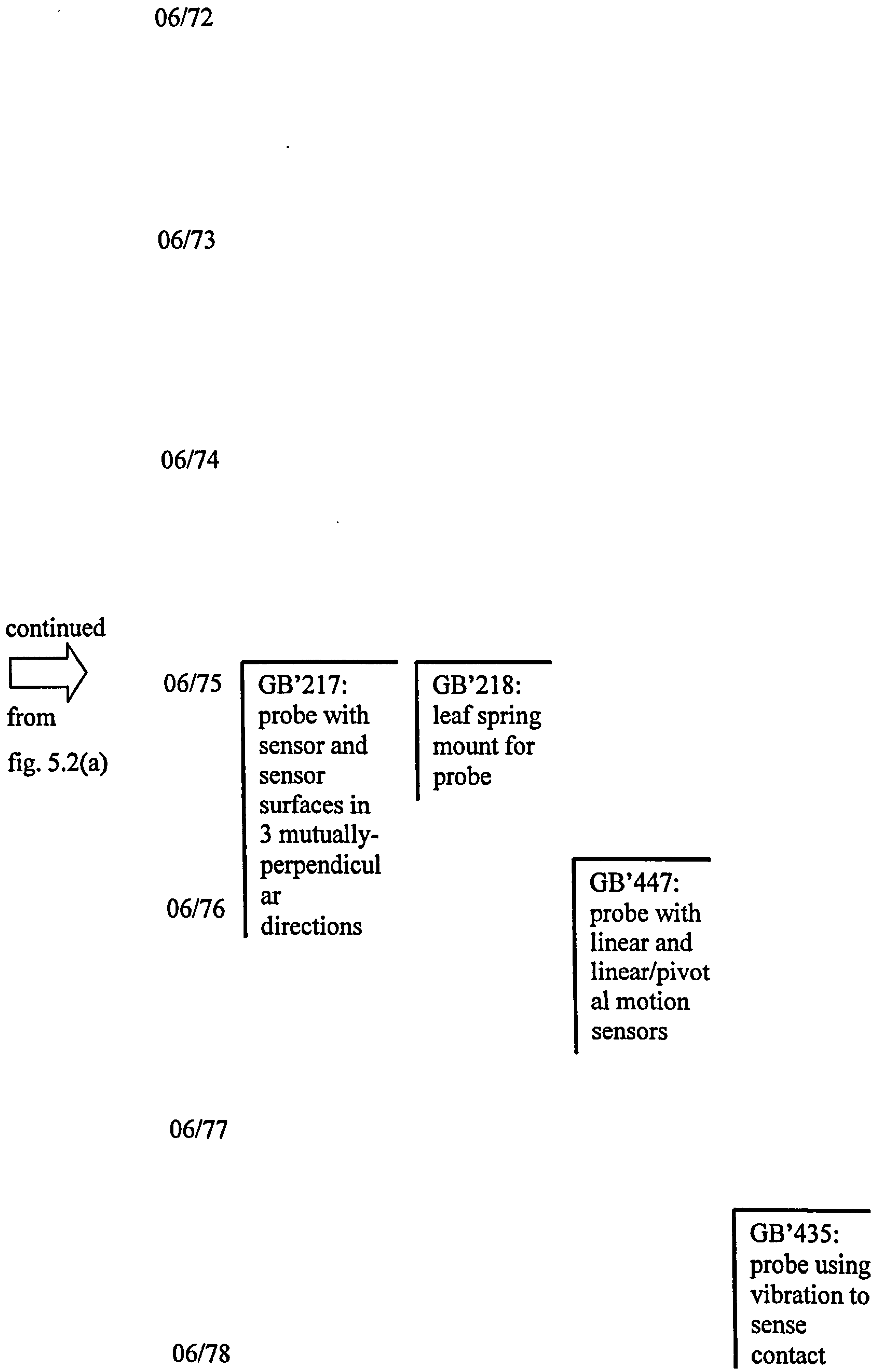

Figure 5.2(b): Scope/Time Diagram for Renishaw portfolio 1972-1975 cont.

5.2.3 Filings made in 1986 and 1995

As has already been noted, many of the patent filings made by Renishaw in 1986 and 1995 bear no relationship at all to the original probe technology, reflecting the development of new product lines by the company. Indeed, it is noted that Renishaw made a filing to a rotary mounting with air bearings as early as August 1977.

Of the filings relating to probes, six of the filings made in 1986 relate to a new kind of optical probe technology that provides an analogue output rather than the digital output of the original touch trigger probe technology.

1986 also saw two filings – EP 0 242 747 and WO88/01726 - to the electronic interface between a probe and the machine on which it is mounted, perhaps reflecting a move by Renishaw to offer a package of probe plus control system rather than just the probe.

Of the remaining filings made in 1986 and 1995, five relate to the initial touch trigger probe technology but only one of these – GB 2 298 488 relating to a probe with indexable sections that are releasable by a lever/motor mechanism – nests within the earlier GB 1 597 842. This is shown in figure 5.2(c) which should be viewed as lying below figure 5.2(a).

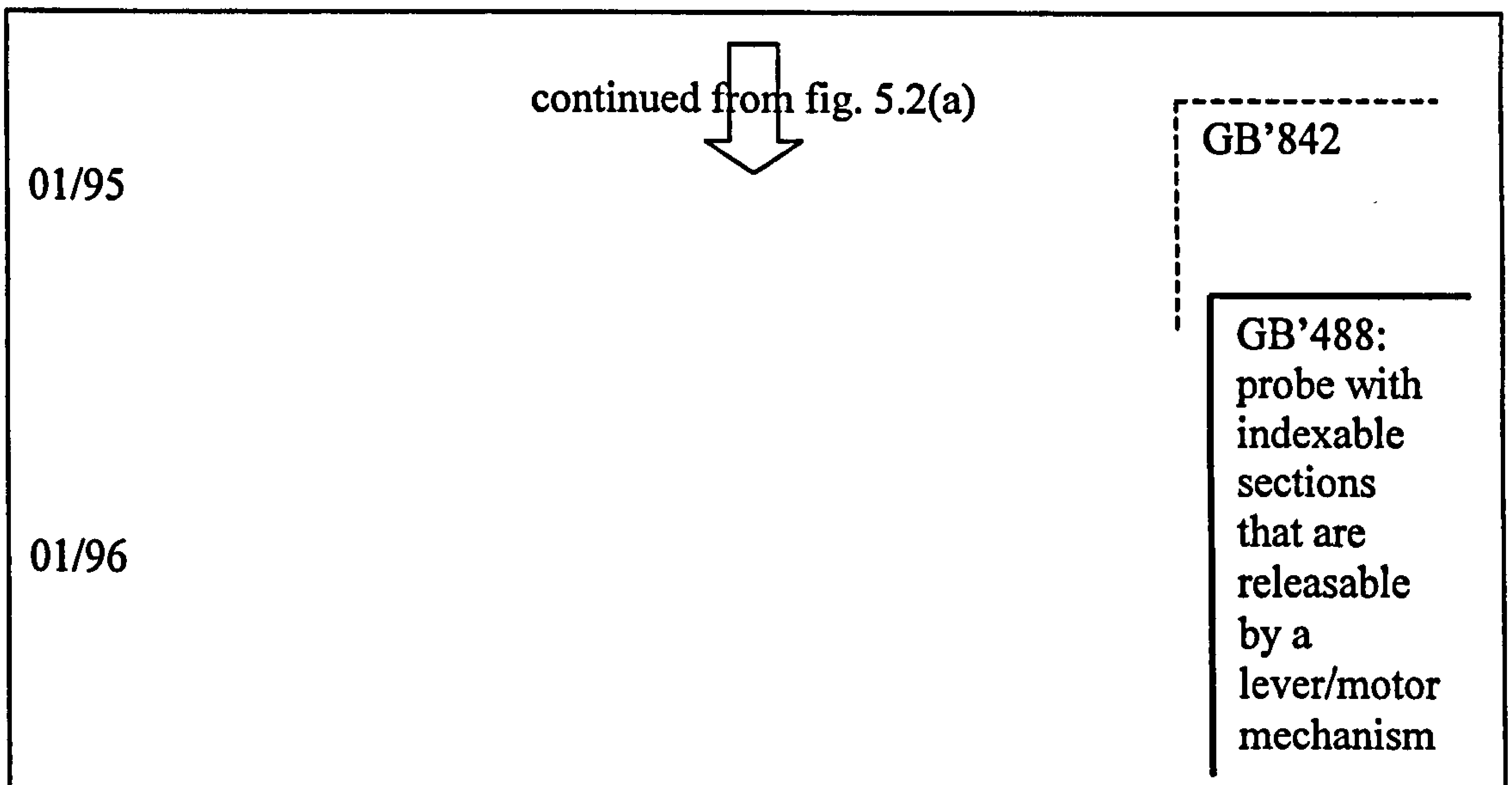

Figure 5.2(c): Scope/Time Diagram for Renishaw portfolio 1995

The other four filings relating to the core touch trigger probe technology do not nest within earlier filings and are accordingly located to the right of the entries in figure 5.2(b) as shown in figure 5.2(d).

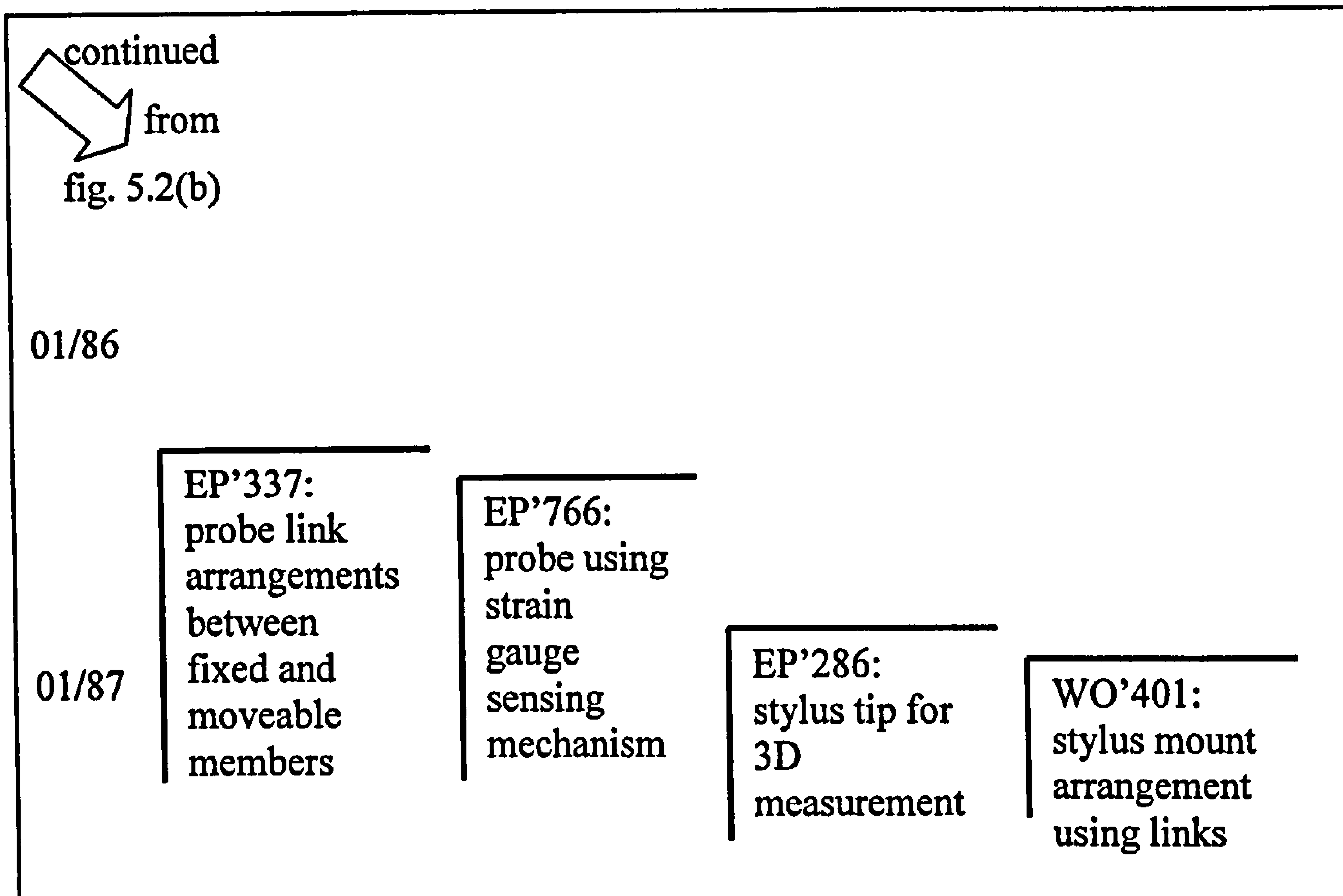

Figure 5.2(d): Scope/Time Diagram for Renishaw portfolio 1986

The remaining five filings in 1986 and three filings in 1995 all concern applications of the core technology. Since there are no nesting relationships, little value is seen in putting these filings into a diagram.

5.2.4 Background Company Environment Information

An extract from the Renishaw Group Profile brochure is included as Annex 3. It effectively summarises much of the information regarding Renishaw's company history contained in the website, flotation prospectus and annual report for 1997, as well as repeating some of the information in the Gourlay (1990) article.

The extract contains two observations regarding the inventor David McMurtry that are of particular interest. The first, on page 8, notes that:

During David's employment at Rolls-Royce, he produced a number of different probe designs which were patented by Rolls-Royce themselves. Although not many of them were marketed by the new Renishaw Company, the effect of these patents made it very difficult for competitors to find a design which could compete effectively without infringing one or more of the patents.

The second, on page 10, states that:

After David McMurtry joined the company full time, in 1979, there was a flurry of new development in probes and probing systems for CMMs [Coordinate Measuring Machines], including new types of styli, extension bars, the motorised head and the probe autochange system. These have been important developments which have greatly contributed to fully automated inspection with fast throughput.

5.3 Discussion

5.3.1 Patent Relationships

That the Renishaw patent portfolio exhibits several of the patent relationships identified in the previous chapter is clearly evident from the diagram of figures 5.2 to 5.6:

Nesting

Figure 5.2(a) shows the 'nesting' patent relationship, with a number of filings falling within the broad concept of GB'997.

New

Figure 5.2(b) shows a number of filings which do not fall within GB'997 and therefore relate to new areas of the technology, i.e. the 'new' patent relationship.

Application

The existence of filings to products in which a patented technology may be used, i.e. the 'Application' relationship, is acknowledged at the very end of section 5.2.3 although not depicted in a diagram.

As already mentioned above, the Renishaw portfolio also contains many filings relating to an expansion of the company's product offering away from the single probe technology. These fall into two groups:

- filings to technology, particularly electronics, that support the core probe technology;

- filings to new product lines, such as Raman spectroscopy, that are completely unrelated to the core probe technology.

It was not evident how the second group of filings could be reconciled with any of the points made in the Literature Critique chapter 4: the decision on whether to pursue completely new technologies would not appear to be a question of patent strategy (although once a new field of technology has been identified, the third party patent right and prior art position in that field will of course need to be reviewed before proceeding).

As regards the first group of filings, these could be considered to relate to the core technology were this to be defined as a touch trigger system rather than than just the touch trigger probe itself. Such a 'system' definition may have been more relevant to Renishaw's business in 1986 than when the business first started in the seventies. As it is, the diagram of figures 5.2(a)-(d) reflects the seventies view of the core technology being the probe construction. However, were the diagram ever to be used in the formulation of Renishaw portfolio structure, a revision to reflect the broader 'system' definition might be in order.

5.3.2 Depiction of Further Patent Relationships

In addition to the relationships shown in the diagram, it was realised that the first quotation above regarding

> *'different probe designs which ... made it very difficult for competitors to find a design which could compete effectively without infringing one or more of the patents'*

did actually describe the 'similar function' patent relationship. Moreover, it was realised that the different probe designs referred to were actually the subject of the four filings gb'217, gb'447, gb'682 and gb'435 on the right hand side of figure 5.2 (see figure 5.2(b)). All these filings provided the fundamental function of McMurtry's initial GB'997 but by means of different mechanisms.

This led to the realisation that by somehow indicating that common function, a portfolio diagram ought to be able to depict the 'similar function' patent relationship. Not only this, inclusion of functional data for each filing could potentially reveal the 'Superseding' relationship by showing which filings had advantages over earlier filings that made those earlier filings obsolete.

5.3.3 Risk Factors and Company Objectives

There was certaintly evidence that some of the risks and risk factors proposed in the Literature Critique chapter applied to Renishaw, viz:

Bypass Risk

The first quotation from the Renishaw Group Profile above acknowledged the risk of Renishaw's patents being bypassed by competitors having significant technological capability;

Expiry Risk

The risk of loss of market share following patent expiry was acknowledged in McMurtry's comment to Gourlay (1990 – see Literature Review chapter) that:

> *Even if competitors are able to make our earlier [products] ... these would not now be accepted in the market because we have better products which remain covered by patents.*

However, the mere mention of these risk factors was not considered sufficient evidence that they were more significant than other risks and thus likely to affect portfolio strategy. The same was true of the internal company objectives identified in the preceding chapter: the background information contained no suggestion of any company objective to use patents as a tool in negotiating access to technology belonging to a third party. However, even if such an objective was significant, it would be unlikely to be acknowledged in public given its commercial sensitivity.

5.3.4 Patent Timing

The inclusion of a time axis in the diagram of figures 5.2 to 5.6 also allows temporal relationships between filings to be identified.

Factors that speed up or slow down filing were identified in table 4.3. However, it is simply not possible to tell from the diagram (or indeed from the underlying patent document) whether a patent filing has been sped up or slowed down.

Temporal relationships could be considered as giving some insight into the amount of strategic intent behind a patent portfolio. Specifically, a significant number of filings having a 'new' relationship to existing technology and made within a short period of time could be indicative of a deliberate 'blanketing' strategy of the kind described by Knight (1996) in subsection 3.6.4 of the preceding chapter. This would not appear to have been the case with Renishaw, however, where the filings made in the first few years (figure 5.2) are spaced at leisurely intervals.

The temporal spacing between nesting filings was also examined for evidence of the the strategy outlined by Driks (1998) in subsection 3.5.4 and repeated in table 4.3 whereby a later filing having a significant technical similarity to an earlier filing is made before publication of the earlier filing. As it happened, the first filing (gb'053) that nested within the first Renishaw filing gb'997 was made under old (pre-1977) UK patent law that allowed so-called 'patents of addition' that did not have to show inventive step over a main patent, in this case gb'997. Accordingly, no conclusions could be drawn here either.

5.4 Conclusions and Proposals for Further Research

5.4.1 Research Objective: Investigate structure and logic of patent portfolios

At the end of the previous chapter, it was suggested that it could be worthwhile attempting to apply the principles of Norris' 'multiple barriers' diagram (cf. figure 3.4) to the patent portfolio of a real company. The pilot review of the present chapter has confirmed that this previously abstract diagram can indeed be adapted to incorporate real life data.

In particular, the diagram has provided real-life examples of three of the patent relationships proposed in the Literature Critique chapter. Moreover, it has been recognized that by including details of the advantages associated with a filing, it might be possible to group together those filings relating to different ways of achieving the same function and thereby show the 'Similar Function' patent relationship.

Indeed, the property of 'advantage' seems to be a hitherto unexplored aspect of patent data, for which there may be several reasons. Firstly, as far the author is aware, explicit advantage information does not appear alongside standard bibliometric data in the searchable fields of online databases (the author is aware of a 'purpose' field in Japanese patent abstracts; however, this is not searchable independently of the rest of the abstract which deals with the features of the patent).

Secondly, there is no standard bibliometric data that reflects advantage, unlike patent scope where, as explained in the Literature Review, patent classification has been used as an indirect measure.

Thirdly, it is noted that whilst patent documents have a specific section (the claims) relating to patent scope, they do not have an equivalent section relating to advantage. Certainly, patent office guidelines state that the description should 'be such that the technical problem, even if not expressly stated as such, and its solution can be understood'. However, the attorney drafting the patent application is at liberty to include such explanation wherever he wishes in a description, which may run to many pages. It follows that in order to be able to successfully extract advantage data from a patent specification, familiarity with language and anatomy of a patent documentation is necessary. Such familiarity is the exception rather than the rule. Also the whole of each patent may have to be studied by someone able to understand the technology.

Accordingly, there seemed to be good grounds for further developing the methodology and diagram of the present chapter to investigate the 'advantage' aspect. However, it was also decided that there was little point in continuing to position filings on the diagram in accordance with their filing date given the comments above regarding patent timing.

5.4.2 Research Objective: Investigate optimal patent portfolio structure for STCs

A key finding from this first review of a real Single Technology Company patent portfolio was that, contrary to the expectations of the Literature Critique chapter, filings to alternative ways of achieving the functionality of the single technology did have a place in STC portfolios. In other words, STC portfolios could include the 'Similar Function' patent relationship upon which Granstrand's 'Fencing' strategy was based.

However, whether analysis of further STC patent portfolios would provide guidance to the IP manager on how to optimise his patent portfolio structure remained questionable. Specifically, it was not clear whether it would be possible to obtain reliable data on the significance (or not) of the various external risk factors and internal company objectives that might then be correlated with patent relationships.

Such correlation would of course be based on the assumption that the Renishaw portfolio was in fact a 'good' portfolio built on logical principles. However, having looked in detail at Renishaw's background, it became evident that whilst patents had played an important role in the company's success, many other factors had also contributed. In particular, the company had been able to bolster the original probe business with many other product lines thanks to David McMurtry's inventiveness – witness the second quote in subsection 5.2.4 above. Put another way, could the Renishaw portfolio simply be the result of a 'patent everything' approach rather than a logical strategy?

As explained in the subsection 5.4.1 above, it had already been concluded that there was value in creating a new type of portfolio structure diagram. With a view to addressing the concerns raised in the previous paragraph, it was decided that this new diagram should also be applied to a new patent portfolio belonging to a company more closely focused on a single technology than was Renishaw. It was felt that relationships between portfolio structure and environmental conditions might be more evident in such conditions. For similar reasons, it was decided to examine an entire portfolio rather than just selected portions as had been the case with Renishaw.

5.4.3 Research Objective: Investigate a Risk Management Approach

The remarks in the previous subsection regarding potential difficulties in obtaining risk factor data did of course call into doubt the viability of the preliminary risk management approach to patent portfolio structure proposed in the preceding Literature Critique chapter.

As in the previous subsection, it was hoped that examination of the portfolio of another company might shed more light on the viability of this approach.

5.4.4 Research Objective: Investigate Hard Data rather than Opinion

Investigation of the individual filings in a patent portfolio clearly yielded useful information, as has been discussed in subsections 5.4.1 and 5.4.2 above. However, at this stage in the research it was not possible to conclude whether it would be possible to extract data from successful patent portfolios that might then provide guidance to IP managers on how to structure their own STC portfolios. It was believed that the answer to this question would become more evident following the analysis of a further patent portfolio as already proposed.

5.5 Summary

Key results of this chapter are as follows:

- a new methodology for analysing patent portfolios, based on the content of the individual filings making up the portfolio rather than bibliometric data, has been developed;

- a previously abstract method of depicting a patent portfolio has been adapted for use with real patent portfolios;

- three of the patent relationships that had been distilled from the teaching of the literature have been identified as existing in a real patent portfolio;

- a hitherto unexplored characteristic of patent filings, namely advantage, has been identified as a potential means for showing the existence of other patent relationships;

- indicators of certain risk factors have been identified and correlated with certain patent relationships, potential difficulties in establishing indicators of other risk factors have been identified.

CHAPTER 6

Second Portfolio Analysis

6.0 Introduction

This is arguably the most demanding chapter both as regards the amount of data presented and the number of concepts to be digested. It details the application of the scope/advantage diagram proposed at the end of the last chapter to the entire portfolio of a high-profile STC.

Having first presented information on the particular company chosen, the step by step construction of the diagram is explained, starting with straightforward examples before moving on to more complex aspects of the implementation. Lessons learned from the actual construction of the diagram are explained as they arise. In this way guidelines are provided on how to implement the diagram in practice.

Finally, the chapter reviews the technical and commercial environment of the company and seeks to correlate this with the characteristics of the scope/advantage diagram.

As explained above, the chapter is demanding, requiring frequent reference to two substantial annexes. However, the task is rendered more palatable by the very interesting nature of both the company and its technology.

6.1 Methodology

6.1.1 Choice of Company

Like Renishaw, the subject of the first portfolio analysis, Torotrak plc, was known from the Literature Review (see Yau (1999)) and had been founded on the basis of a single core technology, namely a continuously variable transmission (CVT) of the toroidal-race rolling-traction type (hence the company name, Torotrak). A brief background to the technology is given in an article from the June/July 1996 edition of 'Automotive Engineer' in Annex 4.

Patents were also vital to Torotrak's business, although not as a result of any litigation. Rather, Torotrak had chosen to follow a licensing model like the author's then employer, Xaar, and as such was arguably closer to the target STC than Renishaw.

However, Torotrak differed from Renishaw in the nature of its 'success', which was measured in terms of profile rather than profits. At the time in question, the company was gearing up for listing on the London Stock Exchange, having up until then been a subsidiary of British Technology Group plc (BTG). It was in this link with BTG that the 'success' of the Torotrak patent portfolio was perceived. As will be gathered from Annex 5, BTG were (and are arguably still) the pre-eminent technology licensing company in the UK and, by analysing a patent portfolio that had been managed by this company, it was hoped that valuable insight could be gained.

6.1.2 Identification of Filings

As part of preparations for listing, a detailed (140 page) prospectus had been published. Reflecting the heavy dependence of Torotrak on IP, this prospectus listed the titles of all the filings in the Torotrak portfolio and for each filing gave a brief technical summary and patent bibliographic details.

Whilst the majority of the filings listed in the prospectus dated from after BTG's acquisition of the core technology and formation of Torotrak in 1987, there were some filings that dated from before that period. Since the strategic and environmental conditions for those filings were not known, they were not included in the analysis. Instead, the focus was on the filings following BTG's introduction of a licensing strategy in 1987.

The filing details in the prospectus were also cross-checked with the results of searches on the online Derwent World Patents Index database, revealing certain inconsistencies:

At least one filing (WO91/08405, priority date 01.12.89; EP 0 306 272, priority date 02.09.87) identified in the online search did not appear in the prospectus, probably because these cases were abandoned before the preparation of the prospectus in July 1998.

A UK filing made 27 April 1998, shortly before preparation of the prospectus, did not appear in the prospectus despite being earlier than other UK filings that are included in the prospectus. Furthermore, this UK filing went on to form the priority basis for WO99/56036 in the name of Torotrak. Accordingly, it was included in the scope/advantage diagram.

Finally, there were two 1998 UK filings in the prospectus that were not picked up by the online search. However, an absence of any corresponding patent publications suggests that these two applications never made it past the priority filing stage.

6.1.3 Analysis of Filings

As with the Renishaw analysis, the Torotrak analysis involved reviewing the independent claim(s) of each filing to determine the scope of protection. However, the Torotrak analysis also required that the advantage as provided by the claimed features be determined. As explained in the last chapter, such information can be spread throughout the patent document. Accordingly, it was also necessary to review and understand the description of each patent filing (the implications of this are discussed in more detail below). Scope and advantage details for each filing were then recorded in a table prior to be being incorporated into the diagram. Due to their size and for ease of reference, both table and diagram have been placed as Annexes (7 and 8) rather than being incorporated in the text.

6.1.4 Environmental Information

The author was very fortunate in obtaining an original copy of the listing prospectus for Torotrak since the circulation of such originals is generally restricted to potential investors. Although copies of prospectuses can be obtained from Companies House, these are only printouts from microfiche and are only available some time after the event, as was the case with Renishaw. Extracts from the Torotrak prospectus are reproduced in Annex 6 and discussed in further detail in section 6.5.

Another difference vis-a-vis the Renishaw prospectus, probably attributable to changes in listing regulations in the fifteen years since that prospectus was issued, was the quantity and nature of the information disclosed. With sections entitled, inter alia, 'Principal Benefits of the Torotrak Infinitely Variable Transmission (IVT)', 'Licence Agreements, Contracts and Strategic Alliances', 'Market Outlook', 'Torotrak Group Strategy', 'Competitive Environment' and 'Risk Factors', the Torotrak prospectus offered unique insight into the factors that might have influenced company patent strategy. Accordingly, no further information was deemed necessary at this stage.

6.2 Results: Core Technology

6.2.1 Basic Diagram Structure

Very early on in the analysis, significant differences between the Torotrak filings and those Renishaw filings analysed in the previous chapter became evident that necessitated changes to the diagram format. Specifically, almost all of the Torotrak filings related to the same single technology so that to distinguish between filings it was necessary to describe them in significantly more detail than had been done in the Renishaw diagram.

To facilitate this, it was decided to reconfigure the diagram such that the claim wording for each filing extended the width of the page. Paragraph indents and bullet points were then chosen as a straightforward way of indicating those filings that fell within the scope of earlier filings, as illustrated in figure 6.1.

• detailed claim language of earlier filing

• detailed claim language of later filing falling within earlier filing

Figure 6.1: Basic Diagram Entry

For convenience, 'detailed claim language of a filing' will henceforth be referred to as the 'Protected Solution' of a filing. The Protected Solutions all belong to Torotrak. Solutions owned by other companies are not considered.

Such a format also facilitated the incorporation of information about the advantage associated with a Protected Solution. As shown in figure 6.2 this was achieved by means of a heading over the respective Solution.

<u>advantage A:</u>
• earlier Protected Solution

<u>advantage B:</u>
•later Protected Solution

Figure 6.2: Basic Diagram Entry with Advantage

In the preceding chapter, it was suggested that advantage information would allow the depiction of the 'Superseding' patent relationship, namely those Protected Solutions having advantages over earlier Protected Solutions. This relationship was shown in this diagram by placing a box around the earlier Protected Solution followed by a reference number.

The corresponding advantage over that earlier Solution is then prefixed by a box symbol '[][1]' together with the reference number, as shown in figure 6.3.

advantage A:

• earlier Protected Solution 1

[]1 / advantage B:

•later Protected Solution

Figure 6.3: Basic Diagram Entry showing 'Superseding' Relationship

This format also allowed the 'similar function' patent relationship to be depicted: figure 6.4 shows a second Protected Solution which offers a different way of achieving a similar functional result (relative to an earlier Solution) to that achieved by a first Protected Solution.

advantage A:

• earlier Solution 1

[]1 / advantage B:

• first Protected Solution
• second Protected Solution

Figure 6.4: Basic Diagram Entry showing 'Similar Function' Relationship

A diagram built using the above elements will henceforth be referred to as a 'Scope/Advantage Diagram'.

[1] A pair of square brackets is used to denote a box because of the inconvenience of inserting a true box symbol.

6.2.2 Initial Application of the Scope/Advantage Diagram to the Real Portfolio

The rest of this section describes the application of the Scope/Advantage diagram structure proposed above to the real Torotrak portfolio. As will become evident, such application was not always straightforward. In particular, relationships between filings were not always immediately obvious and sometimes only became apparent after many other filings had been analysed. The diagrams of Annex 8 represent the results of many iterations. However, in the interests of efficient explanation, the first three examples below have been chosen for their clarity rather than being the first examples of the various relationships in the portfolio to be identified.

As mentioned above, this second portfolio review required diagrams containing significantly more detail than in the first review. Therefore, to keep the size of the diagram to a minimum, the claim language was abbreviated wherever possible, e.g. by use of 'CVT' for continuously variable transmission, '1.' for first, '2.' for second, etc. Nevertheless, wherever there was any doubt that relevant information might be lost in the summarizing process, the full claim wording was used.

The summarizing process as applied to Torotrak filing WO92/11475 is shown in Annex 7, which also details the advantage associated with WO'475, namely that

> *the hinge ... ensures that the associated pistons of the operating mechanisms will rotate in their cylinders whenever ... the CVT ... changes ratio. This may be important because that rotation ... will tend to break any '"stiction" between the pistons and their respective cylinders and thus promote smooth operation (emphasis added)*

Figure A.1 of Annex 8 shows the corresponding diagram entry. Note that in addition to the technical details of the Protected Solution, the diagram contains the publication number and earliest filing date of the filing in parentheses. Furthermore, a '+' sign is used to separate those features which are known from the prior art (and located in the 'preamble' of the claim before a 'characterised in that' term – see Patent Fundamentals chapter) from the new features which make up the new solution (and which are located after the 'characterised in that' in the claim). Thereafter, advantage information is entered as a heading over the entry, as shown in figure A.2. Since the filing in question has two advantages over the prior art – 'improved smoothness of operation' and 'reduced cost', two separate headings are required each reciting the Protected Solution of WO'475 underneath.

It should be noted that a new version of each figure (respectively denoted A.1, A.2, A.3 etc.) has been created each time a filing is added to the diagram so as to make evident how the structure of the diagram – which itself is a key result of the present research – is built up.

The features of the preamble of WO'475 are in fact known from another, earlier Torotrak filing WO90/05860 (see summary in Annex 7). It follows that there is a nesting relationship between these two filings. This is depicted in a further version of the diagram, A.3, by positioning the entry for WO'475 lower than and indented relative to the entry for WO'860.

Furthermore, the solution of WO'475 supersedes the solution of WO'860 by offering the further advantage of 'improved smoothness of operation'. This relationship is denoted by means of a numbered box symbol '[]1' in the heading over WO'475 which refers to the numbered box surrounding the entry for WO'860. A similar entry is made for the 'reduced cost' heading.

As regards the latter advantage of 'reduced cost' over WO'860, an alternative way of achieving this is offered by the later filing WO94/01697. Annex 7 shows the summarizing process as applied to this later filing and figure A.4 shows the corresponding diagram entry.

6.2.3 Incorporation of Prior Art into the Scope/Advantage Diagram

From the examples above, it will be appreciated that prior art plays a critical role in the scope/advantage diagram since it is relative to a piece of prior art that the advantage associated with a Protected Solution is defined. A fundamental consideration is therefore the amount of prior art to be included in the diagram.

One extreme is not to include any prior art and to restrict the diagram to Protected Solutions. Such an approach would exclude the information contained in the 'Background to the Invention' section of each patent filing which, as explained in the Patent Fundamentals chapter, can provide information on the candidate company's view of the benefit(s) of the protected solution over known solutions. Such information is of direct relevance to the exercise in hand.

The other extreme could involve carrying out searches to identify prior art of relevance, or at least incorporating the results of any search reports that might have been published alongside the filings. However, such search results will not reflect the state of the company's knowledge at the time of filing and hence would not be representative of the candidate company's patent filing strategy, which is an objective of the present investigation.

Accordingly, a decision has been taken to include in the diagram only those known solutions which are acknowledged in the filing, and then only in respect of the particular protected solution of the filing. Moreover, where a filing acknowledges multiple prior art, only the earliest is incorporated in the diagram. Other prior art is not included in the diagram.

6.2.4 Scope: Basis in the Filing for 'Nestor'

In the example above, an earlier Solution was the subject of an independent claim. A later, nesting Protected Solution contained all the features of that independent claim plus some extra features that gave an advantage over that earlier Solution. It is convenient to refer to these two elements as the 'Nestor' and 'Nestee' respectively.

However, in the Torotrak portfolio, this has been found to be the exception rather than the rule. Often, a prior art filing is simply cited as an example of a genre of solution without actually having claims covering that genre. This may be because the applicant could not find a prior art filing having such broad claims. Indeed, it may be that such a prior art filing did not exist, the broad concept having been made public by some means other than a patent filing. A less likely alternative is that the applicant may have failed to identify the broad concept and filed narrower claims instead.

In such circumstances, it has proved necessary to base diagram entries on information other than the claims, as explained below

Basis in Preamble of Protected Solution

As explained above, the 'preamble' of a claim lists those features of a solution which belong to the prior art. It will be appreciated that the terms used in the preamble must be sufficiently broad to cover both the prior art and the solution, in which case they may be used as basis for a diagram entry.

For example, it will be seen from Annex 7 that the preamble of the independent claim 1 of WO97/40292 recites 'end loading means for biasing the discs into engagement with each other'. This language covers any mechanism which biases the discs into engagement with each other, including the particular 'hydraulic control means' solution of WO'292. Accordingly, this language is used in the diagram, as shown in figure B.1, the corresponding advantage being improved device efficiency.

It will be noted that in this example, the earlier solution is disclosed in a prior art filing rather than being a Protected Solution itself. To highlight this difference, the Protected Solutions have been entered in bold font, leaving disclosed solutions in regular font. Furthermore, a reference to the filing in which the earlier solution is acknowledged as prior art ('pa') is given in the parentheses. In the example above, the reference takes the form 'pa in WO97/40292'.

Note that a later filing, WO99/34133, offers the same advantages. Corresponding entries are made in figure B.2.

Basis in Description

As mentioned above, a genre of solution may be exemplified in the description of a filing by reference to a prior art filing. The language used to describe the genre may in turn be incorporated into the diagram.

For example, with reference to Annex 7, it will be seen that the description of EP 0 354 013 cites prior art documents GB-C-2 023 753 and EP-A-0 133 330 as disclosing examples of 'hydraulic end stop' mechanisms. Accordingly, this term has been used in the summary of the protected solution of EP'013 as well as in the summary of the prior art solution of GB'753 as incorporated into the diagram – see figure C.1.

As another example, WO90/05860 cites GB-A-1 395 319 as an example of a variator of the 'force-balance type'. Accordingly, this term is used in the summary of the protected solution of WO'860 (followed by a '+' to indicate that it belongs to an earlier solution) as well as in the summary of the prior art solution of GB'319 – see figure A.5.

Note that in this example, it is difficult to identify the advantages associated with the intermediate concept disclosed in GB'319: WO'860 simply indicates that this is an example of the 'force-balance' genre of CVT, without explaining the advantages associated with the genre. An engineer might conclude that the reason is cost - it is a fact that when using hydraulic systems of the kind generally used in other Torotrak designs, it is easier to implement force (pressure) control than position control. Indeed, the Torotrak listing prospectus of Annex 6 notes the cost and high tolerance manufacturing required by a 'ratio control' transmission and suggests that this is overcome by 'torque control'. The article of Annex 4 also states that this system is very much quicker-acting than the earlier system. However, as discussed later, it is not acceptable to include such attorney/engineer insight in the actual diagram, hence the indication of the corresponding advantage is left unidentified.

No Basis for Nestor

As pointed out in the Patent Fundamentals chapter, the amount of discussion of the prior art in a patent application will depend on the personal style of the drafting attorney.

The Torotrak portfolio has been drafted by three attorneys, all employees of BTG or its predecessor, the National Research Development Corporation: early filings (1987 to 1993) were made by Patrick Stables, 1995 filings were made by David Trevor-Briscoe and subsequent filings by Ian Bingham. Filings by Stables and Trevor-Briscoe include detailed discussion of specific prior art documents whereas Bingham filings typically do not acknowledge any prior art documents at all.

An example of the latter kind of filing is WO99/34134. The description makes no mention any prior art document. However, the sole independent claim is drafted in two-part form having a substantial preamble which by definition must correspond to some prior art somewhere. Accordingly, whilst it has been possible to incorporate the solution of this filing into figure B.2, this has been without corresponding advantage or source details.

6.2.5 Scope: Levels within the Diagram

Thus far, Torotrak filings have only been entered on the same sheet of the diagram where there exists a patent relationship between them. Accordingly, WO97/40292 and EP0354013 find themselves on different sheets (B and C) to the filings on sheet A. Within a sheet – for example the preliminary diagram of figure A.4 - it will also be evident that solutions can be divided into levels, with solutions at a high level encompassing solutions at lower levels.

However, it will also be appreciated that there is potential for many - if not all – solutions on separate sheets to be nested within a single top-level concept. In the case of the filings discussed thus far, such a concept could be 'a CVT with input and output discs and roller therebetween'. Furthermore, the level of any one filing relative to such a top-level concept could potentially be a useful indicator of the importance of that filing in the portfolio which could in turn provide a useful metric for the portfolio as a whole.

For example, consider the 'hydraulic end stop' genre identified in EP 0 354 013 as being known from GB2023753 and explained as being provided

> *to resist and arrest further movement of the ram piston should the transmission encounter a driving condition in which the rollers tend to overshoot their normal range of attitudes and so be in danger of running off the edges of the toroidal discs*

i.e. the advantage of 'improved reliability' over earlier known CVTs of the toroidal-race rolling-traction type. WO92/01175 describes another solution providing the same advantage of 'improved reliability' over earlier known CVTs of the toroidal-race rolling-traction type. It follows that there is a 'similar function' relationship between the prior art genre known from GB'753 and the solution of WO'175. Accordingly, these two solutions are placed alongside one another in the diagram as shown in figure C.2. This in turn results in the Protected Solution of EP'013 being located one level lower in the diagram than the Protected Solution of WO'175. The significance of levels will be discussed in more detail later, but for now it is noted that this difference in levels could indicate that portfolio member WO'175 has greater scope and/or value than portfolio member EP'013.

It may be noticed that the claim of WO'175 specifies a 'CVT' whilst other entries on sheet C.2 specify a 'Roller control system for a CVT'. For the present, both types of filing are incorporated into the same sheet, with harmonisation of the two types of entry being discussed later, in subsection 6.4.5. However, a new sheet D.1 has been created to show the additional cost advantage that WO'175 has over the core technology.

As regards the entry in figure C.2 for the earlier 'CVT's of the toroidal-race rolling-traction type', the opening paragraphs of EP'013 indicate that 'such a mechanism is generally well known in the art, and examples of it are described in detail in many published patent specifications, for instance GB-C-2023753 and EP-A-0133330.' This observation is confirmed by the Torotrak listing prospectus which states that 'the concept of using a Toroidal Variator as the basis of an automotive transmission has been known for many years and attempts to apply it were made in the 1930s and 1950s'. Accordingly, rather than indicating the aforementioned GB'753 or EP'330 as the disclosure of this broad concept, the diagram entry simply states 'well known' in brackets.

6.2.6 Scope: Implicit Features of the 'Nestee'

The above examples illustrate different ways of identifying a broad concept when such is not contained in the claim of an earlier filing. The opposite situation also occurs, namely when a filing describes its advantage relative to a certain prior art device yet the claim of the filing does not contain all the essential features of that certain prior art.

For example, referring to Annex 7, it will be seen that WO97/01718 describes its advantage relative to a genre of Torotrak-style, force-balance type variator which is the Protected Solution of another Torotrak filing WO90/05860. However, although WO'860 is acknowledged in the description of WO'718, the claim of WO'718 does not contain the feature of WO'860 relating to the single contact location of the roller assembly. The question then arises: can WO'718 validly be nested within WO'860?

In this particular example there is good reason to think that it can since the operating mechanism specified in the independent claim of WO'718 has the effect of a single contact, even though it has first and second parts. This conclusion is supported by the construction of the known solution of GB1395319 over which WO'860 is distinguished. A corresponding entry has been made in figure A.5.

However, as will have been apparent from the Patent Fundamentals chapter, it is a fundamental principle of patent drafting that only those features necessary to an invention be included in a claim. Accordingly, the example above will be the exception rather than the rule.

In another example, it will be seen from Annex 7 that WO92/08912 describes its advantage (of improved reliability) relative to the 'hydraulic end stop' genre of CVT as discussed above. However, the claim of WO'912 contains no reference to the 'hydraulic end stop' feature, nor does it refer to any feature that might be considered to have a 'hydraulic end stop' effect. Furthermore, in the description, no reliance is placed on this feature to distinguish over the cited prior art. Accordingly, there are no reasons for nesting WO'912 within the 'hydraulic end stop' concept and it is instead placed at the same level as the 'hydraulic end stop' under the same 'improved reliability' heading – see figure C.3.

As an aside, it is noted that the International Search Report for WO'912 cited two 'X' documents[2] with regard to the broad concept of claim 1, i.e. two documents dating from 1948 and 1967 that purport to disclose or render obvious a CVT of the toroidal-race rolling-traction type having stop means mounted adjacent both the outer and inner edges of the part-toroidal races on the discs, to prevent the roller from running off those edges. That such citations were made is perhaps not surprising given the breadth of the concept involved, the fundamental nature of the underlying problem and the age of the technology. However, had the drafting attorney included in the claim the 'hydraulic end stop' concept relative to which the 'improved reliability' advantage was described, these old citations probably would not have been relevant. This is an example of 'patent attorney insight' which, as discussed below, must be excluded from the analysis so as to ensure complete objectivity of the results.

[2] The documents listed in a patent office search report are classified according to their relevance to the invention defined by the claims. Category 'X' is defined as 'a document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.'

6.2.7 Scope: Avoiding Subjectivity

It will be appreciated from the above that the validity of any metric will require that each of the entries at each level of a diagram be chosen in a justifiable and non-arbitrary way. Subsection 6.2.4 above lists several ways of identifying Nestor concepts based on the information explicitly disclosed in the filings.

However, there may be further intermediate concepts that are implicitly disclosed in the filings. Indeed, identification of such concepts from specific examples, otherwise known as 'identifying the underlying invention', is one of the core activities of the patent attorney, as will have been apparent from the Patent Fundamentals chapter.

Whilst such patent attorney insight is essential during the drafting of patent claims, its use during the analysis of patent documents per the present study would introduce solutions into the diagram that might be considered arbitrary - a clearly unacceptable state of affairs.

Consider for example EP 0 354 013 discussed above. This describes a prior art CVT incorporating a 'hydraulic end stop effect' which in turn provides a performance advantage of 'improved reliability' over conventional CVT technology. Another solution providing 'improved reliability' is WO92/08912 to 'stop means on race edges to prevent the roller from running off the race'. A patent attorney might identify a common invention underlying these two solutions, namely 'CVT of the toroidal-race rolling-traction type + means for stopping the rollers running off the discs' (it will be remembered that such 'means for' language has already been used in the claims of WO97/40292 discussed by way of example above). Although such patent attorney insight is valuable when considering the scope of claims to be sought in a new filing, it introduces an arbitrary element when used in the analysis of existing filings and is consequently to be avoided.

As mentioned above in the context of implicit features of a 'nestee', another core activity of a patent attorney is to identify the minimum number of features necessary to provide an advantage over known solutions. It follows that during analysis of filings it may be possible to identify an intermediate generalisation that, by means of a subset of the features of a Protected Solution, provides an advantage over known solutions, albeit not necessarily as great an advantage as the full Protected Solution itself. That such a broader concept was not claimed in the filing itself can be attributed to a number of factors, for example imperfect drafting or perhaps other prior art of which the drafting attorney was aware but which was not acknowledged in the filing. The latter reason in particular makes the incorporation of such intermediate generalisations into the diagram impermissible.

Finally, it is noted that as a review progresses and familiarity with the filings of a portfolio increases, there is a temptation to incorporate into the diagram other prior art that, whilst not acknowledged in the respective filing to which a particular branch of the diagram relates, is nevertheless disclosed in another filing. It can be argued that a diagram constructed in such a fashion gives a better representation of the patent landscape as seen from the perspective of the candidate company. However, such an approach relies on the person analysing the portfolio to consistently identify known solutions of relevance to other protected solutions. Since such consistency cannot be guaranteed, this approach has also not been used in the diagram.

6.2.8 Advantage: Basis in the Filing

It will be appreciated that correct identification of the advantage associated with a filing is essential if 'similar function' patent relationships are to be identified. Occasionally, a patent filing will express an advantage in such a way that it can be incorporated directly into the diagram, as with WO92/11475 discussed in subsection 6.2.2 above. More often, however, a degree of interpretation is required.

Advantage expressed using Different Terminology

Such interpretation may simply be at the level of expressing a problem using the same terminology as used elsewhere in the portfolio in order that solutions providing the same advantage might be grouped together.

For example, WO91/08405 describes an arrangement using multiple standard components that between them transmit a total torque that would have required a much larger, non-standard component had a single output disc been required to transmit the total torque.'

Such an advantage could be interpreted either as 'increased torque capacity' for the same size or 'reduced size' for the same torque capacity. The latter interpretation is chosen, this having occurred elsewhere in the portfolio. The corresponding diagram entry is shown in figure F.1, which also includes entries for WO91/14116 and WO99/54646. Since WO'116 also has a cost advantage, an entry is also made in D.1.

WO'405 is also an interesting example of where two-part form would appear to have been used inappropriately (cf. Patent Fundamentals chapter). It will be noted from Annex 7 that the preamble of the sole independent claim specifies not only the Core Technology features of 'a CVT of the toroidal-race rolling-traction type' but also the feature of 'at least two input discs and at least two output discs arranged alternately in coaxial sequence'. The description of WO'405 indicates that these latter features are known from another filing in the Torotrak portfolio, EP0306272, which relates to a CVT for a tracked vehicle in which two toroidal drives - one for each track - are arranged coaxially. However, the aforementioned advantage of WO'405 is not relative to the CVT of EP'272 but rather to the core technology. Accordingly, EP'272 has not been included as a higher level 'nestor' in diagram for WO'405 (although it is included elsewhere in the diagram - see discussion of 'application' filings below).

Advantage expressed as a Problem with the Prior Art

Alternatively, it may be a matter of turning a statement of a problem with the prior art into an expression of an advantage over the prior art.

For example, WO92/01175 describes problems in the prior art with 'the cost of forming complex passages within a cast casing'. This can readily be turned round into an advantage over the prior art of 'reduced cost' – see figure D.1.

Advantage expressed as an Implication for Performance

A basic appreciation of the technology in question, particularly the performance of the end product, may also be brought to bear:

For example, WO92/08912 states that '... the possibility of the rollers changing orientation rapidly and unpredictably, and even running off the input and/or output races ... becomes a real one and should be guarded against.' It is clear that such a failure mode, whilst not perhaps catastrophic, would nevertheless require repair and consequently impact on the reliability of the device in question. Accordingly, a solution addressing this problem will have the advantage of increased reliability (see figure C.3)

Note that where device failure is catastrophic, the problem changes from one of reliability to one of lifetime. For example, with regard to its Protected Solution, WO90/02277 states that 'while it is desirable that traction should not suddenly fail and should therefore initially be maintained in overload / abuse conditions, it is also important that the raised end load and consequent higher forces of reaction between discs and rollers should not overstress those parts.' Again, it is clear that such overstressing will impact on the lifetime of the device in question. A corresponding entry has been made in figure C.4.

Note that the above interpretation is supported by WO91/11637 which states that '... a net gain in fatigue life can be obtained because life is inversely proportional to a high power of stress ...'. A corresponding entry is shown in figure E.1.

Figure E.1 also includes an entry for WO99/56036 which provides both lifetime and efficiency improvements over prior art document GB-A-2282196 which itself provides improved lifetime. In accordance with the principles outlined above, prior art solution GB'196 has been placed at the same level as Protected Solution WO'637, with Protected Solution WO'036 being placed at the next level down.

Advantage expressed in terms of Simplicity

Instead of expressing advantage in terms of an increase in performance, a filing may describe its advantage in terms of a decrease in complexity. This will have a positive impact on manufacturing cost.

For example, WO 94/01697 gives as an advantage 'the lack of need for any great accuracy in the finish of the solid piston core 32, because the accuracy can be provided by the much lighter sleeve parts 33,34 which are then fitted over it.' As will be seen from Annex 7, this manufacturing advantage has been reduced to the fundamental advantage of reduced cost, as has the statement that 'among the advantages of the construction are ... the simplicity of the jointing of the link shaft 14 to the centre of the piston core 32.' The corresponding diagram entry is to be found in figure A.4

Another example, WO91/06791, has the stated aim 'to adapt and simplify ... a hydraulically-controlled CVT for use where no ... power driven pump is available'. Such simplification has been interpreted as reducing the cost of the final product. A corresponding entry is shown in figure D.1. Note that this filing is another example of where the two-part form of claim has been applied incorrectly: the stated aim is relative to a different document to that upon which the preamble of the claim is based.

Advantage Inapplicable

Not all the advantages listed in a patent filing can always be reconciled with the Protected Solution:

As an example, the aforementioned WO90/02277 gives as one aim 'to reflect any increase in ram cylinder pressure in a higher pressure in the hydraulic mechanism which exerts an end load upon the variator so as to maintain continuous traction between the input disc and the rollers, and between the rollers and the output disc'. However, the Protected Solution makes no mention of the hydraulic mechanism - this is rather the subject of a later dependent claim. Accordingly, such an advantage is not included in the diagram.

In another example, the stated advantage of WO93/21031 relates to effecting a smooth and rapid change from one steady state to another when demanded by the operator, as well as to effecting an automatic and imperceptible transition between two modes of operation of a control system. However, the characterising part of independent claim 1 of WO93/21031 merely specifies that ' the variator is of torque-controlled type and the control system is operable to regulate the reaction torque experienced within the variator.' In fact, the means to sense and correlate CVT and engine parameters that give rise to the stated advantage are specified in the preamble, suggesting that the advantage itself is already known from the prior art. It will be appreciated that this runs counter to the previously-discussed logic underlying the advantage/scope diagram.

However, the fact that WO'031 contains a second independent claim 8 in which the characterising features clearly correspond to the stated advantage confirms that claim 1 represents another artificial application of two-part form. Accordingly, it is the Protected Solution according to claim 8 that has been incorporated into the diagram (see sheet M.2).

Yet another example is provided by WO94/04849. In describing problems with the prior art, the description of this filing states that 'it is not easy to adjust the ratio of a belt so that the variator can take over the drive from the fixed ratio gearing without shock. A toroidal-race variator, on the other hand, will move automatically to a ratio which is synchronous with that of the gearing and the two can thus be used in parallel. Flexibility of installation is thus improved: for instance the axial sequence of the principal components (coupling, gearing, variator) can be changed.' However, the sole independent claim does not specify a toroidal-race variator – this is the subject of a later dependent claim. Accordingly this advantage would not be included in the diagram were it not for the presence of another statement explaining that the two concentric input shafts of the prior art device constrain the location of the principal components, i.e. that the effect of the single input shaft of the invention is to reduce such constraint and simultaneously improve flexibility of installation.

The final example of WO94/16244 states that 'the present invention seeks to provide a CVT of the toroidal-race, rolling traction type, capable of geared neutral and of operating in at least two regimes, with a specially convenient facility for incorporating extra regimes in both forward and reverse'. However, the sole independent claim does not specify the toroidal-race, rolling-traction feature – this is only introduced in the second dependent claim. Consequently, the solution is incorporated in a section (K.1) of the diagram that is not specific to the Core Technology.

Advantage Unclear

As when trying to establish the existence of a nesting relationship, subjectivity must be avoided. Thus interpretation may permissible but attorney/engineer insight is not and where a filing does not contain any advantage information, the corresponding diagram advantage entry must be left unidentified.

For example, WO97/37156 merely states that 'It is an object of the present invention to provide an improved apparatus for the cooling of such rollers' without explaining the nature of the improvement. In this particular example, the advantage has not been left unidentified, rather the above statement has been interpreted to mean 'improved cooling' which in turn translates into improved lifetime. WO'156 covers two concepts and the 'improved lifetime' heading has been applied to both. As will be seen from figure E.1, the first concept nests within the broad Core Technology concept whilst the second nests within the lower level concept of 'Core Technology with a hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith'. It will be noted that since the second concept of WO'156 represents an alternative solution to that of WO99/56036 mentioned above, it is placed at the same level as WO'036 in the diagram. However, it is ranked below WO'036 on the basis - discussed below - that later solutions have a cost advantage over earlier solutions.

A second example concerns EP-B-0149892 which, although not a member of the Torotrak portfolio, is nevertheless acknowledged as prior art in WO91/08406 and represents an intermediate generalisation entry in figure G.2. WO'406 contains no information on the advantage associated with EP'892 and similar filings other than to state that 'sometimes it is desirable to arrange all the major components of such a transmission as nearly as possible coaxial with the operating axis of the variator'. Since there is no single advantage to which a coaxial arrangement can be reduced (although ease of packaging the transmission in a vehicle seems the most likely), 'all major components coaxial with the operating axis of the variator' has been entered in the diagram as the associated advantage.

6.3 Results: Developments in Methodology

The previous section explained the various techniques by which the filings of a patent portfolio might be successfully fitted into the scope/advantage diagram. Moreover, the resulting diagram has fulfilled its promise of showing the 'superseding' and 'similar function' relationships originally identified in the Literature Critique chapter.

6.3.1 Depiction of Cost

With regard to the 'similar function' relationship, figure 6.5 below is an adaptation of earlier figure 6.4 showing three Protected Solutions having a similar function (namely advantage B).

advantage A:

• earlier Solution 1

[]1 / advantage B:

• first Protected Solution

• second Protected Solution

• third Protected Solution

Figure 6.5: Basic Diagram Entry showing three 'Similar Function' Relationships

In the figure, the solutions are ranked chronologically, with the earliest (first) Protected Solution being placed at the top and the latest (third) solution being placed at the bottom. However, the author has recognised that a more meaningful ranking would be by cost, with the lowest cost solution being placed at the top and the highest cost solution being placed at the bottom. This would reflect the comments in the Literature Review by Chisholm (1972) and others to the effect that 'it is of little value to patent one embodiment of a discovery if third parties are free to practice alternate embodiments at equal or lower cost.'

In the particular example of the Torotrak portfolio, it is noted that a straightforward cost ranking of solutions offering similar functionality is generally not possible due to a lack of information. However, logic suggests that, given two filings providing the same performance, the later filing should always be the cheaper since technological development does not involve finding more expensive solutions for the same effect. Accordingly, in the absence of definitive cost information, later solutions are ranked higher than earlier solutions.

However, as already identified in subsection 6.2.8 above, some filings have no advantage over the prior art other than cost, i.e. they offer the same performance as the prior art. To allow the cost ranking mechanism to be used with such filings, a dummy performance advantage has been introduced. It has been called 'basic implementation' to reflect the fact that it is merely the implementation of an earlier concept with no advantage over the earlier concept other than cost. Accordingly, it could equally well have been entitled 'no performance advantage'.

By way of example, figure C.4 shows the example of figure C.3 incorporating this modification. It will be noted that in accordance with its 'lower cost' advantage, the solution of EP 0354013 has been placed at the top of the list of solutions with the prior art solution of GB 2023753 - relative to which it has a lower cost advantage - being placed below. Note also that since the cost advantage of EP'013 is relative to a specific embodiment of GB'753, it is the specific embodiment (as recited in the discussion of the prior art in EP'013) that is placed below

Furthermore, the 'lower cost' advantage heading of the earlier figure is replaced by 'basic implementation' to reflect the fact that both the protected solution of EP'013 and the prior art solution of GB'753 are simple implementations of the higher level concept - disclosed but not claimed in GB'753 - of a CVT of the toroidal-race rolling-traction type exhibiting an hydraulic end stop effect. Note that were EP'013 to have any additional performance advantage over the broad concept of GB'753, this would be incorporated in the diagram under an additional heading along the lines already discussed above.

Figure A.6 shows the example of figure A.5 incorporating this modification. The first modification is the 'reduced cost' advantage of WO'860 over the prior art GB'319. It will be noted that the specific arrangement of GB'319 is placed below the arrangement of WO'860, reflecting the cost advantage of the latter solution over the former. The second modification concerns the 'reduced cost' advantage of WO'475 over WO'860 where it is noted that there are two Protected Solutions under the 'basic implementation' heading in addition to the specific construction of WO'860 over which the two Protected Solutions have a cost advantage. Furthermore, in accordance with the logic outlined above, the later of the two Protected Solutions is placed at the top of the list. Similar modifications to figure D.1 are shown in figure D.2.

In the author's opinion, the 'basic implementation' dummy advantage represents the only real 'fudge' or compromise in the scope/advantage framework and is more than offset by the advantages of cost ranking in the rest of the diagram.

6.3.2 Non-Exclusive and Exclusive Alternatives

Referring again to the three filings having a 'similar function' relationship in figure 6.5 above, another recognition by the author has been that the solutions of such filings may sometimes be applicable independently of one another and, if appropriate, in parallel so as to provide an overall advantage greater than that provided by one solution alone. Such solutions can be designated 'non-exclusive alternatives' so as to distinguish them from 'exclusive alternatives' which can only be applied individually.

A distinction between Non-Exclusive and Exclusive Alternatives is made because, in one sense, the existence of Exclusive Alternatives requires a decision as to which solution to follow. Further increase in performance is then achieved by further development of the solution chosen, with any patent filings to further developments being nested within that solution (and thus being at a lower level). Non-exclusive alternative filings are distinguished by means of lines '---' separating the respective diagram entries.

6.3.3 Depiction of Method Claims

A third recognition concerns the depiction of claims to methods as distinct from claims to devices (the two kinds of claims are discussed in the Patent Fundamentals chapter).

WO97/40296 is an example of such a claim to a method of operating a control system for a multi-regime continually-variable transmission. It has been recognised that although the scope relates to a method of operating a control system for a CVT rather than to a CVT itself, the associated advantage to the customer, namely improved smoothness of operation, should be indistinguishable from that achieved by a development protected by a device claim (see e.g. WO92/11475, the first example discussed in subsection 6.2.2 above). Accordingly, no distinction needs to be made in the diagram – see sheet K.3.

6.3.4 Depiction of Manufacturing Claims

Whilst the Torotrak portfolio does contain filings to methods of operation of a CVT, it does not contain any filings to methods of manufacture of a CVT or any of its components. Nevertheless, it has been recognised by the author that the principle of the previous subsection should also be applicable to such manufacturing methods given that to the customer they will either give rise to a better quality product or a lower cost product, i.e. a performance or cost advantage, both of which are accommodated by the scope/advantage diagram as it stands. Indeed, where the product per se cannot be patented, perhaps because it is an obvious improvement of an existing product (e.g. a chemical of higher purity), a claim to the method of manufacturing the new product may be the only way of protecting it.

6.4 Results: Non-Core Technology

Torotrak core technology was explained at the beginning of this chapter as relating to CVTs of the toroidal-race rolling-traction type. The claims of filings in the Torotrak portfolio extend beyond this definition in a number of ways.

6.4.1 Generalisation of Core Technology

As explained above, the 'generalisation' process that underlies patent drafting means that whilst the description of a filing may describe core technology, the claims may not be so restricted (at least not until prior art is identified that forces such a restriction). This is reflected in a diagram entry that is at a higher level than the Core 'CVT of the toroidal-race rolling-traction type' Technology.

For example, in WO94/24462 the sole independent claim specifies 'a continuously-variable-ratio transmission (CVT) comprising a ratio-varying unit ("variator"), and an epicyclic unit ...'. Such a definition of the term 'CVT' is not consistent with the 'variator only' interpretation suggested by the other Torotrak filings reviewed above. Nevertheless, in view of the fact that the epicyclic unit merely serves to extend the effective ratio of the variator, the arrangement has been grouped on the diagram together with the Core Technology. However, the absence of the Core Technology features of 'a CVT of the toroidal-race rolling-traction type' means that the entry is arguably at a higher level of generalisation than the Core Technology itself - see figure K.2.

In another example, the sole independent claim of WO92/10697 begins 'A continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type ... and including a variator - that is to say a ratio-varying component - and an associated gearing set'. Again, such a definition of the term 'CVT' runs counter to the 'variator only' interpretation used thus far. Nevertheless, this filing has also been treated as a development of the Core Technology given indications in the description that the gearing set merely serves to extend the effective ratio range of the CVT. However, because the claim includes the Core Technology features, it is incorporated in the diagram at a lower level than the example above - see figure G.1.

WO91/08406 is a third example having a single independent claim specifying a CVT of the toroidal-race rolling-traction type capable of operating in two regimes. It also indicates that the two regimes are obtained by means of a speed reducing gear unit and a mixing epicyclic gear unit. Since the latter two features are already present in the prior art cited in WO94/24462 (the first example above), WO'406 could have been incorporated in figure K1 alongside example 1 above were it not for the fact that the first example does not specify Core Technology features. Instead, WO'406 has been incorporated below the 'Core Technology + multi-regime gearbox' known solution in figure G.2.

In a fourth example, the Protected Solution of WO92/03671 nests within the 'CVT of the toroidal race, rolling traction type + multi-regime gearbox' concept – see figure G.3.

As explained above, WO94/04849 has the advantage of improved flexibility of installation over GB-B-2025545 which in turn has the advantage over simple CVTs of improved starting characteristics thanks to the use of a starting device in the form of a torque converter or the like. Since both these advantages relate to the CVT rather than any application thereof, the filing is also incorporated into the diagram as a CVT, albeit at a higher level than Core Technology in view of the fact that the Core Technology is not specified in the sole independent claim of the filing – see figure L.1.

WO97/40296 has three independent claims, all relating to the advantage of 'improved smoothness of operation' and all specifying multi-regime CVTs. However, only two relate to CVTs of the toroidal race, rolling traction type, the other simply relating CVTs with multi-regime gearbox. Accordingly, in addition to the entry in figure K.3

mentioned above, two entries are made in diagram G.3 which represent two different aspects of the same invention that have been identified by the drafting patent attorney. They are not intended to be exclusive – hence the dashed line separating the two solutions.

6.4.2 Competitor Technologies

The Torotrak portfolio contains two filings that relate to competitor technologies, namely WO95/17621 to 'a CVT of the band-and-sheave type' and WO96/28668 to 'a variator ... of the half-toroidal traction roller type'.

Interestingly, both filings have similar objectives. WO'621 indicates that

> *the present invention arises from appreciating how a CVT of the band-and-sheave type may be improved by becoming torque-controllable to the degree that it is required by a modern automotive vehicle, and that is more comparable with the controllability of the toroidal-race CVT's already mentioned*

WO'668 gives as its objective

> *a tilt-controlled CVT of potentially better response and stability in which each equilibrium ratio angle of each roller correlates with a unique orientation of that roller about its tilt axis*

where the description also makes clear that in common with a prior art device disclosed in US3008337, the claimed device has a geometry which

> *makes possible a CVT of the so-called 'torque-controlled' type in which the rollers tend to adopt a ratio angle at which the sum of the torques transmitted by the input and output discs matches the control force applied to the means to pivot each roller about its tilt axis*

Various ways of incorporating these filings into the scope/advantage diagram were considered, the most immediately obvious of which was to nest them within the broader concept of a 'CVT having torque control'. Such an approach is used in patent applications (cf. reference in Patent Fundamentals chapter to 'a detailed account of at least one way of carrying out the invention claimed'). Such a broader concept would also have coved a Torotrak-style 'CVT of the toroidal-race rolling-traction type of the force-balance type' as discussed above and depicted on sheet A.5.

However, with such an arrangement, the advantage of each filing over the broad concept would have depended on the kind of technology on which each filing was based. Thus a 'band and sheave' embodiment of the broad torque control concept would probably have a different advantage relative to the prior art than a 'half-toroidal' or 'full toroidal (Torotrak)' embodiment of the same concept. This runs counter to the apparent strategy underlying these filings, namely to prevent third parties from gaining the advantages of controllability, i.e. response and stability, inherent in the Torotrak technology.

Instead, the two filings were entered on separate sheets I.1 and J.1 relating 'band and sheave' and 'half toroidal' technology respectively, the advantages of the core technology in each case being entered as 'improved response' and 'improved stability' – advantages that have already been mentioned elsewhere in the diagram.

6.4.3 Applications of Core Technology

In the examples given so far, arrangements of CVT and gearbox have been incorporated as developments of the Core Technology on the basis that that the additional features contribute to the functionality of the Core Technology. Another criterion that yields the same result is the manner in which the subject-matter of the claim is likely to be sold: Torotrak literature (discussed in more detail below) suggests that the variator and gearbox of the above examples are likely to be sold together as a single unit. However, the Torotrak portfolio does contain filings where the fact that these two criteria do not apply suggests that they are better classified as application filings:

WO90/07660

The Protected Solution of this filing specifies a driveline for a wheeled vehicle comprising an engine driving a CVT which in turn drives two shafts adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts. The advantages are summarised in Annex 7 as 'reduced size [of engine and transmission]' and 'half shafts of equal length'.

Neither of these advantages relate to the functionality of the Core CVT Technology. Nor does the Torotrak literature - particularly the Listing Prospectus – contain any suggestion of an engine and CVT being sold as a separate unit. Accordingly, this filing has been classified as an Application of Core Technology, with the corresponding diagram entry being made in figure M.1.

WO93/21031

Independent claim 8 of this application initially specifies 'a driveline' but goes on to recite several features of the Core Technology, viz. 'variator is of the toroidal-race rolling-traction type', 'the control system regulates the variator reaction torque by controlling the operating force applied to the variator rollers' and 'in which the roller operating force is exerted hydraulically, the hydraulic control pressure being regulated by the control system'.

However, since the stated advantage relates to improved smoothness of operation resulting from interaction of various components of the driveline overall, it follows that the solution is at the driveline level. Figure M.2 shows how a corresponding entry has been added to figure M.1 under the broad concept of a 'driveline with CVT'. Note that since WO'031 does not discuss the distinction between drivelines with CVTs, drivelines with CVTs of the toroidal-race rolling-traction type and drivelines with CVTs of the force-balance variety, corresponding distinctions and intermediate generalisations have not been made.

WO95/09996

This filing has an independent claim 1 to 'a method of controlling a vehicular driveline'. As discussed in subsection 6.3.3 above with regard to WO97/40296, the 'method' format of the claim has no impact on the protected scope or advantage.

Moreover, since both the claim and the associated advantage (conventional variation of acceleration with engine note) relate to a driveline rather than the functionality of the core technology, it was considered appropriate to classify this filing as an application and make a corresponding entry at the end of figure M.3.

EP0306272

This filing relates to the application of a CVT (not necessarily of the toroidal-race rolling-traction type) to a vehicle having first and second laterally-displaced rotary driving members and steered by differential rotation of such members, e.g. a tracked vehicle such as a bulldozer. There can be no question as regards the 'application' nature of this filing: two CVTs are required in combination with two epicyclic gearboxes plus further features. As the only filing to this kind of application, it is the subject of its own diagram section – N.1.

6.4.4 Applications of Core Technology excluded from the Diagram

It should be noted that not all application claims are incorporated into the diagram: as mentioned in the Patent Fundamentals chapter, it is standard drafting practice to include not only a claim to the apparatus but also a claim to a known device incorporating that apparatus, e.g. a claim to an engine and also a claim to a car incorporating the engine of the first claim.

Given the routine nature of such 'known device incorporating apparatus' claims, their incorporation into the diagram has been considered to be unnecessary duplication. This is particularly the case given that this practice, although 'standard', is still not observed by all - witness WO99/54646 which has claims to a roller control unit for a CVT but no claim to the supersystem of a CVT including such a roller control unit.

One explanation may be that such claims may get overlooked where an applicant is not actually developing and/or manufacturing at the supersystem level.

An exception to the above is where the filing specifies a new application for the Core Technology. In such circumstances, the inventive step may lie simply in the identification of the new application. The nearest that the Torotrak portfolio comes to such a filing is WO97/18982 which relates to a position servo system incorporating a CVT of the variable-ratio epicyclic type. However, although different from the conventional driveline applications of a CVT, such a servo system application is not entirely new: as shown in figure H.1, the application per se is already known from a Japanese patent document. Accordingly, the Torotrak filing must be restricted to a particular implementation of that known concept.

6.4.5 Subordinate Integers (Components) of Core Technology

Just as there was doubt as to whether certain known applications of core technology should be included in the diagram, so there was doubt as to whether certain subordinate integers of core technology should be separately acknowledged. As may be remembered from the Patent Fundamentals chapters, the term ‘subordinate integer’ was used by Micklethwaite (1946) to describe a component of a device itself the subject of a claim. A case in point is WO99/58883 which has independent claims both to a CVT and to ‘an hydraulic control circuit for a CVT’.

With regard to the criteria proposed above for inclusion of applications in the diagram, there can be little doubt that a CVT component will affect the functionality of the CVT as a whole. However, it can be questioned whether the component is likely to be sold separately or only as part of a CVT. In the latter case, there would seem to be little value in a separate entry in the diagram.

For example, WO97/01718 claims ' a roller control system for a continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type' and then goes on to define the features of the system with reference to 'the position of the roller centre' and 'the torus centre circle'. In this case, it is clear that the claim affects the functionality of the CVT rather than just the roller control system component. A corresponding amendment to read a 'CVT of the toroidal-race rolling traction type' is therefore made in figure A.7.

Claim 1 of WO90/05860 also begins 'a roller control system for a CVT of the toroidal-race rolling traction type' but goes on to define the system as being 'located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism', i.e. with reference to other components of a Torotrak-style CVT. It follows that this claim also relates to the CVT system rather than any control sub-system. A corresponding modification to the diagram entry for W0'860, as well as to the entries for WO92/11475 and WO94/01697 which nest within WO'860, is therefore also shown in figure A.7.

WO90/02277 claims 'a hydraulic circuit for a CVT including a first ratio-varying component of variable orientation and at least one second engageable component having variable capacity to transmit torque when engaged'. However, the claim text that follows specifies control means that reduce the torque-transmitting capacity of the second engageable component, suggesting that the protection is at a higher level. The description confirms that the advantage relates to the lifetime of the variator, i.e. the core technology. Since WO'277 also specifies a 'hydraulic end stop effect', it has been depicted as nesting within GB2023753 on sheet C.4.

WO99/58883 also has an independent claim 1 to 'an hydraulic control circuit for a CVT transmission' as well as a further independent claim 26 to 'a continuously-variable transmission having an hydraulic control circuit as claimed in any one of claims 1 to 25'. Since the hydraulic control circuit is unlikely to be sold independently and expresses its functionality via the improved response of the CVT, the diagram entry has been made on sheet G.4 nesting within WO97/40296.

Even where the 'for use' language is used correctly by indicating an intended purpose (e.g. 'for use in a system') but then making no further reference to that purpose, it makes little sense to categorize the claimed invention as a subordinate integer if the corresponding advantage relates to the core technology.

Such is the case with WO99/54646 which claims 'a roller control unit for a CVT of the toroidal-race traction type' having the advantage of reduced length. The description of WO'646 makes clear that 'one of the problems encountered in practice by CVTs ... is that the length of the stroke that the piston must execute in order fully to control the roller is relatively long. Consequently, the housing for the piston/cylinder is of such a length that [the CVT] can be difficult to install within the tight confines of, for example, an engine compartment'. Therefore, in this case, the filing has been entered into sheet F.1 of the diagram as core CVT technology under the advantage of 'reduced size'.

A similar modification has been made (in figure C.5) to the entry for EP0354013, claim 1 of which reads 'In or for a transmission of the toroidal-race, rolling-traction type:- a hydraulic ram comprising a cylinder etc.'.

However, there is a distinction to be made when a claim relates to a different, independent product to that of the Core Technology. In particular, when the advantages associated with a subordinate integer apply at the level of that integer as well as at the system level, such advantages being realised when that subordinate integer has applications outside those outlined in the patent filing.

The sole example of this in the Torotrak portfolio is WO97/40292 which as an independent claim 16 to a valve. The description of this filing indicates that 'the lowest-pressure-wins valve of figure 2 and figure 9 may find use in a number of applications other than those described above and this valve is therefore now described in more detail.' That the valve design in question had applications outside of CVTs was reinforced by the filing in November 1999 of a 'divisional' European patent application based on WO'292 and directed exclusively to the valve. Accordingly, this filing is placed on a separate sheet (O.1) of the diagram.

6.5 Results: Overall Diagram

To allow relationships across the portfolio to be viewed, the various diagram pages must be linked together as shown in figure 6.6 below. Note that for completeness' sake, every filing in the Torotrak portfolio was made the subject of an example in the discussion in this chapter. However, it will be understood that this is not entirely necessary: since many filings fall within the same category, they are amenable to the same treatment so that mere table and diagram entries would have sufficed.

Core Technology

• CVT (well known) 1

[] 1 / (advantage not determined)

• CVT of the toroidal-race rolling-traction type (well known) 2

[] 2 / (advantage not determined - see section 6.2.4)
• CVT of the toroidal-race rolling-traction type + of the force balance type
Sheet A.7

[] 2 / improved efficiency
• CVT of the toroidal-race rolling-traction type + end loading means
Sheet B.2

[] 2 / improved reliability
• CVT of the toroidal-race rolling-traction type + end stop effect
Sheet C.5

[] 2 / basic implementation
• CVT of the toroidal-race rolling-traction type + etc.
Sheet D.2

[] 2 / improved lifetime
• CVT of the toroidal-race rolling-traction type + etc.
Sheet E.1

[] 2 / reduced size
• CVT of the toroidal-race rolling-traction type + etc.
Sheet F.1

[] 2 / extended ratio range
• CVT of the toroidal-race rolling-traction type + multi-regime gearbox
Sheet G.5

[] 1 / (advantage not determined)

• CVT of the band and sheave type (well known) 3

[] 3 / improved response, improved stability
• CVT of the band and sheave type + torque sensitive connection
Sheet I.1

[] 1 / (advantage not determined)

• CVT of the half-toroidal traction roller type (well known) 4

[] 4 / improved response, improved stability
• CVT of the half-toroidal traction roller type + etc.
Sheet J.1

Figure 6.6: Overview of Scope/Advantage Diagram for Torotrak Patent Portfolio
(continued on next page)

Core Technology (cont.)

• CVT
(well known) 1

[] 1 / extended ratio range
• CVT + multi-regime gearbox
Sheet K.3

[] 1 / improved starting characteristics
• CVT + starting device capable of slip, fixed ratio component, 1st one-way clutch
Sheet L.1

Application of CVT

• driveline + CVT
Sheet M.3

• first and second CVTs with first and second epicyclic gear sets
Sheet N.1

Application of CVT of the variable-ratio epicyclic type

• position servo system incorporating CVT of the variable-ratio epicyclic type
Sheet H.1

Subordinate Integer of CVT

• valve
Sheet O.1

Figure 6.6: Overview of Scope/Advantage Diagram for Torotrak Patent Portfolio (continued from previous page)

6.6 Results: Portfolio Characteristics

It will be evident that the above results have a number of novel aspects, namely:

- development of new methodology for analysing and establishing relationships between patent documents in a portfolio;
- identification in practice of relationships previously only proposed in abstract terms;
- establishment of the properties, i.e. the detailed form, of the patent portfolio of an apparently successful STC.

The first aspect requires little discussion besides that in the Conclusions section at the end of this chapter. The second aspect is the basis of the next chapter. What follows, therefore, is a discussion of the third aspect, namely the specific properties of the Torotrak portfolio.

6.6.1 Patent Relationships

In the discussion that follows, the same headings are used as in the Literature Critique chapter, albeit in a slightly different order:

'Superseding' Patent Relationship

i.e. filings having advantages over earlier filings that make those earlier filings obsolete.

The diagram contains four entries meeting this criterion, i.e. just under one eighth of the 33 filings in the portfolio:

Sheet A7:

- filing WO92/11475 has the advantages of improved smoothness of operation and reduced cost over filing WO90/05860;
- filing WO94/01697 has the advantage of reduced cost over filing WO90/05860;
- filing WO97/01718 has the advantage of reduced size over filing WO90/05860;

Sheet G.5:

- filing WO99/58883 has the advantage of improved response over filing WO97/40296;

It is notable that three out of the four superseding filings relate to WO90/05860 which is the earliest and broadest filing in the portfolio to a Torotrak-style CVT of the force balance type.

'Nesting' Patent Relationships

One key realisation that results from arranging the portfolio in the scope/advantage format is that the Nesting and Superseding relationships are fundamentally the same. The difference is simply a matter of emphasis: Nesting emphasises the scope aspect of the relationship whereas Superseding emphasises the advantage aspect. Thus it is that the four filings mentioned in the previous section also represent the extent of nesting in the portfolio, namely just under one eighth of the portfolio.

'New' Patent Relationship

I.e. filings which do not fall within the scope of earlier filings in the portfolio.

Taken in its very broadest sense, the above definition could include every filing that does not fall (nest) within the scope of an earlier filing, i.e. the remaining 29 filings in the portfolio. However, this would include the application and subordinate integer filings of sheets M.3, N.1, H.1 and O.1 which by definition do not nest within the core technology.

Furthermore, the remainder of the filings, although not nesting within other Torotrak filings, nevertheless nest within broader prior art concepts that themselves relate to the core toroidal-race rolling traction concept. Indeed, that fact that such filings do not themselves claim broader concepts is due to this prior art. Accordingly, it is questionable whether these should be classed as examples of the 'new' relationship either.

'Similar Function' Patent Relationship

I.e. filings to different technical solutions for achieving a similar functional result.

The diagram contains ten instances of this relationship involving seventeen filings, i.e. just over half of the 33 filings in the portfolio:

Sheet A7:

- WO94/01697 and WO92/11475 both offer solutions having the advantages of reduced cost over WO90/05860;

Sheet B.2:

- WO99/34133 and WO97/40292 both offer solutions having the advantages of improved efficiency and improved lifetime over the prior art device disclosed in GB1078791;

Sheet C.5:

- WO92/01175 and WO92/08912 both offer solutions having the advantages of improved reliability over the well-known Torotrak-style CVT;

Sheet D.2:

- WO92/01175, WO91/14116 and WO91/06791 each offer a solution having the advantage of reduced cost over the well-known Torotrak-style CVT;

Sheet E.1:

- WO97/37156 and WO91/11637 both offer solutions having the advantage of improved lifetime over the well-known Torotrak-style CVT
- WO99/56036 and WO97/37156 both offer solutions having the advantage of improved lifetime over the prior art device disclosed in GB2282196;

Sheet F.1:

- WO91/08405, WO91/14116 and WO99/54646 each offer a solution having the advantage of reduced size over the well-known Torotrak-style CVT;

Sheet G.5:

- WO97/40296 has claims to two different ways of achieving the advantage of improved smoothness of operation over the prior art arrangement disclosed in GB1078791;

Sheet K.3:

- WO94/24462 and WO94/16244 both offer solutions having the advantages of reduced cost and reduced size over the prior art arrangement of CVT, multi-regime gearbox and geared neutral arrangement;

Sheet N.1:

- EP0306272 has claims to two different ways of achieving the advantages of reduced cost, reduced size, improved efficiency, identical steer performance and synchronous change over the prior art arrangement disclosed in US4718299;

Note, however, that in only three of the ten instances (sheets A.7, E.1 and K.3) are the multiple solutions mutually exclusive, i.e. not separated by a dashed line in the diagram.

'Application' Patent Relationship

I.e. filings to products in which a patented technology may be used.

It is interesting to note that whilst the portfolio does contain application filings (on sheets H.1, M.3 and N.1), none of these is restricted to the core Torotrak-style technology. The arrangements of M.3 and N.1 are generally applicable to CVTs whilst the arrangement of H.1 specifies CVTs of the variable-ratio epicyclic type.

'Subordinate Integer' Patent Relationship

I.e. a component of a device (that itself may be the subject of a claim).

A further key result from this second portfolio analysis has been the confirmation of the 'subordinate integer' patent relationship, albeit only in the single instance on sheet 0.1.

'Manufacturing' Patent Relationship

i.e. filings to key manufacturing methods for patented technology

Another key result of this analysis has been the identification of this relationship, in principle if not in practice, in subsection 6.3.4 above.

6.6.2 Other Characteristics of the Torotrak Scope/Advantage Diagram

In addition to the patent relationships above, certain other characteristics of the portfolio have become evident.

Types of Advantage

The breakdown of entries by advantage heading is detailed in table 6.1 below. That the total number of entries (54) is significantly greater than the total number of Torotrak filings (33) is attributable to the fact that some entries have more than one advantage associated with them. That the total number of advantages (13) is just over a third of the total number of Torotrak filings is attributable to the fact that many filings provide the same advantage, although sometimes relative to different prior art. Finally it is notable that almost a quarter of entries fall under the heading of reduced cost.

	Advantage Heading	Entries	% of Total Entries
1	Reduced cost	13	23%
2	Reduced size	10	18%
3	improved lifetime	7	13%
4	improved efficiency	7	13%
5	improved smoothness	5	9%
6	improved response	3	6%
7	improved reliability	2	4%
8	improved stability	2	4%
9	especially convenient for extra regimes	1	2%
10	half shafts of equal and efficient length	1	2%
11	conventional engine note variation	1	2%
12	identical steer performance in both regimes	1	2%
13	Synchronous change between regimes	1	2%
	total	54	100%

Table 6.1: Advantage Headings Scope/Advantage Diagram for Torotrak Patent Portfolio

<u>Distribution of Filings between Levels</u>

In subsection 6.2.5 of the Results section above, it was suggested that the level of a filing relative to a top-level concept such as 'a CVT' had the potential to be a useful indicator of the importance of that filing in the portfolio.

Leaving aside the filings relating to applications of CVTs, applications of CVTs of the variable-ratio epicyclic type and subordinate integers of CVT, the distribution of filings within that part of the diagram relating to Core Technology is set out in table 6.2.

Level	Example	No. of Entries
1	CVT	0
2	CVT of the toroidal-race rolling-traction type CVT of the band and sheave type CVT of the half-toroidal traction roller type CVT with multi-regime gearbox CVT with starting device capable of slip, fixed ratio component, 1^{st} one-way clutch	0
3	CVT of the toroidal-race rolling-traction type + of the force balance type CVT of the toroidal-race rolling-traction type + multi-regime gearbox CVT of the band and sheave type + torque sensitive connection	14
4	CVT of the toroidal-race rolling-traction type + of the force balance type + in which the roller assembly is located by only three contacts etc. CVT of band and sheave type + torque sensitive connection + input power tends to causes the axial separation of the sheaves etc.	12
5	CVT of the toroidal-race rolling-traction type + of the force balance type + in which the roller assembly is located by only three contacts etc. + the piston and the roller carriage are connected by a pivotal joint etc. CVT of the toroidal race rolling traction type + multi-regime gearbox + control system for controlling the clutch apply pressure etc. + valves are connected in flow series and by a first fluid directing valve means etc.	6

Table 6.2: Distribution of Levels within Torotrak Filings relating to Core Technology

It will be noted that the total number of entries in table 6.2 exceeds the total number of core technology filings. This is attributable to the fact that several of the filings contain multiple concepts.

In spite of steps having been taken to avoid subjectivity – see subsection 6.2.7 above - concerns remain regarding the use of diagram levels as a metric. A case in point is figure F.1 which lists three solutions, all of which contain a great many features which would generally suggest that they are of limited scope. However, a lack of any intermediate prior art document means that these filings are all ranked at level 3, one level below the broad concept of a CVT of the toroidal-race rolling traction type. In contrast, WO90/05860, mentioned elsewhere as appearing to protect a key aspect of Torotrak's product offering, is placed at a lower level 4 (see sheet A.7) as a result of more intermediate prior art being included in the diagram.

Obviously, it is important that any ranking correctly reflects the importance of a filing in a portfolio. Unfortunately, this is not the case in the example given above for the fundamental reason that intermediate diagram entries depend on their being identified in the patent filings. Where this is not done – as with the three solutions of figure F.1 – a filing can have a ranking that is not consistent with other filings in the portfolio where more prior art has been identified.

Since the author could see no way round this problem, it was decided that further investigation of diagram levels would not be a fruitful line of research.

Filings to other CVT technologies

Another notable characteristic of the Torotrak portfolio is the presence of two filings to 'band and sheave' and 'half-toroidal' technologies. These technologies are explicitly acknowledged as competitors in the Listing Prospectus.

6.7 Results: Company Background Data

As explained in subsection 6.1.4 at the beginning of this chapter, the Torotrak listing prospectus contained a chapter on Risk Factors. This is is a normal feature of modern listing prospectuses. However, the Risk Factor chapter of the Torotrak prospectus was unusual in having a section entitled 'Uncertainties inherent in patent protection'. The author attributed this to Torotrak's relationship with BTG which was itself a listed IP-based company having a substantial patent department. The section acknowledged most of the risks previously identified in section 4.5 of the Literature Critique.

6.7.1 Invalidity Risk

This risk is acknowledged by the statement in the aforementioned section of the prospectus that:

> *the application or patent may be challenged on the grounds that a previously published documents, or other document in the public domain, discloses the invention described in the application or patent*

6.7.2 Expiry Risk

The prospectus acknowledges that:

> *There can be no assurance that the present or future issued patents will protect the Company's technological lead. The Torotrak Group's patents that have been obtained or applied for will expire during the period from 1998 to 2018.*

6.7.3 Market/Technology Risk

Under the heading of 'Technology' the prospectus notes that:

> *there are a number of outstanding technical issues ... Whilst solutions to these issues are being developed, there can be no guarantee that they will be resolved or that further technical issues will not arise in the future*

i.e. uncertainty regarding the technology. Moreover, the 'Driver Acceptability' section notes that:

> *the success of Torotrak is dependent on drivers of vehicles fitted with powertrains that incorporate the Torotrak IVT being satisfied with its performance ...there can be no assurance that drivers will accept the change to Torotrak's IVT technology and thus Torotrak's IVT may not achieve market acceptance*

i.e. uncertainty regarding the market

6.7.4 Bypass Risk

This is acknowledged in the 'Competition' section of the prospectus which notes that:

> *The Torotrak Group is not aware of any company with directly competitive technology which has performance characteristics similar to Torotrak's IVT. However, it is possible that competitors may develop more effective technologies than, or may produce products superior to, those of the Torotrak Group.*

6.7.5 'Offensive Negotiating Position' Objective

The prospectus contained no suggestion of Torotrak pursuing an offensive patent strategy aimed at gaining access to third party technology. However, as already noted in the previous chapter, it is questionable whether such an admission would be made even if the company did have such a strategy.

6.7.6 'Extract Value at Multiple Points along the Route to Market' Objective

The prospectus contains no explicit mention of this objective, although there is reference to contracts and strategic alliances with companies other than major automotive manufacturers, e.g. Shell (oil manufacturer), INA (bearings), Busak and Shamban (seals) and British Steel (metals).

6.7.7 Litigation Risk

For completeness, it is noted that the prospectus also acknowledges the risk of litigation, even though this has been excluded from further consideration in the present study (see subsection 4.5.2). Under the heading 'Licence Agreements and reliance on OEMs' the prospectus states that:

Competitors or potential competitors may have filed patent applications or may have been granted patents which could affect the freedom of licensees to use Torotrak's technology. If patents are granted to other parties that contain claims having a scope that is interpreted to cover any of the Torotrak Group's products, there can be no assurance that the Torotrak Group will be able to obtain licenses to such patents at reasonable cost, if at all, or be able to develop or obtain alternative technology

6.8 Discussion

6.8.1 Patent Relationships

As noted in section 6.6.1 above, the Torotrak portfolio exhibits all the known patent relationships with the exception of 'manufacturing'. This shows that - at least in principle and contrary to the suggestions made in the Literature Critique chapter 4 - all patent relationships are appropriate to the STC.

Moreover, there are two instances of a link between a relationships and an element of the background company information, at least the first of which would seem to provide some guidance to the IP Manager of the STC as to when to apply such patent relationships.

Superseding Relationship

As noted in section 6.6.1, such superseding relationships as occur in the Torotrak portfolio are concentrated around the feature of 'torque control'. The listing prospectus confirms that:

> *One of the key features of Torotrak's IVT is that the transmission is not ratio controlled, it is torque controlled to provide the required power to the wheels.*

whilst the 'Automotive Engineer' article of Annex 4 states that:

> *... the most significant change of all ... is in the control medium. The control parameter is no longer roller position (i.e. ratio) but instead is the reaction torque between input and output.*

This suggests that, risk factors aside, the patent/publish decision should err on the side of patenting where a development relates to a commercially-important advantage.

Superseding Relationship in pursuit of an objective to establish an offensive position

As noted in subsection 6.4.2 above, the 'torque control' principle also underlies the two Torotrak filings to competitor technologies. As mentioned in that subsection, the temptation to nest these two filings within a broad concept of 'a CVT having torque control' has been resisted. Instead, each filing has been entered on a sheet relating to the respective core technology and under a heading corresponding to the advantage over that core technology.

Even without the scope/advantage diagram, it was evident that the two filings in question were the product of some strategic thinking on the part of Torotrak's IP managers, perhaps to 'stop competitor technologies from reaping the benefits of torque control', the latter feature having been highlighted as key in the Listing Prospectus. However, putting these filings in a scope/advantage diagram suggests that the actual strategic value of these filings is not as great as it might at first seem.

Referring to sheet I.1, it can be seen that Torotrak's WO95/17621 provides the advantage over earlier band and sheave technology of 'improved response' and 'improved stability'. Nevertheless, only one way of achieving those two advantages is protected, leaving competitors plenty of opportunity to design around those filings to achieve the same ends. Furthermore, there are other competitive advantages (detailed in table 6.1 above) where the filing has no preventative effect. As such it seems to be a rather half-hearted implementation of a strategy. The same is true of sheet J.1 to half-toroidal technology.

As to the nature of Torotrak's strategy, it seems to share with Glazier's 'picket fence' strategy (see Literature Review subsection 3.6.6) the objective of obstructing the freedom of competitors. Unlike that strategy, however, the resulting filings are not 'application' filings but rather relate to an advantage over the core competitor technology. This suggests that Glazier's reference to 'incremental innovations represent[ing] the preferred products in which the core technology may be used commercially' may also extend to core technology filings where the associated advantage is one that a preferred product would need to exhibit. Thus with regard to the Tortrak examples above, it may be that certain levels of response and stability are required for any CVT technology to be commercially viable.

The fact remains that the single filings to each competitor technology are a far cry from the dedicated strategies discussed in subsection 3.6.6 of the Literature Review and may of course be attributable to lack of resource for any greater filing programme. They are not conclusive evidence that the 'picket fence' strategy is necessarily appropriate for an STC.

Similar Function Relationship

A final indicator of strategic intent in the Torotrak portfolio, albeit not attributable to any element of the background company information, is considered to be the three 'similar function' filings that can only be implemented exclusively of other solutions. Since any final Torotrak product can only employ one of those solutions, the other two solutions must represent an attempt to prevent competitors bypassing the product.

6.8.2 Correlation of Risk Factors/Company Objectives with Patent Relationships

As explained in the previous two chapters, another approach to extracting guidance from real-life portfolios of successful STCs has sought to correlate risk factors with patent relationships.

However, in spite of its comprehensive treatment of risks, the Torotrak prospectus did not provide any more information on the significance of those risks than did the Renishaw documentation.

However, it did put beyond any doubt the unsuitability of using the mention of a risk as an indicator of that risk being significant: it was apparent that all the patent risks had been mentioned in the prospectus on precautionary grounds and not because they were necessarily significant. As such, it mirrored the comment made in the Introduction chapter, section 1.1.3, about patent attorneys who are trained to identify all possible pitfalls but who do not have the data to put the risk of those pitfalls into perspective.

There also remained concern that, in spite of being managed by BTG, the Torotrak portfolio still might not be an example of a 'good' portfolio constructed along logical lines. This was prompted *inter alia* by the half-hearted nature of the 'picket-fence' strategy detailed above and the lack of commercial success of the company (at the time of writing, Torotrak technology has still not entered production).

6.8.3 Correlation with other Characteristics

The lack of conclusiveness described in the previous subsection is also true of other characteristics of the portfolio such as the types of advantage discussed in 6.6.2 above. In particular, it is not possible to determine whether the relatively low number of advantage types (approximately one third of the total number of filings in the portfolio) and the emphasis on reduced cost is a feature of the portfolio or a reflection of the automotive industry, where customer needs are well established and – asis well known - cost is key.

6.9 Conclusions and Proposals for Further Research

6.9.1 Research Objective: Investigate structure and logic of patent portfolios

At the end of the previous chapter, it was concluded that further exploration of the advantage aspect of patent filings might allow further patent relationships to be depicted which in turn might provide further insight into patent portfolio structure.

This chapter has established that it is indeed possible to identify a complete underlying structure to a patent portfolio. The Results section above describes how the structure can be applied in practice while the chapter 7 that follows reviews the underlying theory and reconciles it with the findings of the Literature Critique.

The chapter has been successful in identifying structure in spite of the fact that, as legal documents, patents and patent applications are inherently vague, demanding a complex system of skilled judges backed up by detailed case law to decide questions of infringement. Admittedly, certain compromises and approximations have been required. However, the author has been selective in this regard and not all the approximations considered have been deemed acceptable. Diagram levels, in particular, have been rejected as a measure of patent value.

Furthermore, it is believed that the benefits in being able to visualise an approximate structure of a portfolio more than outweigh any inaccuracy that may arise during interpretation of the individual patent documents. Not only is the scope/advantage diagram structure easy to understand, it is also accurate in its depiction of patent relationships. This is to be contrasted with the portfolio depiction methods presented in section 3.7 of the Literature Review chapter which only ever seem to depict one of the portfolio dimensions of scope, advantage and integration. Worse still, they sometimes give a misleading impression of the scope of the portfolio as discussed in section 4.8 of the Literature Critique chapter.

A clear deficiency in the diagram as currently proposed is the lack of information on competitor filings. As acknowledged in the literature, the ownership of certain key concepts by competitors will have an influence on the way a company's patent portfolio develops. Having said that, Torotrak did not appear to have any competitors in its particular area of interest, namely the toroidal-race rolling traction type CVT. Moreover, it is not believed that inclusion of competitor data would have affected the principles that underlie the diagram.

Indeed, it is felt that the present chapter successfully and completely addresses the first research objective of understanding the structure and logic of patent portfolios. As explained in more detail in the next chapter, it provides the basis of a framework by means of which all the patent strategies discussed thus far can be expressed.

6.9.2 Research Objective: Investigate optimal Patent Portfolio Structure for STCs

The previous chapter concluded from the Renishaw patent portfolio that the 'similar function' patent relationship had a role to play in STCs. It also concluded that investigation of the patent portfolio of a company that was more closely focused on a single technology than Renishaw might yield further insight. The present chapter has taken up the long and complex challenge of such an exercise.

Although the exercise has been very valuable in allowing the framework discussed in the preceding subsection to be derived, it has not proved so successful in determining an optimal portfolio structure for STCs. Whilst it has confirmed that all patent relationships can be used in the patent portfolio of an STC, in this case Torotrak, it has not provided IP Managers with definitive guidance on when to use a particular patent relationship in their own portfolios. This is in part due to the difficulty in isolating factors such as market uncertainty that are believed to determine the need for such relationships.

One way of simplifying the exercise would be to cut down the number of factors by restricting analysis to portfolios from the same industry, turning the investigation into more of a benchmarking exercise. Although interesting from a purely academic point of view, such an investigation would be of limited use to IP managers outside the industry. More particularly, it would be of limited use to the author who, as already mentioned, has worked in a number of different technical fields in the course of his career.

Thus it was decided not to analyse any further portfolios. This was not to be the end of the 'hard data' approach, however, as will be explained in the chapters that follow.

6.9.3 Research Objective: Investigate a Risk Management Approach

A risk management framework linking patent relationships to risk factors and company objectives was proposed in the Literature Critique chapter 4. Chapter 5 then investigated risk factors and patent relationships in a real patent portfolio and concluded that it was difficult to obtain meaningful risk factor data, a conclusion that has been confirmed by the present chapter.

Nevertheless, the risk management approach is still considered to be valuable insofar as it shares responsibility and thus makes for better decision making. These aspects are developed in the chapter that follows.

6.9.4 Research Objective: Investigate Hard Data rather than Opinion

The previous chapter concluded that investigation of the individual filings of a portfolio yielded useful information. The present chapter has confirmed this.

In particular, it has been successful in providing an insight into Torotrak's actual patent strategy as opposed to the patent strategy that the company would like others to believe it has. For example, the 'Intellectual Property' section of the Torotrak Listing Prospectus suggests that 'the patent strategy employed by the Torotrak Group is to ensure that the patent portfolio as a whole is robust' – whatever 'robust' may mean. In contrast, the scope / advantage analysis above provides a picture of what the portfolio actually protects, namely greater or lesser numbers of solutions to various customer needs.

6.10 Summary

Key results of this chapter are as follows:

- a new methodology for analysing patent information that involves consideration of the advantage(s) provided by a patent filing has been tried and shown to work;

- looking at patents from the advantage rather than the established scope perspective is new. A technical analogy might be the difference between looking at response data in the time domain and in the frequency domain;

- a corresponding new model for patent portfolio structure – the scope/advantage diagram – has also been tried and shown to work;

- the new model seems to be consistent with principles that have been distilled from the literature, an aspect that is investigated further in the chapter that follows.

- the new model provides further insight into the principles that have been distilled from the literature, yet another aspect that is investigated in more detail in the chapter that follows.

CHAPTER 7

Theoretical Aspects of the Scope/Advantage Diagram

7.0 Introduction

This chapter seeks to reconcile the practical scope/advantage diagram developed in the last chapter with the theoretical concepts developed in the Literature Critique chapter.

The chapter starts with a new and fundamental recognition – that a patent portfolio has three dimensions. This is then applied to all the patent relationships identified in the Literature Critique chapter. The implications for patent metrics are also considered.

Thereafter, the risk factors of section 4.5 of the Literature Critique chapter are reconsidered and revised in the light both of the three portfolio dimensions and the findings of the Second Portfolio Analysis. This is followed by a discussion of how the various sections of this chapter might actually be used in day-to-day IP management as a complete filing decision-making framework.

7.1 Portfolio Depiction

A key recognition of the present research – presented for this first time in this chapter - is that each sheet of the diagram developed in the previous chapter can be considered as having the dimensions of scope and advantage. Furthermore, the separate sheets for core technology, application and subordinate-integer filings can be considered as representing a third dimension, namely the degree of integration into the sold product (hereafter simply referred to as 'Integration'). Figure 7.1 illustrates this three dimensional framework.

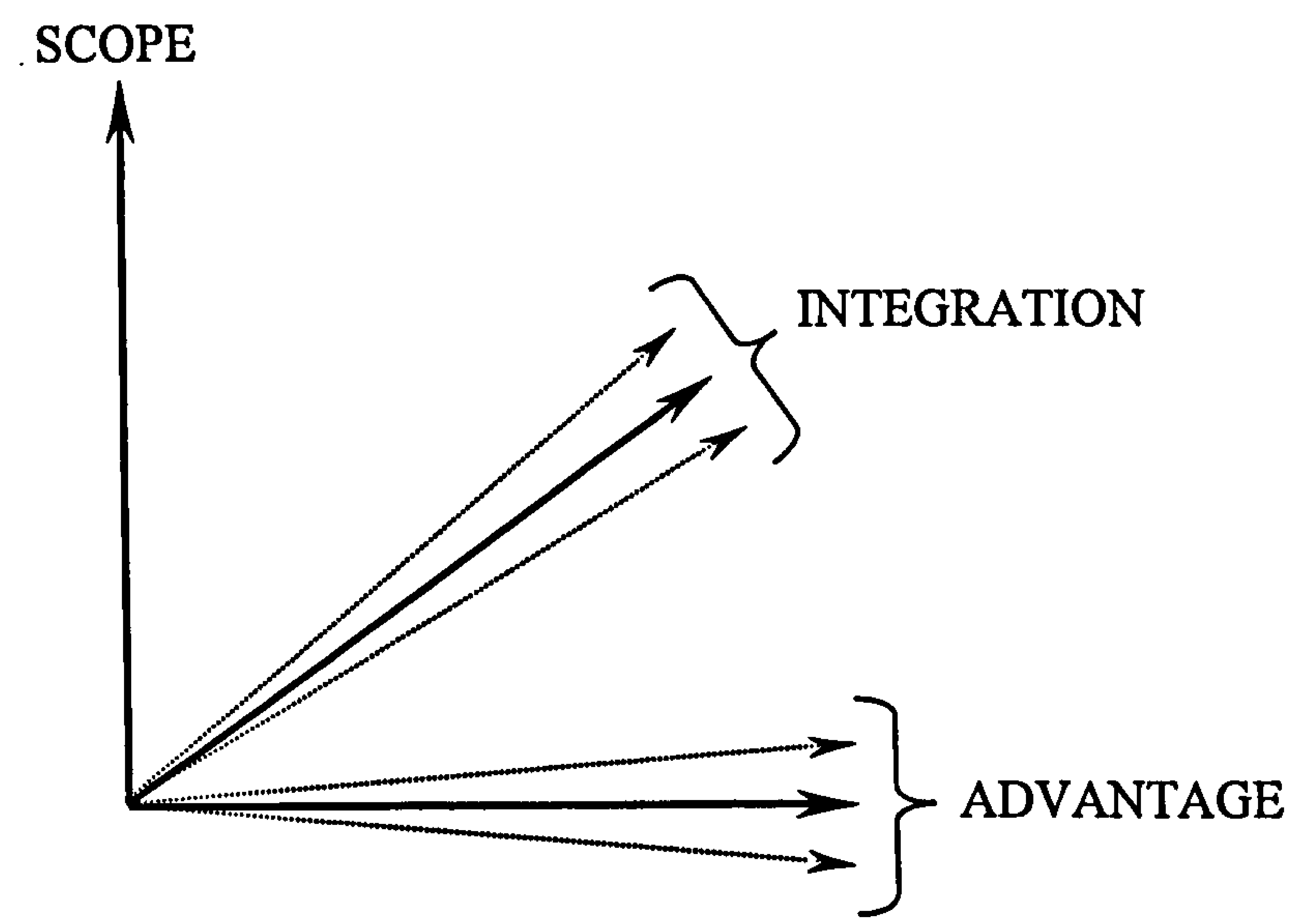

Figure 7.1: The Three Dimensions of a Patent Portfolio

It will be noted that multiple lines have been used in the figure to show the dimensions of Advantage and Integration so as to reflect the fact that there are many advantages and many routes of integration. In a practical diagram, each advantage would be represented by a respective 'branch' of the diagram and each route of integration by a respective diagram page.

Furthermore, the three dimensions of Scope, Advantage and Integration can be considered as defining 'technology space', a concept that has been mentioned by Grandstrand (2000) but only in abstract terms.

7.2 Patent Relationships

Another key recognition of the present research is that all of the patent relationships variously identified in the Literature Review, Literature Critique, First Portfolio Analysis and Second Portfolio Analysis chapters can in fact be expressed in terms of the three dimensions Scope, Advantage and Integration:

7.2.1 'Superseding' Relationship

As previously explained, this relationship involves a filing having advantages over an earlier filing that makes that earlier filing obsolete. It is depicted in figure 7.2, from which it will be noted that it involves no change in the scope dimension (the new solution nests within the scope of the earlier solution and so is in fact of narrower scope) but does involve a change in the advantage dimension, the new solution having a further advantage (B) over the earlier solution that renders the advantage (A) of that earlier solution no longer desirable, i.e. obsolete. The practical diagram implementation of this relationship is shown in figure 7.3.

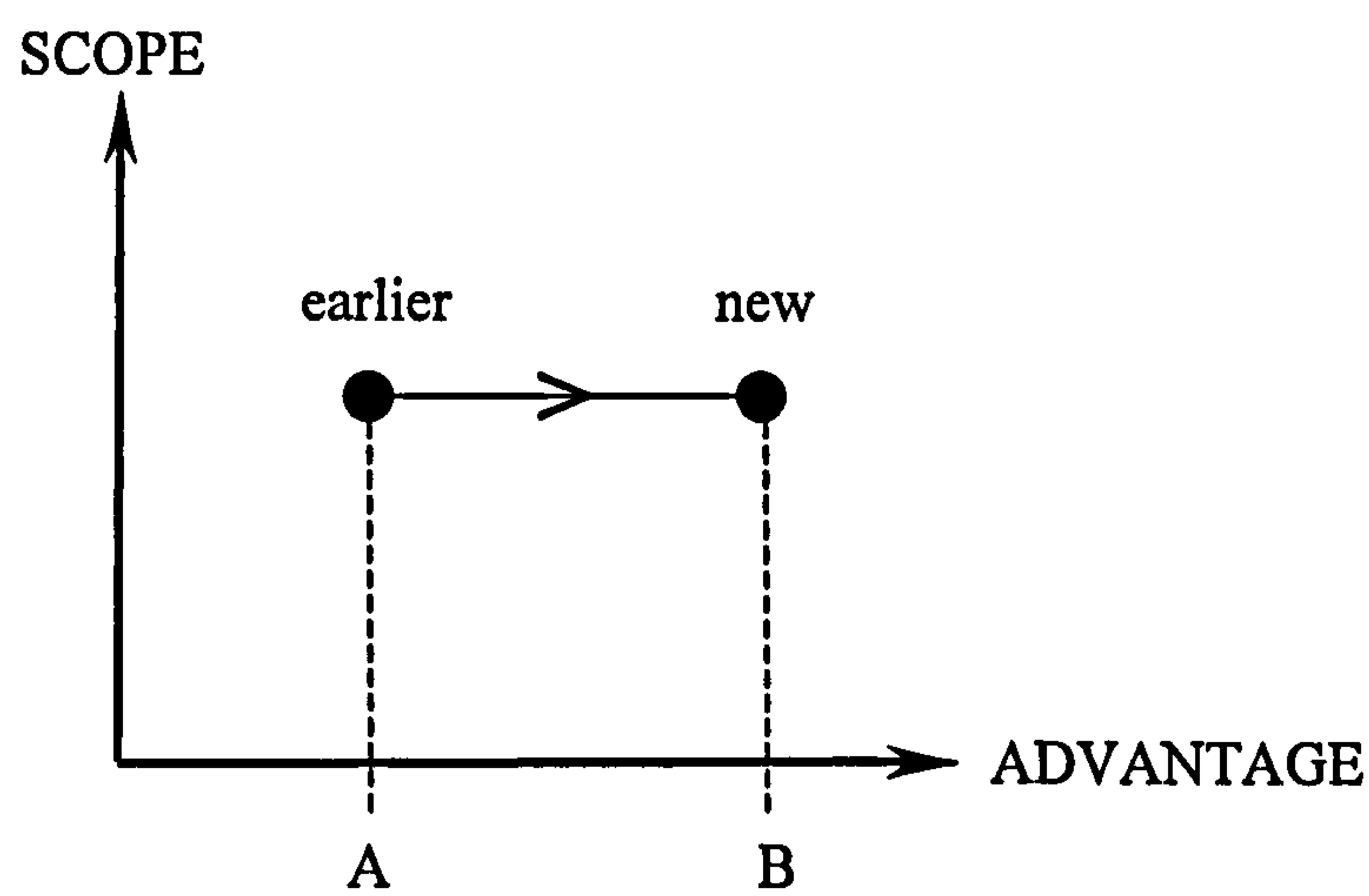

Figure 7.2: 'Superseding' Relationship - Theory

advantage A:

• earlier solution 1

[]1 / advantage B:

• new solution

Figure 7.3: 'Superseding' Relationship – Practical diagram implementation

7.2.2 'Similar Function' Relationship

As previously explained, this relationship involves a filing to a different technical solution for achieving a similar functional result to an existing filing. This is depicted in three dimensions in figure 7.4, with the practical diagram implementation being shown in figure 7.5. It will seen that be the relationship involves no change in the advantage dimension (the new solution has a similar advantage A to that of the earlier solution) but, as a new technical solution, it does involve a change in scope relative to the earlier filing.

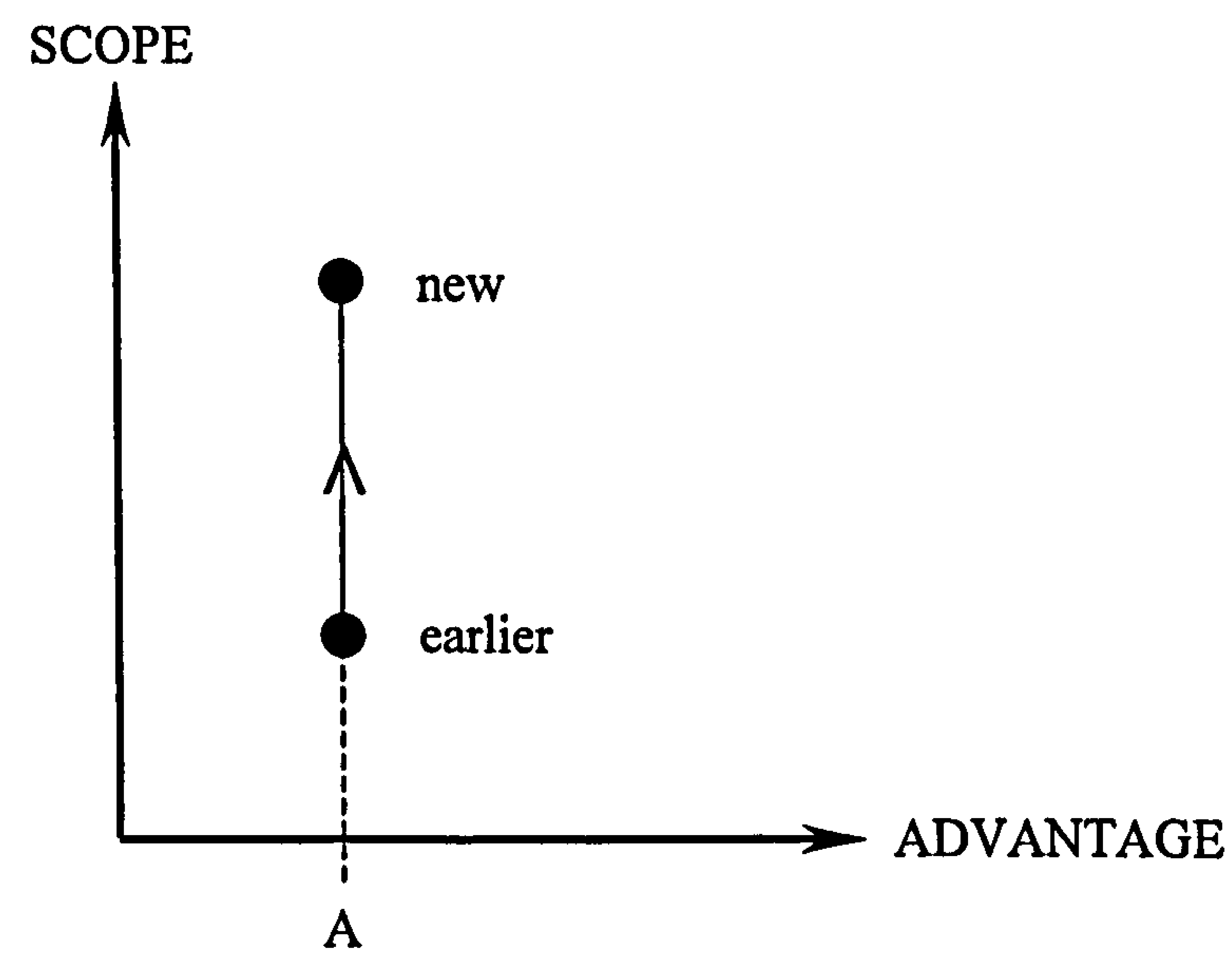

Figure 7.4: 'Similar Function' Relationship - Theory

advantage A:

- new solution
- earlier solution

Figure 7.5: 'Similar Function' Relationship - Practical diagram implementation

7.2.3 'Nesting' Relationship

This relationship is included for the sake of completeness, it having been mentioned in the Literature Critique and First Portfolio Analysis chapters. However, a key realisation in the preceding chapter was that it was actually fundamentally the same as the 'Superseding' relationship already discussed above – see subsection 6.6.1.

7.2.4 'New' Relationship

Previously defined as involving a filing which does not fall within the scope of earlier filings in the portfolio, it will be clear that this relationship must involve a change in the scope dimension. As regards the advantage dimension, it will be clear that if the new filing has the same advantage as the earlier filing, then the resulting diagram will be the same as for the 'Similar Function' relationship above. However, if the advantage is also different relative to the earlier filing, then the further arrangement of figure 7.6 results.

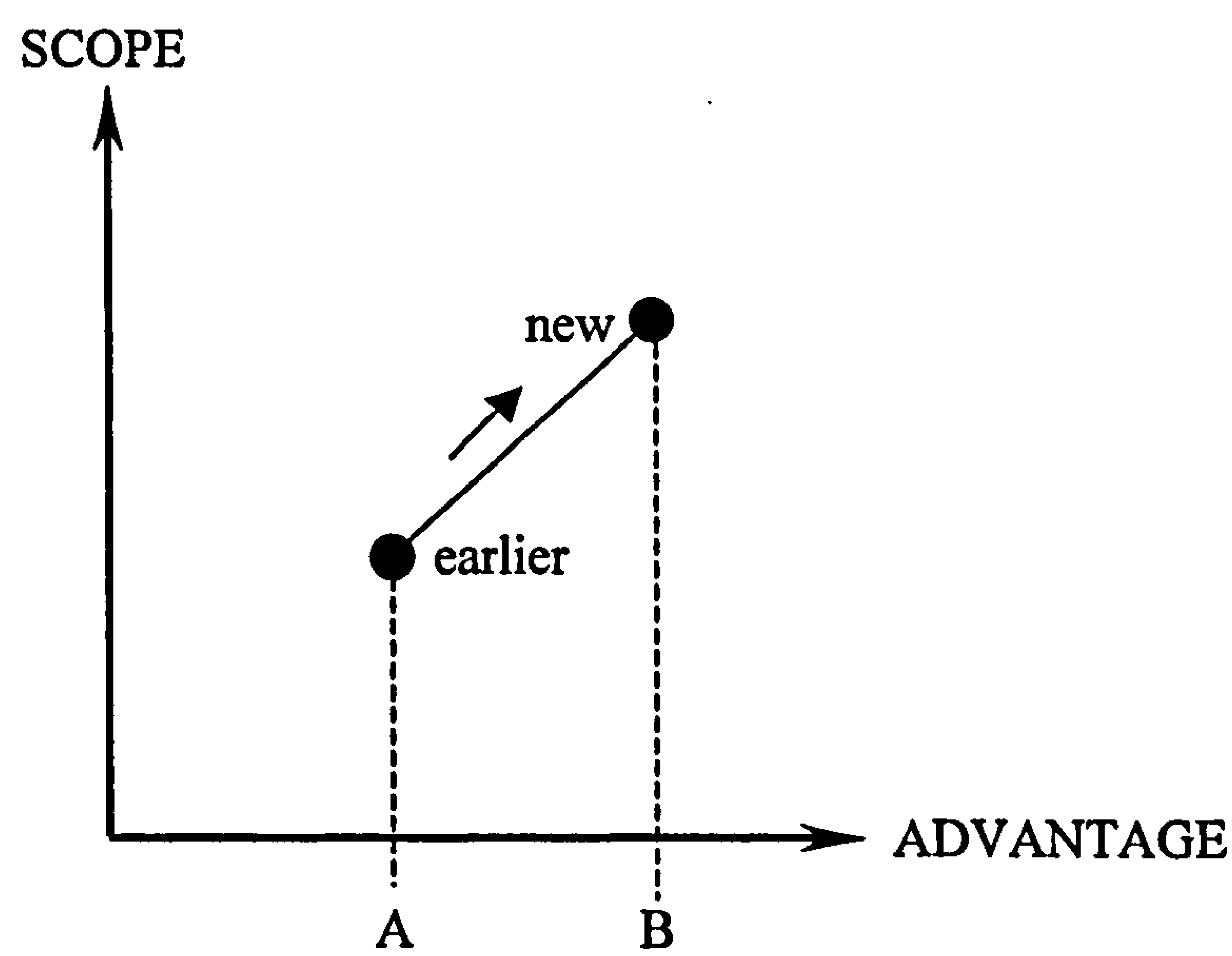

Figure 7.6: 'New' Relationship - Theory

existing advantage A:

• earlier solution

new advantage B:

• new solution

Figure 7.7: 'New' Relationship - Practical diagram implementation

7.2.5 'Application' and 'Subordinate Integer' Relationships

This relationship was described in the Critique as the making of filings to products in which a patented technology may be used. As explained at the beginning of this chapter, such a relationship may be considered as a change in the Integration dimension. The 'Subordinate Integer' relationship also represents a change in the Integration dimension, albeit in the direction of less integration rather than more. The two relationships are depicted in figure 7.8. In practice, the two relationships manifest themselves as entries on different diagram sheets to that of the Core Technology, as illustrated in figure 7.9.

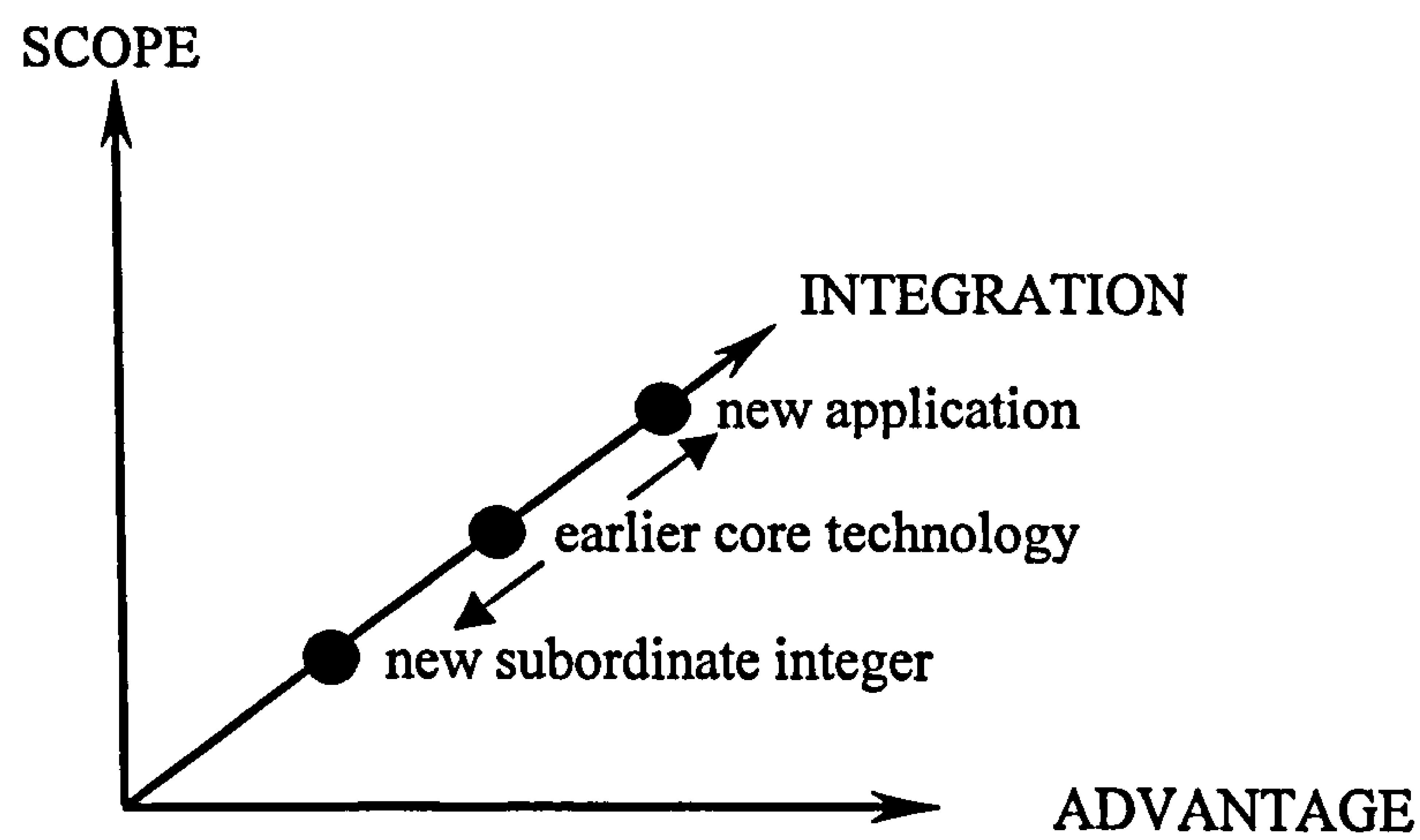

Figure 7.8: 'Application' / 'Subordinate Integer' Relationships - Theory

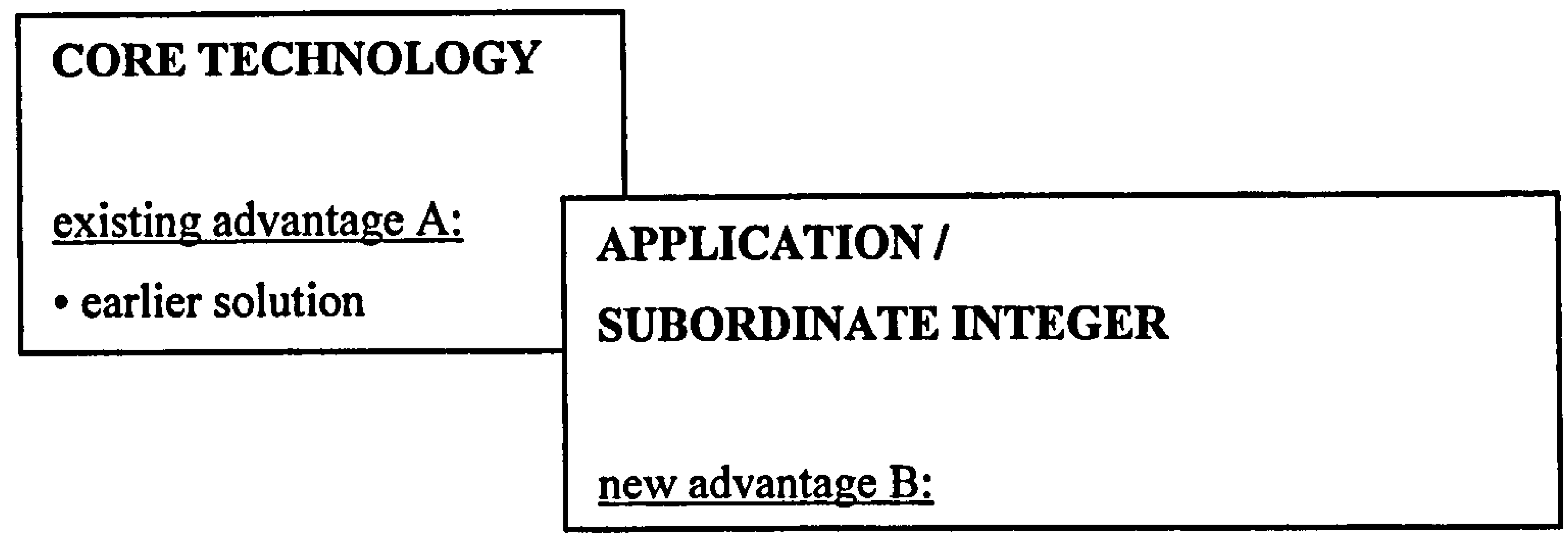

Figure 7.9: 'Application' / 'Subordinate Integer' Relationships - Practical diagram implementation

7.2.6 'Manufacturing' Relationship

A finding of the preceding chapter was that a filing to a manufacturing method could be expressed in the diagram in terms of the product manufactured according to that method. The relationship of that product to the product of earlier filings will then fall within one of the relationships outlined above.

7.2.7 A Fourth Dimension

It will be appreciated that the earlier statement to the effect that it is possible to express all patent relationships in terms of the three portfolio dimensions does of course require that cost be considered an advantage as well. If a distinction is made between cost and performance, as is possible in the scope / advantage diagram developed in the previous chapter, then cost could be considered a fourth dimension.

7.3 Portfolio Metrics

The viability of portfolio metrics was discussed in the previous chapter, the conclusion being drawn that the typically large number of variables would tend to make metrics meaningless except perhaps when used to compare portfolios relating to the same area of technology. Nevertheless, the 'three dimensional' approach does suggest, at least in theory, the following portfolio parameters:

7.3.1 Portfolio Breadth

Referring to the 'Similar Function' relationship above, it follows that where there are a number of solutions providing the same advantage, this could be represented in three dimensions as a number of points in the scope direction along a line of constant advantage. The actual number of points could then be considered as a measure of portfolio 'breadth', as depicted in figure 7.10.

Breadth clearly relates to a single advantage, of which there may be many in a framework for an entire portfolio, as has been seen in the portfolio analysis of the preceding chapter. Accordingly, for a portfolio as a whole, a corresponding metric might be the average number of protected solutions per advantage at each level, i.e. the 'average portfolio breadth'.

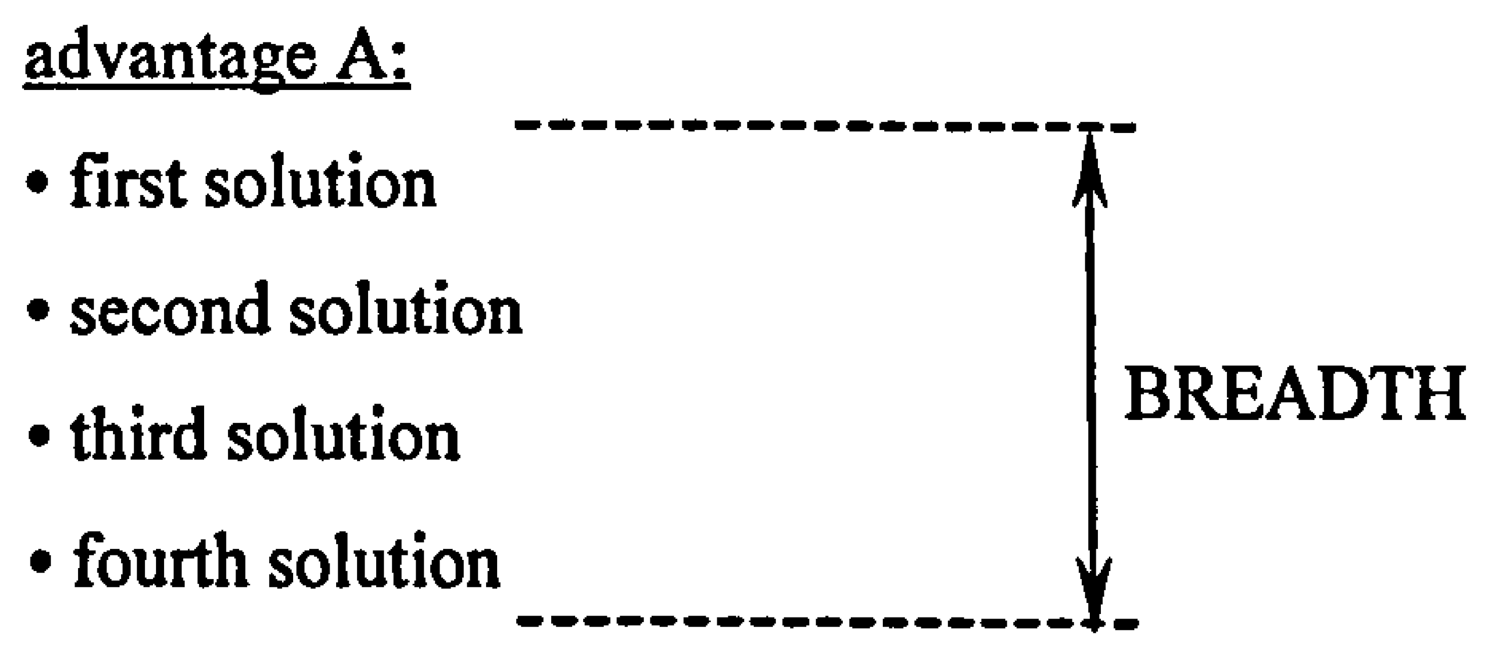

Figure 7.10: Breadth within the Portfolio

7.3.2 Portfolio Depth

As shown in figure 7.11, it is possible to conceive a similar concept of 'depth', namely the number of solutions having the same scope. In three dimensions, this could be represented as a number of points in the advantage direction along a line of constant scope.

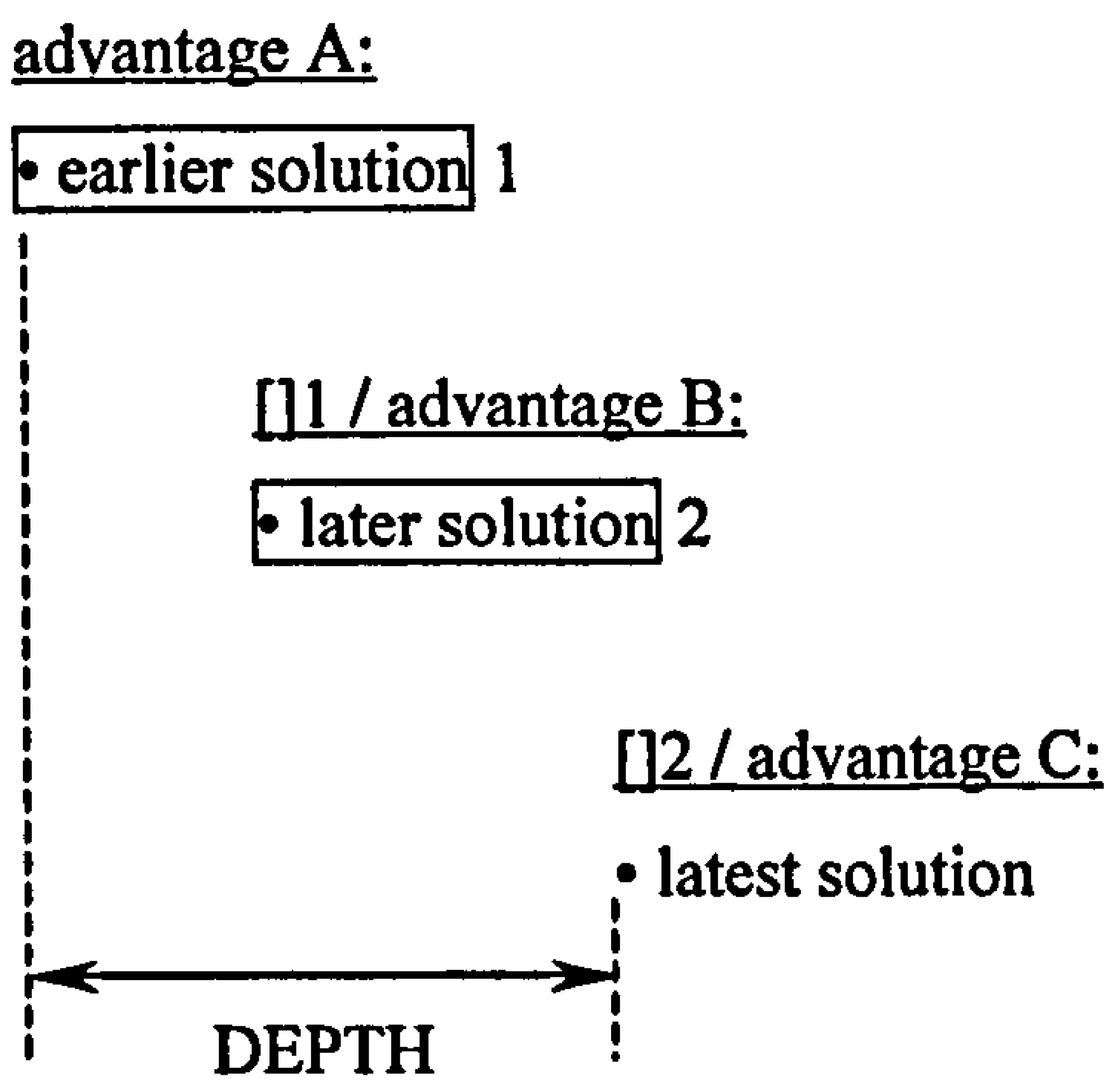

Figure 7.11: Depth within the Portfolio

7.3.3 Applicability

A third metric results from the Integration dimension of the framework, in particular the number of application axes shown in figure 7.1, each of which corresponds to an application route for the Core Technology. Although it is tempting to call this metric 'height' so as to be consistent with the 'breadth' and 'depth' metrics discussed above, a more accurate descriptor is 'applicability'.

7.4 Portfolio Factors

The Literature Critique chapter proposed a methodology for making decisions on new patent filings which comprised three sections relating to the Secrecy vs Patent decision (table 4.1), Factors/Objectives determining Patent Relationships (table 4.2) and Patent Timing Decisions (table 4.3). Although the portfolio analysis of the preceding chapter and the portfolio dimensions of the present chapter have little bearing on the first and last sections, they do shed light on the Factors/Objectives as discussed below.

7.4.1 Factor: Significant Technological Capability of Competition

Table 4.2 suggested that both Technology and Marketing departments are responsible for assessing this factor and that, where significant, it would necessitate 'superseding', 'similar function' and 'new' patent relationships. The underlying risk is that of losing market to a competitor who is able to bypass a company's existing patents.

As explained above with regard to figures 7.2 to 7.5, the 'superseding' and 'similar function' relationships are quite distinct, corresponding as they do to orthogonal directions in the scope/advantage plane. It is therefore surprising that they should both have been proposed with regard to this factor. Indeed, the present author did for a time wonder if a mistake had been made in the literature. Certainly, it was known from the first (Renishaw) portfolio analysis that the 'similar function' patent relationship could be used to foil the bypass efforts of technologically-capable competitors but neither of the analyses suggested the use of the 'superseding' relationship in this regard.

Accordingly, the author referred back to the source literature and in particular section 3.6.1 of the Literature Review chapter where Knight (1996) notes that:

> *In the wall strategy, the first company assumes some of the patents they obtain will eventually be bypassed by competitors, and that the true value for the patent is the time delay caused by the need for extra work by a determined competitor which wants to get around the 'wall' of the patent* (underlining added)

To assume that patents will be bypassed does at first sight seem to be a defeatist approach that ignores (or reflects an ignorance of) the possibility of making 'similar function' filings of the kind identified in the Renishaw portfolio. However, as has been noted in previous chapters, Knight's comments often seem to relate to his experience within the multinational chemical company DuPont. Moreover, it is the author's experience from the field of light emitting polymer technology that chemical technologies typically provide many different ways of achieving the same end. In such circumstances, it may be more economic to try stay ahead of the competition that to try to deny the competition access to all alternatives. This is what it is believed Knight was referring to.

Accordingly, the factor of 'Significant Technological Capability of Competition' has been divided into two: 'Significant Technological Capability of Competition – Many Alternatives' and 'Significant Technological Capability of Competition – Few Alternatives', the former being addressed by the 'Superseding' relationship and the latter by the 'Similar Function' relationship.

However, it should also be noted that an assumption that 'patents will eventually be bypassed' is prima facie incompatible with the business model of the STC as defined in the Introduction chapter, namely to develop a technology protected by fundamental patent rights. Specifically, if the patent(s) on which an STC is founded are bypassed, the fundamental competitive position on which the STC is based would appear to be lost. The corollary of this would seem to be that STCs in technical fields where there are many alternatives have a higher likelihood of failure.

Table 4.2 also suggested that the 'significant technological capability of competition' factor could necessitate the 'new' patent relationship. This was based on another proposal by Knight, namely that where only 'narrow' patents are available in a technology area, it may be possible to obtain a degree of exclusivity in that area by means of a 'maze' of narrow patents.

Whilst the concept of a 'maze' of patents was credible at the time of reviewing the literature – particularly in view of Knight's attractive diagram as reproduced in figure 3.14 – it is harder to understand when considered from the three dimensional perspective developed in the present chapter. Specifically, it is not clear how 'narrow' patents can inter-relate other than according to the patent relationships identified above. Such 'superseding' and 'similar function' patent relationships can certainly make it more difficult for a competitor to bypass a patent portfolio and the more patent relationships, the more difficult bypass may be. However, this would seem to be the long and short of the matter. In particular, there would not appear to be any additional benefit associated with using the 'new' patent relationship. For these reasons, it has been concluded that the 'maze' strategy is not actually a strategy at all but simply an artefact of the 'fence' style diagram discussed in section 4.8 of the Literature Critique chapter 4.

7.4.2 Objective: Significant Need to Establish Offensive Negotiating Position

Table 4.2 suggested that the Marketing department would be primarily responsible for setting this objective, in which case the 'application' relationship would be necessary. The 'application' relationship was defined in the Literature Critique chapter as a filing covering a product in which the technology of an earlier patent application could be used.

A finding from the second portfolio analysis is that, to arrive at a commercially-acceptable product, many improvements in the performance and/or cost of the core technology itself may also be necessary. This in turn suggests that a company objective to establish an offensive negotiating position may also be implemented by identifying necessary performance and/or cost improvements and making filings to corresponding solutions, i.e. along the 'Advantage' axis of the framework. Expressed more generally, the strategy can be implemented in two dimensions rather than just the one dimension previously considered by the literature.

7.4.3 Factor: Lifetime of technology greater than patent lifetime

Table 4.2 suggested that both Technology and Marketing departments were responsible for assessing this factor and that, where significant, it would necessitate the 'superseding' relationship. The underlying risk is that of losing market to competitors on expiry of the company's patents.

Having looked in detail at the concept of advantage as part of the second portfolio analysis, it has become evident that the efficacy of this approach in extending a monopoly beyond expiry of an earlier patent will depend on the extent to which, once the earlier patent has expired, a market will continue to require product that does not have the advantages of (and is not protected by) the later filing.

It is suggested that in fields such as pharmaceuticals, where the customer need to cure a particular medical condition is unlikely to change significantly with time, there is a significant likelihood that a market for product will still exist once the earlier patent has expired. In other fields, customer needs may change so rapidly that the technology covered by a filing may be obsolete before that filing has actually reached grant. As already mentioned above with regard to bypass risk, the latter scenario would appear to be incompatible with the business model of the STC as defined in the present research.

The author also notes that this may be another instance of where a strategy may be implemented in two dimensions: the expiry risk underlying the above factor can also be addressed by 'application' filings in the Integration dimension. Thus, using the 'Boots and Bootlaces' analogy introduced in the Literature Review chapter, a filing made according to this strategy along the Integration dimension could preserve a monopoly e.g. to 'Boots as part of a hill climbing kit' once the original patent for 'boots' had expired.

7.4.4 Factor: Significant Market/Technology Uncertainty

Table 4.2 suggested that both Technology and Marketing departments were responsible for assessing this factor and that, where significant, it would necessitate the 'new' patent relationship.

Whilst the literature does not distinguish between market and technology uncertainty, such a distinction is useful for the present framework because it determines the parties having input to the respective strategy and therefore risk management responsibility. Thus:

Market Uncertainty
is defined as the uncertainty surrounding the existence of the customer need met by the patented solution, the underlying risk being that the patented solution will not sell.

Technology Uncertainty
is defined as the uncertainty as to whether the technology will actually meet that need, the underlying risk being that the technology will not work.

Granstrand (2000) has suggested that Market and Technology Uncertainty are addressed by making additional filings. However, it will be appreciated that in the case of Market Uncertainty, such additional filings need to relate to solutions having new advantages, i.e. the 'New' relationship discussed above.

Of course, new advantages are also provided by the 'Superseding' relationship, but only relative to existing technology having an existing advantage. Since addressing Market Uncertainty requires solutions having advantages other than existing advantages, the 'Superseding' relationship is not appropriate.

In the case of Technology Uncertainty, additional filings need to relate to new solutions for providing existing advantages, i.e. the 'Similar Function' relationship.

The above analysis suggests that Market and Technology Uncertainty can be dealt with by logical patent relationships rather than the arbitrary approach suggested by the terms 'Flooding' and 'Blanketing'. Indeed, it suggests that, like the alleged 'Maze' strategy discussed above, 'Flooding' and 'Blanketing' are not so much strategies (that is, a course of action intended to bring about a desired end) but rather descriptions of non-strategic patenting behaviour, the terms 'flood' and 'blanket' being artefacts of the 'fence' approach to visualising patent portfolios. For this reason, they have not been included in the figure 7.2.

Furthermore, it is noted that both the above strategies address deficiencies in the Core Technology. Accordingly, and unlike some of the other strategies discussed above, filings in the other - Integration – dimension cannot help.

7.4.5 Objective: Significant Opportunity to Extract Value at Multiple Points along the Route to Market

Table 4.2 suggested that the Marketing department would be primarily responsible for setting this objective, in which case the 'application' relationship would be necessary.

It has since been established that the 'subordinate integer' relationship plays a similar role and, together with the 'application' relationship, defines the Integration dimension discussed above. There would not appear to be any scope for applying the strategy in any other dimension.

7.4.6 Factor: Significant Likelihood of Prior Art

Table 4.2 suggested that the IP department would be responsible for assessing this factor and that, where significant, it would necessitate the 'nesting' patent relationship which has since been realised to be equivalent to the superseding relationship. The underlying risk is loss of market to a competitor as a result of loss of legal monopoly caused by patent invalidity.

The present author has recognised that this is another case where the underlying invalidity risk can be addressed not only by filings to further advantages ('superseding') but also filings to new products ('application'). These relationships extend in the Advantage and Integration dimensions respectively.

7.5 A Risk Management Approach to Patent Portfolio Structure

As already mentioned earlier in this chapter, the Literature Critique chapter proposed (in subsection 4.5.5) a preliminary risk management approach to patent filing. The approach comprised three stages: firstly a decision on whether to keep a development secret, secondly a decision on whether a development should be protected or published, and thirdly a decision on whether to speed up or slow down patent filing.

The portfolio analyses of chapters 5 and 6 have not thrown up anything that calls this earlier approach into question, although the conclusions of the preceding section 7.4 do suggest certain revisions to the 'factors and relationships' table 4.2. These are shown in table 7.1 on the next page.

Risk	Apparent Factor	Responsible Department	Portfolio Dimensions (Patent Relationship)					Literature Strategy
			Change of advantage (Superseding)	Change of Scope (Similar Function)	Change of advantage and scope (New)	Increase in Integration (Application)	Decrease in Integration (Subordinate Integer)	
Bypass	Significant technological capability of competition – many alternatives	Technology/ Marketing	X					Wall
	Significant technological capability of competition – few alternatives	Technology/ Marketing		X				Fencing
Expiry	Lifetime of technology greater than patent lifetime	Technology/ Marketing	X			X		Improvement
Market	Significant market uncertainty	Marketing			X			Blanketing / Flooding
Technology	Significant technology uncertainty	Technology		X				
Invalidity	Significant likelihood of relevant prior art	IP	X			X		Multiple Barrier
Objective: Establish offensive negotiating position		Marketing	X			X		Picket Fence
Objective: Extract value at multiple points along route to market		Marketing				X	X	Patent Along Supply Chain

Table 7.1: Revised Table of Factors/Objectives, corresponding Patent Relationships and Company Departments responsible for assessment of Factors/Objectives

Chapter 4 suggested that once a company's departments had made their respective assessments of commercial objectives and external risks, the information' of table 4.2 – and now table 7.1 - should allow a company to structure its patent portfolio using the various patent relationships. The manner in which this was done would of course depend on the manner in which new developments were made, as is now discussed.

7.5.1 Risk Management Approach for New Filings – Pro-active Approach

Once a company has established which factors and objectives are significant to its business, table 7.1 allows a company to identify the corresponding patent relationships to address those factors and objectives and to proactively make new developments that fit those patent relationships.

The extent to which a company is able to 'invent on demand' was discussed in subsection 3.5.2 of the Literature Review, with Jorda (2003) noting that months and years of experimental work may be required in 'empirical' industries such as biotech, chemical and pharmaceutical. It is nevertheless true that by investing large amounts of money in research, pharmaceutical companies in particular hope to arrive at the corresponding developments as soon as possible (and in any event before their competitors).

7.5.2 Risk Management Approach for New Filings – Reactive Approach

Table 7.1 can also be used in a reactive fashion as a filter for new developments that arise in the course of day-to-day activity. Thus a new development can be analysed to establish what patent relationship it has to the existing portfolio. The question can then be asked whether any of the factors or objectives that might justify such a patent relationship according to table 7.1 actually apply to the company, the responsibility for assessing the various factors being indicated in the 'Responsible Department' column of table 7.1. If they do, then a new filing can be made. If they do not, then the default position is publication of that development.

7.5.3 Existing Filings – Managing Invalidity Risk

The approach outlined above can be used not only to decide on new portfolio filings but also to actively manage the patents and patent applications already in the portfolio, adapting it to changing circumstances.

Thus, from the IP perspective, there is the possibility of changing the portfolio structure as confidence in the validity of other filings in the portfolio increases or decreases. This generally occurs whenever a search report is received from a patent office (cf. Patent Fundamentals chapter). Therefore, whenever a 'good' Search Report arrives that does not identify any prior art of relevance to a particular filing, consideration could be given to reducing the 'depth' of the portfolio at levels below that filing. Conversely, when a 'bad' Search Report arrives, consideration could be given to maintaining portfolio depth.

Given a portfolio as shown in figure 7.12 and having filings on a number of levels providing increasing degrees of the same advantage, portfolio depth can be decreased in three ways: firstly, the earliest, highest-level filing can be dropped, at shown at 1. Secondly, a filing at an intermediate level can be abandoned, as shown at 2. Thirdly, the most recent filing at the lowest level can be dropped, as shown at 3.

advantage A:

• earlier solution 1

[]1 / more of the same advantage A:

• later solution based on earlier solution 2

[]2 / yet more of the same advantage A:

• latest solution based on later and earlier solutions 3

Figure 7.12: Possible Abandonment Scenarios

Clearly, it would be unwise to drop filing 1, which provides the broadest obstacle to competitors wishing to provide advantage A. Dropping filing 3 would also seem to be unwise given that this relates to the highest performance solution ('yet more of the same advantage A') and, as the most recent filing, should also provide the longest monopoly. The question is therefore whether the intermediate filing 2 is necessary.

The answer to this question will be influenced by the degree of confidence in the validity of filing 3 which in turn will be determined by the available Search Reports for this filing. The assessment of the likelihood of prior art is a question for the IP function.

7.5.4 Existing Filings – Managing Expiry Risk

As will be evident from figure 7.1, expiry risk and invalidity risk are addressed by the same combination of patent relationships, namely superseding and application. This reflects the fact that patent invalidity and patent expiry both have the same effect, namely loss of patent monopoly.

In the example above, this means that expiry should also be taken into account before deciding to abandon filing 2. Specifically, once filing 1 has expired, will competitors still be interested in operating at the level of performance protected by filing 2 or will performance at this level be obsolete? This is a question for the commercial function. Timing also needs to be considered: will filing 3 have been granted (and thus be enforceable) by the time filing 1 expires? This is a question for the IP function.

Although the issue of patent expiry seems straightforward, it is the author's experience that it is seldom acknowledged in a start-up STC, generally because the date of patent expiry lies well beyond the time horizon of the company. Table 7.1 is valuable not least because it identifies the expiry risk, giving a company the option to address it even if, due to short term financial pressures, the option is not taken up.

7.5.5 Existing Filings – Managing Bypass Risk

For the sake of completeness, it is noted that 'superseding' filings that, at least in part, address invalidity and expiry risks also address the bypass risk where there is significant technological capability of the competition and many technology alternatives. However, as explained in section 7.4.1 above, such filings achieve this by protecting technology that renders earlier bypassed technology obsolete. As such, they are subject to the same considerations as filings addressing invalidity risk.

7.5.6 Existing Filings – Managing Market Uncertainty

Much as invalidity risk decreases with the issue of search reports over time, so market uncertainty decreases as developments move from concept to market, allowing corresponding filings to be abandoned.

It is noted that a company operating a licensing model typically has less control over how its technology is implemented in product. Accordingly, market uncertainty remains higher with the result that more filings addressing this risk may need to be maintained in the portfolio.

7.5.7 Existing Filings – Managing Technology Uncertainty

As a technology is developed over time, the uncertainty as whether it will perform should decrease. This would seem to be true regardless of whether the technology is being manufactured or licensed.

7.5.8 Existing Filings – Managing Bypass Risk

However, as with the management of invalidity risk, the decision on whether to maintain the filings that address technology uncertainty is complicated by the fact that those filings also address bypass risk. Such filings have a 'similar function' relationship that also addresses the risk of bypass resulting from the significant technological capability of competition where there are few alternatives.

It is suggested that the latter risk may be less likely to decrease over time unless, of course, the solutions of such 'similar function' filings turn out to be very much less advantageous from a cost perspective than the preferred solution of the company. It is the role of the technology function to make such an assessment. Note that the scope/advantage/integration diagram allows such relative cost to be depicted in the diagram – see chapter 6, subsection 6.3.1.

7.5.9 Management of Objectives

In addition to risks, table 7.1 also mentions two objectives – the establishment of an offensive negotiating position and the extraction of value at multiple points along the route to market.

However, unlike the risks, these objectives do not need to be assessed: rather they simply result from a conscious decision on the part of the company.

7.5.10 The Effect of Customer Need

The decision on whether to make a development the subject of a new patent filing, or alternatively to maintain an existing patent filing to a development, will depend not only on the factors and objectives outlined above but also the advantage to which the filing in question relates.

Specifically, a new development is more likely to be made the subject of a patent filing where it relates to a key competitive advantage. This realisation stems from the second portfolio analysis, where multiple nesting filings were only made in relation to the concept of 'torque control' which was identified as being of key commercial significance in the background information of both Annex 4 and 6.

Similarly, if it is established that a certain customer need is less important than previously thought, consideration can be given to reducing the 'breadth' of filings that meet that need, reflecting the fact that the organisation's exposure to a design-around relating to that customer need is less. Conversely, an increase in breadth can be made whenever the technology function has doubt as to whether a currently-protected solution will meet a customer need.

The determination of which competitive advantages are important is clearly the role of the marketing function, whilst the generation of developments that meet those customer needs is the responsibility of the technology function. It follows that the 'breadth' of a patent portfolio is the result of the marketing and technology functions and has nothing to do with the IP department.

7.5.11 A Risk-Management Approach rather than a Strategic Approach

In placing responsibility with technical and marketing functions, the above approach represents a radical departure from the normal state of affairs described in the Introduction chapter where the management of a company is quite content to leave responsibility for the patent portfolio with the IP Manager.

With the exception of the two objectives mentioned above, the above approach also does not involve any strategies. This too is a departure from the literature – witness the substantial section of the Literature Review chapter 3 dedicated to patent strategies and the fact that both the Knight (1996) and Glazier (1995) textbooks have the word 'strategy' in their titles.

Rather, the above approach is based on assessments of risk and consequently reaps the benefits noted in the Introduction with reference to Barnes (1993), namely:

> *to change the emphasis from risk-avoidance to opportunity seeking, with acceptance of some risk and uncertainty*

7.5.12 Implications for the IP Manager

By relieving the IP Manager of much of the perceived responsibility, he/she is set free to focus on two particular activities where a real contribution is to be made.

The first is implementing the IP management principles outlined above. This involves prompting the marketing and technology functions to make the necessary assessments of risk factors. It then involves explaining to marketing and technology personnel how their assessments determine the patent relationships that are required. It further involves prompting the marketing function to identify the customer needs on the one hand and the technology function to identify technical solutions on the other. These can then be moulded into patent portfolio that addresses the commercial background (or environment) that company is operating in.

The second activity is the ongoing assessment of the likelihood of invalidity that in part determines the number of superseding and/or application patent relationships required in the portfolio.

Both of these activities require specialist understanding and, in the case of the second activity, specialist data. Accordingly, the IP Manager need no longer find him/herself in the position described in the Introduction chapter of being unable to defend proposals for patent portfolio structure.

7.6 Conclusions and Proposals for Further Research

7.6.1 Research Objective: Investigate structure and logic of patent portfolios

At the end of the previous chapter, it was concluded that the scope/advantage diagram successfully addressed this first objective of understanding the structure and logic of patent portfolios. This has been confirmed by the present chapter, which has reconciled the diagram with the theoretical proposals made in the Literature Critique chapter and identified three dimensions – scope, advantage and integration – in terms of which a patent portfolio can be expressed. Accordingly, this first objective can be considered to have been comprehensively met, providing a valuable contribution to the knowledge of the IP Manager.

7.6.2 Research Objective: Investigate optimal patent portfolio structure for STCs

As already concluded in the previous Torotrak Analysis chapter, the data generated from the Renishaw and Torotrak portfolios will not provide a general basis against which all other portfolios can be benchmarked. However, the research has yielded a decision-making framework to allow the portfolio to be tuned to the commercial, technological and IP circumstances of an organisation, as discussed in more detail under the next heading.

7.6.3 Research Objective: Investigate a Risk Management Approach

The previous chapter concluded with the suggestion that the preliminary risk management framework originally proposed in the Literature Review chapter 4 was valuable. The present chapter has developed that framework further, integrating it with the scope/advantage diagram to provide a complete risk management approach to patent portfolio management.

From the perspective of the IP Manager, the approach is attractive because it makes clear that responsibility for many of the properties of a company patent portfolio lies with technology and marketing departments rather than with the IP function.

However, there remain four risk factors for which the IP function has – at least partial – responsibility. These are, from table 7.1 of the present chapter:

1. significant likelihood of prior art;

and, from table 4.3 of the Literature Critique chapter:

2. significant activity in the technical field;
3. significant relationship of development to as yet unpublished earlier patent application;
4. requirement for well-supported patent application.

Whilst the latter two factors will clearly differ from filing to filing within a portfolio and must therefore be assessed on a case-by-case basis, the first two factors would appear to apply to all filings in a portfolio within a particular technical field.

Moreover, the literature suggests a possible measure for the likelihood of prior art, namely the observation by Knight (1996) that, in a very general sense, the degree of exclusivity a patent can provide is inversely proportional to *the number of prior inventions previously disclosed in the technology area* (emphasis added). This in turn suggests *growth in the number of prior inventions disclosed in a technology area* as a possible measure of the second factor, namely activity in the technical field.

From the description in the Introduction chapter of the typical problems facing the IP Manager, it will be appreciated that the facility to base risk factor assessments on hard data rather than mere assertion would be of real value. It was for this reason that it was decided to investigate the above literature suggestions in more detail and to see if it would be possible to correlate them with actual patent invalidity data. This is the subject of the next chapter.

7.6.4 Research Objective: Investigate Hard Data rather than Opinion

Being of a theoretical nature, the present chapter has made little reference to data – this is more the subject of the chapter that follows. Nevertheless, the fact that the theory is based on a study of real portfolios may give it more credibility – an important issue for the IP manager when seeking to justify major spending decisions to senior management, investors and the like.

7.7 Summary

Key results of this chapter are as follows:

- Three portfolio dimensions – Advantage, Scope and Integration – have been identified as defining 'technology space', a concept previously identified in the literature only in the abstract;

- It has been shown that all the patent relationships identified in the preceding portfolio analyses can be expressed in terms of the three portfolio dimensions;

- It has also been shown that most of the strategies identified in the literature can be expressed in terms of the three portfolio dimensions. However, certain of the 'strategies' listed in the literature have been revealed as being mere patent filing patterns;

- A new risk management approach to patent portfolio structure based on the revised factors and objectives has been proposed. The approach is applicable both to new and existing filings in a patent portfolio.

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CHAPTER 8

Investigation of Patent Invalidity Factors

8.0 Introduction

This chapter focuses on the particular area of patent risk management that is the responsibility of the IP manager, namely patent invalidity risk. It represents another aspect of the research approach employed in previous chapters, namely that of examining real-life patents for guidance. In the present case, it aims to examine real-life patent invalidity with a view to understanding the influence of certain factors, namely the number of prior inventions in a technology area and the rate of growth in those prior inventions.

The chapter begins with a review of the points in the lifecycle of a patent at which invalidity might be identified followed by a review of the ways in which a patent might be invalidated and the categories into which these various risks fall. Thereafter, the various possible sources of data on patent invalidity are reviewed

The next stage investigates two of the patent invalidity data sources in detail to arrive at a preliminary assessment of the effect of the two factors mentioned above. The chapter concludes with a discussion of the relevance of these assessments results to the objectives underlying the research and the risk management framework developed in earlier chapters.

8.1 Background to Patent Invalidity

The term 'Patent Invalidity' is used here to describe the condition in which a patent document, particularly the claims of that document, does not meet the requirements of the patent laws. In the same spirit as the Patent Fundamentals chapter, there follows a review of the points in the patent lifecycle at which invalidity might be established together with a review of the ways in which a patent might actually be invalidated.

8.1.1 Points in the patent lifecycle at which a patent may be invalidated

Examination by a Patent Office

During the examination procedure explained in the Patent Fundamentals chapter, a patent application may be said to be in an invalid condition when the search report cites a prior art document that anticipates or renders obvious the subject-matter defined in one or more of the claims.

Even if no documents of relevance are cited in the search report, a patent application may still be in an invalid condition if a relevant prior art disclosure is identified elsewhere, e.g. in a search report for a family member application in another territory. Of course, there may not be any requirement to disclose this document to the patent office in question, in which case the patent application may well be granted by that office.

Revocation as part of Opposition Proceedings before a Patent Office

Many patent systems have a provision for third parties to oppose the grant of a patent by filing appropriate arguments and prior art evidence with the respective patent office within a fixed period following patent grant (9 months at the European Patent Office). In such situations, a third party will look not only for relevant documents that may have been cited against family member applications, they will typically carry out additional searches for prior art that may not have been picked up in the patent office search reports.

Such submissions are considered by the patent office and a hearing involving both patentee and third party held before a decision is made on whether to maintain the patent – perhaps in amended form – or to revoke the patent.

Revocation before Patent Office

Many patent systems allow the validity of a patent to be challenged at any time during its life, not just after grant. Known as revocation actions, they occur particularly whenever a patent owner is seeking to assert a patent against a third party.

Revocation during litigation

Where a patent owner is seeking to assert a patent against a third party by means of litigation proceedings in the courts, a revocation action may in some countries be brought as part of the same proceedings.

In summary, invalidity can come to light during examination, opposition, revocation or litigation. These four points indicate where we to look to try to find data about invalidity.

8.1.2 Modes of Patent Invalidity under European Law

Since a patent can only be invalid on legal grounds, the legislation provides a precisely worded framework defining the grounds on which a patent can be invalid. The research has focused on the statutory grounds for patent revocation in opposition, litigation or revocations actions since, with few exceptions, these grounds also apply to rejection in the examination process.

A complete list of the grounds on which a granted European patent can be revoked is contained in Article 138(1) of the European Patent Convention (EPC), paragraph (a) of which states that a European patent may be revoked *"if the subject-matter of the European patent is not patentable within the terms of Articles 52 to 57"*.

Of the Articles 52 to 57, Article 52(1) EPC specifies the fundamental conditions for patentability, namely that *"... patents shall be granted for any inventions which are (1) susceptible of industrial application, which are (2) new and which (3) involve an inventive step."* A patent that fails to meet one or more of these conditions is consequently vulnerable to revocation.

Condition (1): Patent Excluded

The criteria for an invention being 'susceptible of industrial application' are in practice defined by a list of inventions that are *excluded* from patent protection:

Article 52(2) EPC states that *'the following in particular shall not be regarded as inventions... (a) discoveries, scientific theories and mathematical methods; (b) aesthetic creations; (c) schemes, rules and methods of performing mental acts, playing games or doing business, and programs for computers; (d) presentations of information.'*

Article 52(4) EPC specifies that *'Methods for treatment of the human or animal body by surgery or therapy ... shall not be regarded as inventions which are susceptible of industrial application ...'*

Further exclusions are given article 53 EPC, namely that *'European patents shall not be granted in respect of: (a) inventions the publication or exploitation of which would be contrary to 'ordre public' or morality ...; (b) plant or animal varieties or essentially biological processes for the production of plants or animals;*

It follows that if a patent granted for an invention is found to fall into one of the excluded categories outlined above, that patent will be liable to revocation.

Condition (2): Patent not New

The concept of 'newness' or 'novelty' is defined in Article 54(1) EPC which states that *"An invention shall be considered to be new if it does not form part of the state of the art"*, the latter being defined in Article 54(2) EPC as *"everything made available to the public by means of a written or oral description, by use, or in any other way, before the filing date of the European patent application"*

This means that a patent for an invention can be revoked if it established that the invention was made public in any way before the application for the patent was filed.

Condition (2a): Patent not First Filed

The 'state of the art' is not restricted to material that was in the public domain before the filing date of the patent: according to Article 54(3) EPC *"the content of European patent applications as filed, of which the dates of filing are prior to the [date of filing* *of the application] and which were published ... shall be considered as comprised in the state of the art."*

This means that a patent for an invention can be revoked if it is established that another patent application for the same invention was filed before the application for the present patent. This is the so-called 'first-to-file' principle of patent ownership that applies in most countries of the world. This invalidity only comes to light at the substantive examination stage, by which time relevant patent applications filed before the patent in question have been Published.

Condition (3): Patent not Inventive

The concept of 'inventive step', also known as 'non-obviousness', is defined in article 56 EPC as follows: *"An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art."*

This means that even if an invention is not already publicly known, a patent to that invention can still be revoked if it is established that, on the basis of publicly-available information, the invention would be obvious to a technologist working in the field of the invention. This condition is intended to prevent patents being granted for developments that, whilst new, are nevertheless of insufficient technical merit to warrant the award of a patent monopoly.

Condition (4): Patent not Sufficient

Returning to article 138(1) EPC, paragraph (b)
states that a European patent may be revoked *"if the European patent does not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art;"*

This condition corresponds to a fundamental principle of all patent systems, the so-called 'bargain' between inventor and state, according to which the state grants an inventor a legal monopoly to practice his invention in exchange for full disclosure of the invention by the inventor in a patent application. Society benefits from being able to practice the new development by reading the patent application and the inventor obtains the competitive advantage of a legal monopoly.

However, if it is established that a patent does not disclose all the information necessary for society to be able to repeat the new development, then the patent will again be liable to revocation.

Condition (5): Patent Extended

Paragraphs (c) and (d) of article 138(1) EPC specify that a European patent may be revoked *"if the subject-matter of the European patent extends beyond the content of the application as filed'* or *"if the protection conferred by the European patent has been extended"*.

This condition ensures that the filing date of the application is respected. As will be evident from conditions (2) and (3) above, the filing date is key in defining which documents belong to the 'state of the art' which in turn is key in determining whether an invention is considered to be new and involving an inventive step. It follows that a patent containing subject-matter added after the filing date of the patent application will be liable to revocation.

Condition (6): Patent not Entitled

The last condition for revocation specified in article 138(1) is where *"the proprietor of the European patent is not entitled"*. Entitlement to a European patent is regulated by Art. 60(1) EPC which states that:

"The right to a European patent shall belong to the inventor or his successor in title. If the inventor is an employee the right to the European patent shall be determined in accordance with the law of the State in which the employee is mainly employed ..."

Revocation is therefore possible where it is established that the owner of a patent is not entitled to the invention.

8.1.3 Additional Modes of Patent Invalidity under US law

Given the importance of the US market to any technology company, revocation conditions under US law are also considered. Also included are provisions under US law that, whilst they do not affect the validity of a patent, nevertheless determine its enforceability in any litigation. Since the end results of a lack of validity and a lack of enforceability are fundamentally the same, viz. a loss of monopoly, the enforceability provisions are also considered.

Condition (7): Patent not First Invented

In contrast to the 'first to file' system found in most countries, the US patent system allocates patent rights on the 'first to invent' principle. A corollary of this is paragraph 102(g) 35 USC, according to which *"a person shall be entitled to a patent unless ... before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it."*

This sometimes means that a patent owner can lose his patent to an invention if a third party is able to prove that it made the same invention before the patent owner.

Condition (8): Patent not Best Mode

Not only must the patent application disclose the invention in a manner sufficiently clear and complete for it to be carried out (cf. 'Patent not Sufficient' above), paragraph 112 35 USC requires that it *"set forth the best mode contemplated by the inventor of carrying out his invention"* or otherwise be found invalid.

Condition (9): Patent Indefinite

Furthermore, failure to conclude the application with *"one or more claims particularly pointing out and distinctly claiming the subject-matter which the applicant regards as his invention"* (paragraph 112, 35 USC) can also render a patent invalid.

Condition (10): Patent Granted Elsewhere

Peculiar to US patent law is the requirement that any US patent application be filed before the grant of an equivalent patent elsewhere. Failure to meet this condition will render any resulting US patent invalid. This is a complex but rare occurrence, that is not in practice important enough to merit further discussion.

Condition (11): Patent not in Good Faith

US patent rules (paragraph 1.56, 37 CFR) also require that *"Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the [US Patent] Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability"*. Again, failure to observe this requirement during prosecution of a patent application can lead to non-enforceability of any resulting patent in the courts.

8.2 Categories of Patent Invalidity Hazard

It is proposed to categorise the above causes of patent loss into three groups depending on the nature of the underlying hazard. Such an approach has a precedent in the context of insurance where Berliner (1982) has distinguished between three main categories of risk according to the underlying hazard, namely 'natural risks', 'risks dependent on human beings' and 'risks dependent on human beings some of whom may have an interest in the occurrence of a loss event'.

8.2.1 Extrinsic Hazards

Thus for conditions (2): not New, (2A): not First Filed and (3): Not Inventive - above, the hazard is posed by the 'state of the art', i.e. everything made available to the public before the filing date of the patent application.

Public disclosures made by the inventor him- or herself will of course fall within this definition. However, in any technical field of significance, there will also be many other parties making public disclosures in the form of products for sale, advertising brochures, conference papers, books, academic papers, as well as in the form of their own published applications for patents. Since such 'third party' disclosures will typically represent the vast majority of the state of the art, conditions (2), (2A) and (3) are designated extrinsic hazards.

Long-term Extrinsic Hazards

Within the class of extrinsic hazards, distinction is made between the state of the art as defined in condition (2) above and that defined in condition (2A). In the former, it is held to comprise *"everything made available to the public by means of a written or oral description, by use, or in any other way, before the filing date"*. As such, it spans a long time, from the very earliest documents (some patent examiners have been known to cite the Bible) to documents published the day before the filing date of the patent. Consequently, the conditions (2) and (3) which are based on such long-term state of the art are described as long-term extrinsic hazards.

Short-Term Extrinsic Hazards

Short-term extrinsic hazards, on the other hand, relate to the state of the art as defined in condition (2A) above, namely other patent applications that have been filed *but not yet published.*

An 18-month delay between the filing of an application for patent and the publication of that application is a typical feature of patent systems and, for the patent applicant, represents a double-edged sword. On the one hand, it gives that applicant a 1½ - year head start before any potential competition has to be able to learn of the application. On the other hand, it represents a substantial period of uncertainty during which an earlier-filed patent application to the same invention could publish at any time, thereby putting paid to any hope of a patent monopoly. However, once 18 months have passed, the applicant can be more certain that no conflicting third-party patent application exists. Hence the description of this hazard as short-term extrinsic.

Included within this category is also condition (7): Patent not First Invented. There is a requirement under US law that a patent invention date may only be claimed if, subsequent to that date, the invention is diligently 'reduced to practice' which in practice means filing a patent application. It follows that the longer the period between invention and patent filing, the less likely that diligent reduction to practice will be considered to have taken place and that the invention date will be recognised. The fairly well-defined 18 month period of uncertainty in the European system is replaced in the US system by a less well-defined period of uncertainty during which prior inventions may surface.

8.2.2 Intrinsic Hazards

For the remaining conditions, the hazard is posed by deficiencies in the patent itself, hence their designation as intrinsic hazards. They typically result from the patent application being drafted in ways that are not in agreement with the patent law as interpreted by the courts. Condition (11): Patent not in Good Faith, although not intrinsic to the patent document itself, is nevertheless intrinsic in the sense of being within the control of the patentee.

8.2.3 Discussion and Implications for Risk Management

The terms 'external' and 'internal' validity, corresponding to the 'extrinsic' and 'intrinsic' categories identified above, are colloquially used in the context of UK Patent Agent qualification examinations. In the Patent Risks section of the Literature Review, chapter 3, both Short-term and Long-term Extrinsic risks are acknowledged, although not using this particular terminology. In the present work it is proposed that all three types of risk should be recognised.

Given the above definition of Intrinsic risks as being within the control of an organisation, it seems reasonable to conclude that the main factor affecting the likelihood of Intrinsic risks is the quality of patent drafting and prosecution. Unfortunately this is not an issue that appears to have any prospect of being quantified. All the parameters identified in the Literature Review relate to the productivity of patent departments. However, since Intrinsic risks relate to legal intricacies, the legally trained IP manager should be in a better position to give an opinion on intrinsic risks than others not having a patent legal background.

As regards the long- and short-term extrinsic hazards, the factors underlying these are investigated in the sections that follow.

8.3 Sources of Data on Patent Invalidity

8.3.1 Patent Office and Patent Court Decisions

Subsection 8.1.1 above identified the various points in the patent lifecycle when a patent or patent application might be invalidated. It will be appreciated that each point represents a decision by a patent office or patent court for which corresponding documentation should in theory be available.

In practice, however, obtaining such decisions can be difficult, especially in the large numbers necessary to identify trends. Thus, to date, the majority of researchers have turned to databases, particularly computerised and online databases, to access their information – see section 3.8 of the Literature Review chapter in this regard. The present researcher was no different in this regard in looking to such databases for patent invalidity information.

8.3.2 Online Data Sources

Details of over 300 established online patent data sources are held by the British Library in three key references: Rimmer (1992), Sibley (1991) and Armstrong (1995). A review of these references identified thirteen databases of apparent relevance for which respective data sheets were obtained. Of these, eight actually contained fields relevant to invalidity and these are listed below:

(1) Inpadoc Legstat, (2) PAST, (3) OG Plus, (4) United States Patents Fulltext, (5) US Patents Gazette

The invalidity-relevant data of these five databases is the same, because they all take data from the same source, namely the US Patents Gazette. The relevant data is (a) patents that have been subject of a re-examination request, and (b) patents that have been subject to an adverse decision in interference.

Regarding (a), this is the US equivalent of the patent office revocation proceedings discussed in 8.1.1 above. Any member of the public can request re-examination of a US patent by presenting prior art that raises a "substantial new question of patentability".

Item (b) relates to final decisions that have been rendered that the respective patentees are not entitled to patents containing the claims listed in the weekly USPTO Official Gazette, i.e. issued patents that have been rendered invalid by the prior invention of a third party. Patent *applications* subject to an adverse decision do not appear in the database since, until a recent change in US patent law, US patent application procedure remained confidential until issuance of a corresponding patent.

(6) EPAT

This database contains information on European patent opposition procedure. Searches are possible on number and date of oppositions filed plus opponents' name and country. There are also indicator fields for inadmissible opposition, rejection of opposition, amendment of patent and revocation of patent. However, there is no detail on the individual grounds for opposition (lack of novelty, insufficiency, etc.).

(7) Claims/Citation

This database is designed to answer the question of which later US patents cite another patent. Each record includes a US patent number plus patent numbers (both US and non-US) cited to that patent by other US patents. Records from the database give the numbers of the cited / citing patents but no indication as to the relevance of the cited documents.

(8) Patstats (www.patstats.org)

Patstats gives annual statistics on the specific grounds on which US patents have been revoked. Compiled by Johnson, Wong and Janicke of the University of Houston Law Centre

8.3.3 Patent Office Data Sources

In addition to the above, the official publications of the UK, European and US patent offices were investigated. It was established that all information published by the European and US offices was already available through the online databases discussed above. The UK Patent Office also offered, for a fee, printouts of 'Term Frequency Lists' detailing how many patents have been allocated certain technical classifications and 'Annual Indices' of cases arranged under legislation subject index headings. Neither of these was considered relevant to the task in hand.

8.4 Investigation of Technology Area Size as a Risk Factor in Long-term Extrinsic Patent Invalidity

8.4.1 Relative Merits of Data Sources for Long-term, Extrinsic Risks

Important in the choice of data source for assessing this risk was not the format (individual decision, online data, etc.) of the source but rather the point in the patent lifecycle to which it related.

Specifically, it was considered that data on the failure of patent applications during patent examination would be flawed since applications do not all start from a common validity baseline: the claims of some applications will have been drafted after a careful review of the prior art and as such will be less likely to be invalid than claims of other applications that have been drafted without any regard to the prior art. Accordingly, it was decided to focus on the revocation of granted patents which, in theory at least, will have all been subject to a uniform examination procedure.

However, there are also issues regarding the point in the patent lifecycle at which revocation takes place. It is by no means compulsory for a third party potentially affected by a patent to file an opposition or revocation action with the Patent Office. Indeed, where little relevant prior art is available, it may be advisable not to highlight this fact by filing a weak opposition. There is therefore a danger that the number of patent office opposition or revocation actions that fail to invalidate a patent will not be representative.

In contrast, a party faced with patent infringement litigation would seem to be compelled to launch a counter-claim for patent invalidity as part of its defence, regardless of the state of the prior art. Moreover, the high stakes as evidenced by the fact that the matter has come to court suggests that the searches for prior art will be correspondingly thorough.

Accordingly, court revocation actions were chosen as being more representative of the true situation, particularly where no relevant prior art exists. One downside of this approach was that the data set was smaller owing to the fact that far fewer patents are litigated than are opposed. Another disadvantage was that patents court invalidity data was not available on any database, so that individual court decisions had to be reviewed.

Unfortunately, no way was found of remotely accessing US court decisions (The authors of the Patstats database, Johnson, Wong et al. at the University of Houston Law Centre were unable to enlighten the author as to how they obtained their information) so that it was necessary to use UK patents court decisions which, it will be appreciated, are far fewer in number. Even then, obtaining a full set of decisions for a single year was not straightforward. Although a diary listing all the decisions issuing from the England and Wales Patents Court is available from the Court Service website (www.courtservice.gov.uk), only a selection of the decisions is available for downloading. The remaining decisions had to be obtained using a combination of the commercial Lawtel database (www.lawtel.com) and by visiting the Patents Section of the British Library in London.

The above difficulties resulted in the initial analysis being restricted to court decisions for the single year 2000, the most recent year for which full data was available at the time. Once all decisions had been obtained, it was a matter of reading through each decision to determine whether the patent in suit had been invalidated and, if so, on what ground(s).

8.4.2 England and Wales Patents Court Data

Before considering the effect of technology area size, it is interesting to consider the distribution of causes of loss of granted patents as shown in figure 8.1. This figure also includes corresponding data for the US courts as obtained from the Patstats internet source.

As expected, long-term extrinsic causes represent the majority in both the UK and the US, the only difference between the two territories being the exact nature of the cause – 'patent not new' or 'patent not inventive' – which is attributed to differences in interpretation between the two legal systems.

All the same, the results do suggest that the respective patent examination systems are not entirely effective in ironing out all intrinsic and short-term extrinsic deficiencies prior to grant. 'Patent not Sufficient' is particularly significant and may reflect the attempts of patent owners to assert their rights over subject-matter that is not rightly covered by the patent.

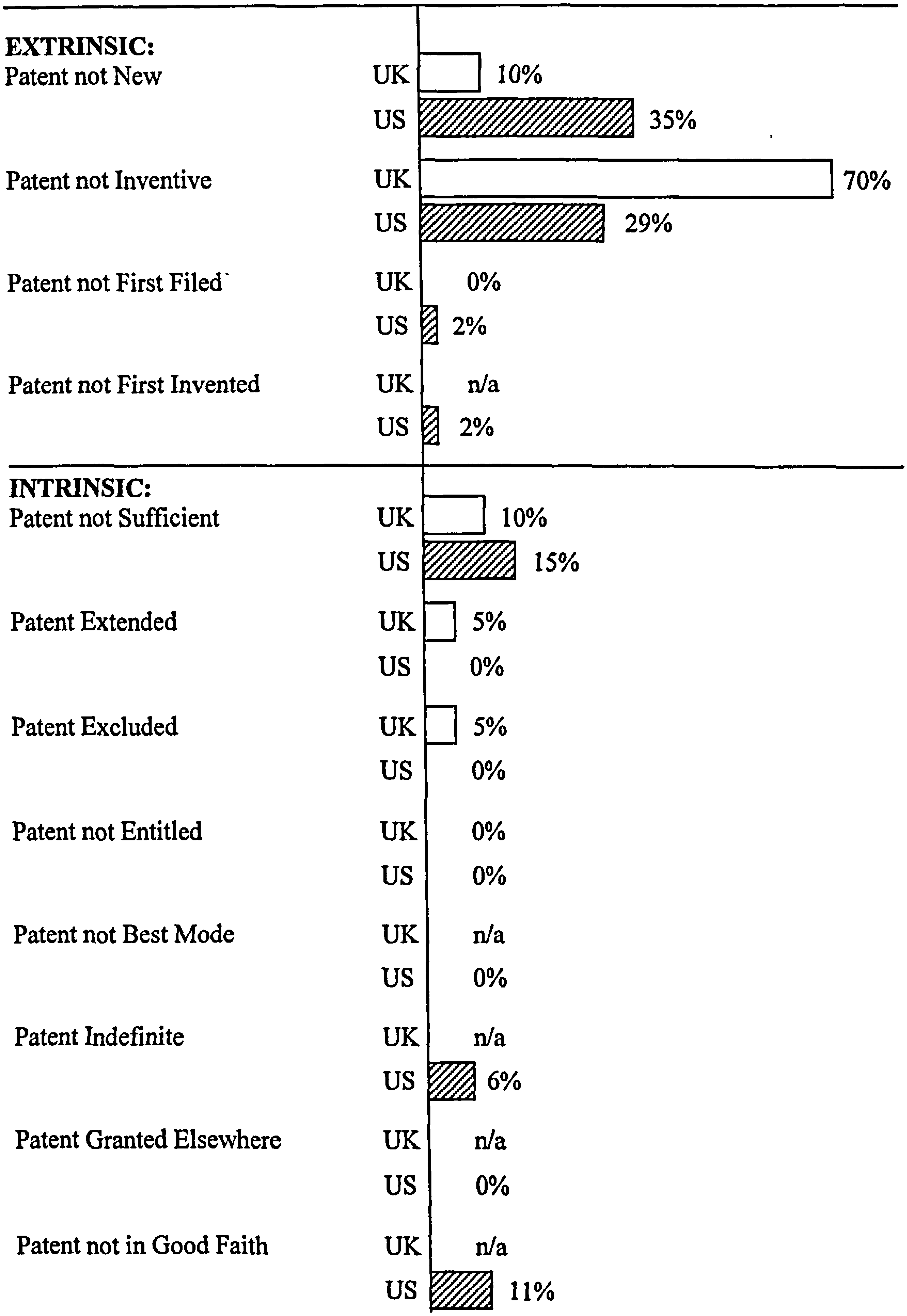


Figure 8.1: England & Wales and US Patents Court Published Decisions 2000 – Relative Frequency of the Various Causes of Patent Loss (n/a indicates Cause of Patent Loss not applicable in E&W or US)

8.4.3 Defining Technology Area Size

There are well established patent office classification systems for technology that have certainly been used as a measure of patent scope – see reference to Lerner (1994) in section 3.2.1 of the Literature Review chapter.

International Patent Classification (IPC)

All patent offices use – to a greater or lesser extent - the International Patent Classification (IPC) system as administered by the World Intellectual Property Organisation (WIPO) in Geneva. This divides technology into eight areas: Human Necessities, Performing Operations / Transport, Chemistry / Metallurgy, Textiles / Paper, Fixed Constructions, Mechanical Engineering, Physics, Electricity.

Within each area, there are a handful of groups each comprising a number of classes sharing a common first digit. Section C, for example, comprises a chemistry group of classes C01 to C14 and a metallurgy group of classes C21 to C30. Class descriptors are either products (e.g. "glass, mineral or slag wool") or processes (e.g. "biochemistry").

Each class is broken down into a larger number (typically 10-15) of subclasses each designated by a letter suffix. For example, class C12 relating to biochemistry, brewed products, microbiology and genetic engineering has 12 subclasses C12C,F,G,H,J,L,M,N,P,Q,R and S.

A further, numeric suffix serves to distinguish technical areas within the subclasses. Thus subclass C12Q relating to "measuring or testing processes involving enzymes or micro-organisms; etc." has within it a technical area "measuring or testing processes involving enzymes or micro-organisms" (C12Q 1) covering the particular field of "testing for sterility conditions" (C12Q 1/22).

US Patent Classification

The US Patent and Trademark Office (USPTO) also has a classification system which divides patentable subject-matter (which includes business methods as well as technology) into approximately five hundred classes each containing a substantial number of subclasses, the equivalent US classification to C12Q 1/22 above being class 435 ("Chemistry: Molecular Biology and Microbiology"), subclass 31 ("Testing for Sterility Condition"). As a result of the US being the largest market in the world, the US patent classification also has wide usage.

Determining Size of Technology Area

Neither of the two systems described above define a clear unit of 'technology area'. However, each of the five hundred-odd classes of the US patent classification presents a more immediate and manageable unit of technology area than, say, the IPC where the eight technology areas are clearly too large but where some of the lower levels in the hierarchy may be so small that a single patent application spreads across multiple areas.

As regards the particular number of prior inventions in a technology area, this was taken as the number of (US) patent filings in a US patent class. Such data was directly available from a number of online databases including the 'United States Patents Fulltext' database discussed above. Figure 8.2 shows the number of US patents in each of the US patent classes in 1998, shortly before the year 2000 for which the England and Wales Patents Court data was obtained.

It should be noted that, being European and UK documents, the patents that were litigated before the England and Wales Patent Courts in 2000 were not classified according to the US system. Therefore, to determine the particular technology area of a patent, it was necessary to refer to the US equivalent filing or, in the few instances that such an equivalent filing did not exist, to identify the US classification that most closely matched an existing IPC classification.

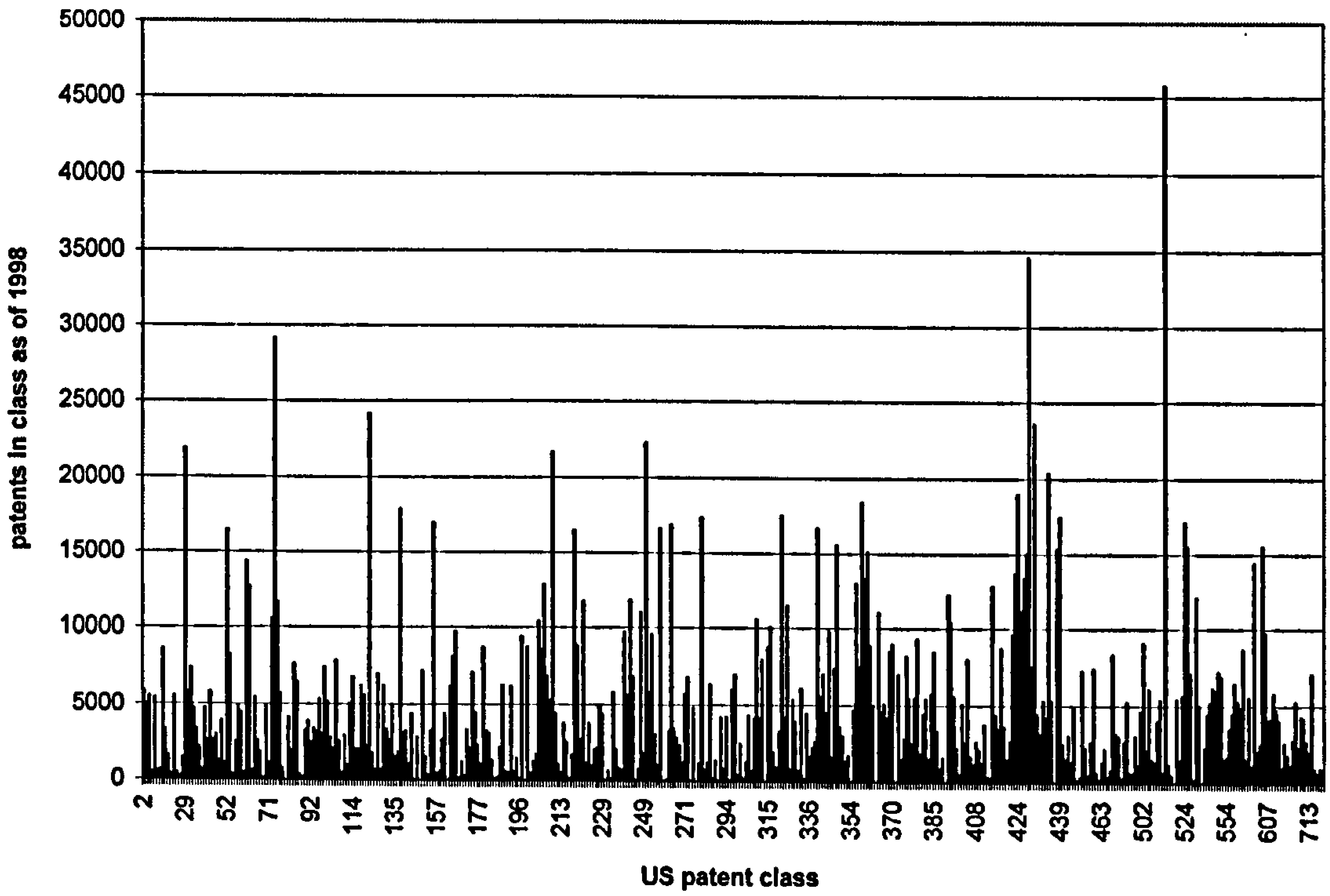
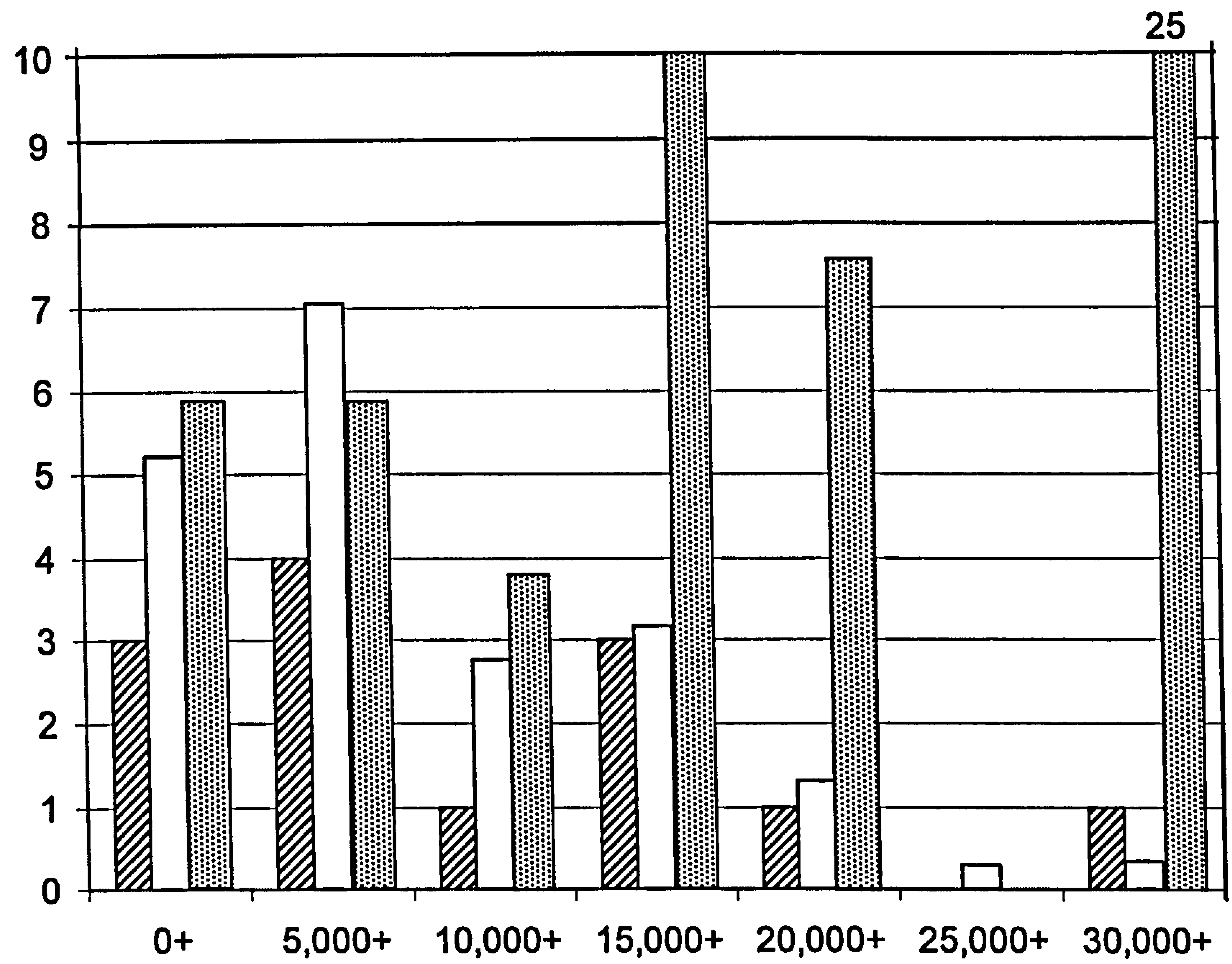


Figure 8.2: Number of US patents in each US patent class in 1998



number of patents per technology area

KEY:	hatched:	invalidity events
	white:	total patents (x100,000)
	shaded:	invalidity events per million patents

Figure 8.3: Patent Loss due to Extrinsic, Long-term Causes - Distribution with Patent Class Size

8.4.4 Correlation of Patent Invalidity due to Long-term Extrinsic causes with Technology Area Size

Figure 8.3 illustrates the variation in occurrences of patent invalidity due to extrinsic, long term causes with the number of prior inventions in a technology area. The figure also shows the total number of patents in each technology area of a certain size as well as the normalised invalidity rate, i.e. the number of invalidity events per million patents.

The primary observation must be that, as anticipated, the number of data points generated by this particular investigation is very low. This does of course impact heavily on the significance of the results. The second observation is that both invalidity and validity events seem to vary as the total number of patents in each technology area of a certain size. This too is to be expected. However, when the normalised invalidity rate is considered, a trend more in line with that suggested by the literature appears: an increase in the likelihood of invalidity with increase in the number of prior inventions in the field.

Clearly the data set as it stands is too small to draw definitive conclusions. In particular, the data may be skewed by the acknowledged fact that the two patent classes containing the largest number of filings (514 and 435 – see figure 8.2) both relate to pharmaceuticals, an area renowned for the very kind of court actions from which the present data is derived.

8.5 Investigation of Technology Area Growth Rate as a Risk Factor in Short-term Extrinsic Patent Invalidity

8.5.1 Relative Merits of Data Sources for Short-term, Extrinsic Risks

Of the available data, only 'patents that have been subject to an adverse decision in interference' (published in the online US Patents Gazette and also available via Inpadoc Legstat, PAST, OG Plus and United States Patents Fulltext) was considered to be of relevance to short-term extrinsic risks.

Interferences were discussed above in the context of litigation. However, interference can also strike a granted patent before litigation if another patent application going through the Patent Office happens to claim the same invention and if the publication date of the granted patent is not sufficiently early for it to have a prior art effect against the patent application. Interference proceedings are then necessary to establish entitlement to the invention under US 'first to invent' rules and where the first, granted patent loses its entitlement to the invention (in whole or in part), notice to this effect is published in the US Patent Office's Official Gazette.

Furthermore, since interference proceedings are instituted by the US Patent Office rather than by third parties, there is less chance of the results being unrepresentative in the manner discussed in section 8.4.1 above with regard to oppositions.

Obtaining the necessary data was straightforward, if labour intensive, involving a review of the online US Patent Gazette for each week of the year 2000 to establish the patents that had been the subject of adverse interference decisions. For each of these patents, the respective patent classification was then determined.

8.5.2 Defining Technology Area Growth Rate

Technology area has been comprehensively discussed in subsection 8.4.3 above, with figure 8.2 showing the number of patents in each US patent classification as of 1998. As an indicator of technology area growth rate, the percentage increase in the number of patents in a US patent classification over the five years prior to 1998 was calculated.

8.5.3 Correlation of Patent Invalidity due to Short-term Extrinsic causes with Technology Area Growth Rate

Figure 8.4 shows the number of 'adverse interference' events reported in 1998, grouped by percentage growth in the number of patents in the respective patent class over the preceding five years. Also shown for each growth class is the total number of patents in that class and the interference rate (in units of events per million patents).

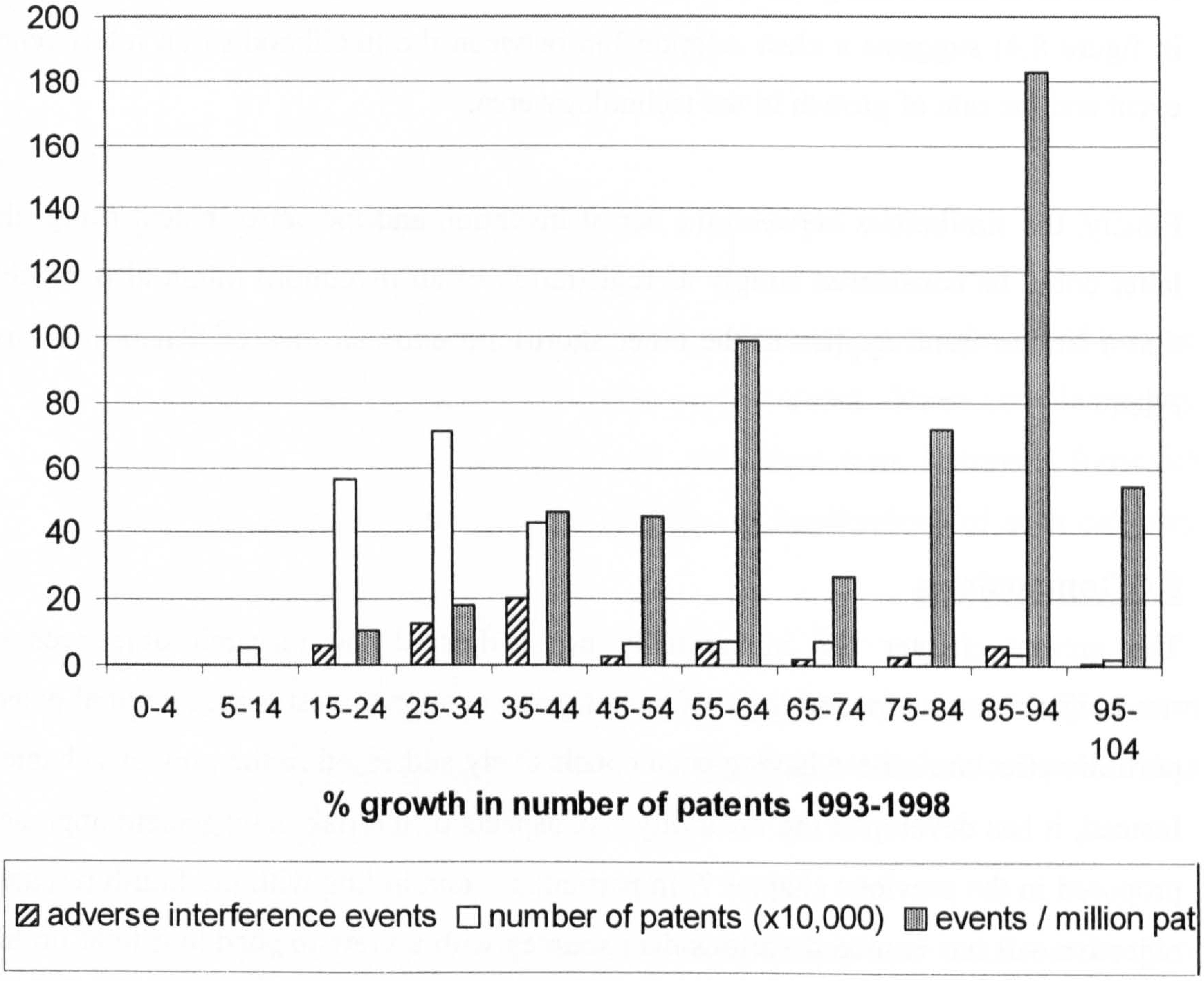


Figure 8.4: Patent Loss due to Extrinsic, Short-term Causes - Distribution with Patent Class Growth Rate. Vertical axis

As before, the primary observation must be the number of data points which, at around 60, is greater than in the previous section but still low.

However, unlike the previous section, the number of interference events in a growth class does not closely mirror the total number of patents in that growth class. Furthermore, normalising the number of interferences (indicated by shaded columns in figure 8.4) suggests a clear relationship between the likelihood of an interference event and the rate of growth in the technology area.

Finally, the similarities between the act of invention and the act of patent filing (the latter could be considered simply as registration of an invention) might also suggest that a similar trend applies to the other short-term extrinsic risk of 'Patent not First Filed'.

8.6 Conclusions

The present chapter has intentionally not addressed the research objectives of 'investigating structure and logic of patent portfolios' or 'investigating optimal patent portfolio structure', these having been conclusively addressed in the previous chapter. Instead, it has developed the invalidity risk aspects of the risk management approach proposed in the previous chapter 7. In particular – and in line with the fourth research objective – it has explored various data sources with a view to shedding light on the occurence of patent invalidity. This approach is in contrast to research where existing bibliographic data sources are analysed in order to look for trends.

Unfortunately, the nature of the available data sources is such that sample sizes have been low. Nevertheless, two methodologies have been developed that will allow further data to obtained. Furthermore, if the trends identified above are confirmed, then they will represent a useful tool for the IP manager when seeking to justify further patent filings to address the risk of patent invalidity due a significant likelihood of prior art or to justify speed in invention and patent filing when operating in a field where there is significant growth.

In particular, the latter results may be of use to the couple of companies identified by Pickering et al (1998) who:

> *... doubted whether the risks of losing a patent and the attendant costs of this were sufficiently high as to justify the additional costs which rigorous maintenance of laboratory books imposed.*

8.7 Summary

Key results of this chapter are as follows:

- The modes of patent invalidity in the two major economic territories of Europe and the United States have been considered in detail. Three complementary categories of patent loss causes (Long- and Short-term Extrinsic, Intrinsic) have been proposed and the risk management implications of each category have been considered;

- With a view to investigating factors underlying the Long- and Short-term extrinsic categories of patent loss, a comprehensive review of patent data sources has been carried out;

- Methodologies for analysing two previously unexplored data sources have been developed;

- Using the new methodologies, preliminary results have been obtained that would seem to be consistent with trends proposed in the literature regarding the likelihood of long- and short-term extrinsic causes of patent loss.

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CHAPTER 9
Final Conclusions

9.1 Introduction

In the opening chapters, the problems which had given rise to the project were discussed, the literature was reviewed and specific objectives identified on which research could be based. This final chapter reverses that initial process and considers the extent to which the results of the research have addressed the problems which prompted the research in the first place. It also considers the contribution to knowledge of the research from an academic perspective.

9.2 Extent to which the problems that prompted the Research have been addressed

9.2.1 Justifying Portfolio Growth and Portfolio Budget

In the Introduction, it was noted that investors often to look to growth in a company's patent portfolio as a sign of company health, but that the patent filing and prosecution activity associated with such growth also consumes the very cash which has been invested.

The three-dimensional framework that has been developed in the present research allows the structure of a patent portfolio to be explained in a simple visual manner that can be understood even by those unfamiliar with the technology, the market and/or patents. In particular, it can be used to address the question raised in the Introduction chapter of the value of extra filings once the basic technology has been protected.

The framework also provides a platform on which to discuss the various market, technical and IP assumptions that underlie the portfolio structure and thereby justify the amount of money spent on the portfolio (which could be more or less than that expected by the investors).

9.2.2 Justify Portfolio Structure

The Introduction chapter noted that similar problems to the above could also be encountered when an IP Manager discussed portfolio strategy with the senior management of a single technology company. In particular, it was noted that the IP literature was overwhelmingly based on opinion rather than on hard data and as such its recommendations were difficult to defend, for example against the opinions of those sitting on the company board.

The research has addressed this problem in two ways: firstly, it has provided a framework for discussion that, whilst new, is nevertheless based on established patent principles. Secondly, it has backed up with hard data some of the assertions made in the literature (e.g. regarding the significance of speed of filing in a fast developing field) whilst clarifying other possible misconceptions.

9.2.3 Handling the uncertainty inherent in patents

The Introduction chapter also queried the patentability of new developments relating to an existing technology which is already known from earlier patents. More generally, it noted that senior management are uncomfortable with the inherent uncertainty surrounding patent validity.

The research results do not change the fact that assessment of the patentability of an individual filing remains a matter for patent attorneys, patent offices and the courts. However, it does contribute several tools for handling that uncertainty:

Firstly, when deciding whether to proceed with a filing, the framework provides an indicator of the status of the filing in the portfolio which can be weighed against any perceived risk of invalidity of that filing. Secondly, the framework illustrates how further filings can be put in place to reduce the exposure to patent invalidity.

Furthermore, the understanding of patent invalidity risk by senior management has been facilitated by reducing the various grounds of patent invalidity to just three groups (intrinsic, extrinsic long-term, extrinsic short-term) and by providing supporting data.

9.2.4 Apportioning Responsibility

The Introduction noted that the complexity of patent issues often prompted senior management to avoid involvement in management of the patent portfolio until such time as problems arose, at which point there could be surprise, anger and blame, even though no blame may be justified.

A solution to this problem is offered by the research, which has established clear lines of responsibility between the various elements of a patent portfolio and the marketing, technology and IP functions within a company. For the IP Manager, it has also provided hard data with which he/she can back up his/her position in the event that any problem turns out to be IP-specific, e.g. loss of monopoly due to patent invalidity.

9.2.5 Motivating Technologists

The Introduction chapter noted that a company's technologists typically see patent filings as an acknowledgement of technological merit and that having patent applications filed for their new ideas is important to their motivation, which in turn may be important for the success of the company. On the other hand, an unfocused programme of patent filings will consume substantial resources to no commercial effect and be equally damaging to the success of the company.

The framework of the present research allows a technologist to understand the place of his new idea within the overall patent portfolio as well as to understand the criteria on which his idea is being assessed for patent filing. Whilst there will always be scope for argument over whether the criteria are met, there will at least be transparency as to exactly what is being argued about. For obvious man-management reasons, this is preferable to an ungrounded rejection of an inventor's ideas.

Perhaps more importantly, an awareness of the filing criteria may bring new focus to the technologist's work, making it more productive in terms of IP.

9.3 Contribution of the Research to the academic knowledge

9.3.1 New Methodology

To access the information contained in the body of a patent document (rather than just its bibliographic data), a new research methodology has been developed based around the recognition of Scope and Advantage as key parameters.

When applied to a portfolio, the methodology provides direct, first-hand data on actual patent filing patterns rather than the indirect, hearsay evidence obtained, for example, by interviewing patent managers about their patent filing behaviour.

In common with other PhD research carried out at Cranfield's R&D Management Centre, for example Falkingham (1998), the methodology requires a researcher who is familiar with the field: whilst a clerk might be able to count bibliographic data, a librarian classify that bibliographic data and a researcher identify research techniques that might be used to further process that data, only a researcher familiar with the field - in this case the structure and technical content of patent documents – is in a position to extract all the required information. As both a patent attorney and an ex-patent examiner, the present researcher has been well placed to do this.

9.3.2 New Depiction Method

In parallel with the new methodology, it has been necessary to develop a new depiction method capable of presenting all the new information obtained, not only for a single filing but for all the filings in a portfolio.

Furthermore, ways have had to be found of presenting the information in a manner consistent with acknowledged patent strategies. Achieving this has in turn yielded new insights on those strategies, in particular the realisation that a patent portfolio has three dimensions (Scope, Advantage and Integration) and that some strategies can be applied in more than one of these dimensions.

9.3.3 Focus on Single Technology Patent Portfolios

The research has focused on patent portfolios relating to a single technology with a view to addressing questions that are not answered by the literature, which only deals with patent portfolios in a general sense. In particular, it has looked at the interrelationship of patent filings all relating to a single technology. This has resulted in an improved understanding of the various roles played by the filings in a single technology portfolio and the marketing, technical and IP factors that influence that role.

9.3.4 Validation of Assertions made in the Literature

By accessing previously unexplored data sources, the research has validated one assertion made in the literature, namely the need for speed in technical fields where there is much development activity, and provided insight into another, namely the relationship between patent invalidity and the number of prior disclosures in a field.

9.3.5 Exploration of the Limitations of New Data Sources

The research is characterised by the use of several new data sources, *inter alia* the full content of patent documents and of UK court decisions. In addition to the contributions mentioned above, the research has identified the limitations of such sources.

Thus it was that the chronology of the filings in a patent portfolio was not investigated further once the analysis of the Renishaw portfolio had been completed: it became clear that the available data provided no means of establishing whether a particular filing chronology was good or bad.

Similarly, although the analysis of the Torotrak portfolio resulted in the framework described above, it also highlighted that the data was not available to qualify as good or bad the particular framework of the Torotrak portfolio.

9.4 Proposals for Further Research

As discussed in the previous paragraph, one contribution of the present research has been to explore certain new sources of data and identify their limitations. As also discussed in the previous paragraph, the research has yielded a framework which - in spite of these limitations - would appear to be able to represent all possible patent portfolio strategies.

Nevertheless, one route of further research would be to further validate the framework by applying it to other portfolios. In this regard, it is noted that the author has already successfully applied the techniques described herein to the portfolios of the various companies that he has worked with, although it has not been possible to include the results in the present work for obvious commercial confidentiality reasons.

To address the aforementioned problem with qualifying patent portfolios, another route of further research might be to apply the framework to portfolios containing patents that have been litigated (e.g. in the UK courts) on the basis that 'patents that have been litigated must be valuable'. Data could then be collected on the position of such 'valuable' patents in their respective portfolios. Such an approach could be compromised given the findings of Schankerman (1999) that litigated patents are most likely to be 'broad' patents, although it is noted that Schankerman's research used bibliographic data, the limitations of which were discussed in more detail in the Literature Review chapter 3.

Analysis of other court decisions would certainly be useful: analysis of UK Patents Court decisions for years after 2000 would increase the sample size and hence the reliability of the data collected thus far. It would also be interesting to analyse court decisions from other jurisdictions, e.g. the US, to see if there are any significant variations in the likelihood of invalidity that might warrant a different portfolio structure in those territories.

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Annex Contents

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ANNEX 1:

Summaries of two of the projects in the DTI/ESRC/IPI 'Intellectual Property Initiative' Research Programme

Intellectual Property Initiative

RESEARCH PROGRAMME ON INTELLECTUAL PROPERTY

Director: Professor J.N.Adams 1998

1. *How SMEs see their intellectual property rights*

Dr Robert Blackburn of Kingston University talks to David Fishlock

"Most owner-managers of SMEs are not backward at managing their intellectual property", believes Robert Blackburn. "They may not know the legal jargon but they know what's important to them".

Dr Blackburn is director of Kingston University's Small Business Research Centre, specialising in the study of small and medium size enterprises (SMEs) of fewer than 250 employees. In 1996 the centre began to study experiences of managing and attitudes towards intellectual property rights among SMEs in the UK. It is part of the Intellectual Property Institute's research programme on intellectual property (see also page 4).

The thrust of this research programme is to discover whether IPR is being taken seriously enough by those who are making industrial policy.

In the UK 99 per cent of businesses employ fewer than 250 people. Policymakers see collaboration - between SMEs, with bigger firms, with universities, etc. - as crucial to industrial vitality.

But do SMEs really fear collaboration as a possible way of losing their IPR? Do such worries inhibit development of new products and processes by SMEs?

Researchers led by Blackburn have conducted lengthy telephone interviews with principals – owners or managers – of 400 SMEs in four disparate industrial sectors: software, mechanical engineering, design and electronics. Over half had fewer than ten employees.

"We had to establish our credibility and went for the personal touch."

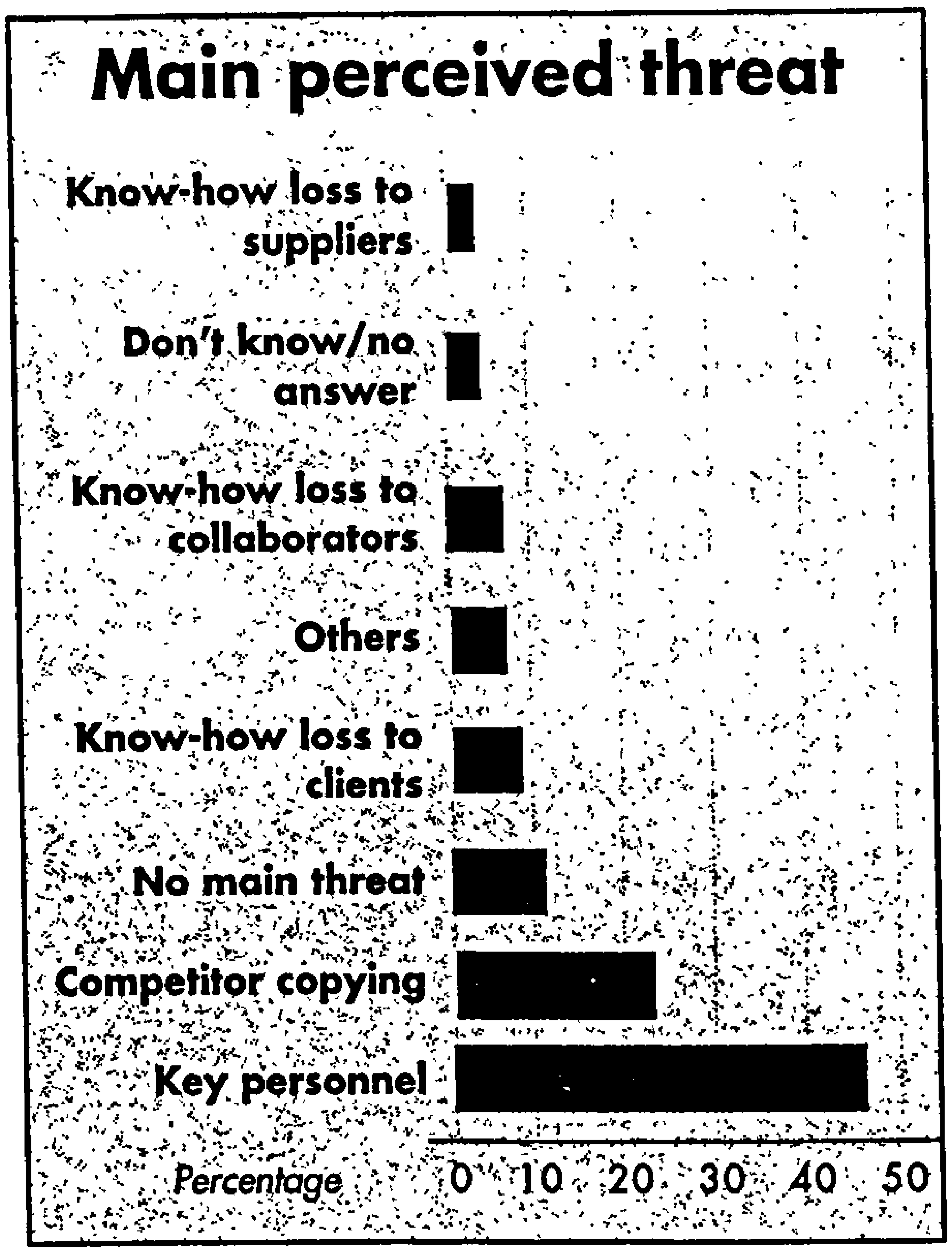
They tried to avoid jargon - even the phrase "intellectual property" unless the respondent first used it. "We talked of specialist knowledge or confidential knowledge, or know-how".

Their questions embraced product development, collaboration, and specific experience of intellectual property.

Nearly two-thirds of the 400 said they had changed their product or service over the past two years. (The researchers had learned to avoid the word "innovation", as a fashionable practice people like to claim even when they can offer no real evidence of it.)

Software, unsurprisingly, showed the most change, 84 per cent. Mechanical engineering lagged far behind other sectors with only 29 per cent.

> ***"We had to established our credibility and went for the personal touch. We talked of specialist knowledge or confidential knowledge, or know-how" –***
>
> *Dr Robert Blackburn*



In working practices, mechanical engineering was a little better, with 36 per cent claiming changes over the last two years compared with 31 per cent in software, 41 per cent in electronics and 57 per cent in design.

Nearly half the SMEs questioned claimed that they collaborated with others in developing new products and services. But again mechanical engineering firms fell well behind other sectors, only 21 per cent.

More specifically, no mechanical engineering firm questioned was collaborating with a university or a designer. Of those who did collaborate, over 80 per cent of mechanical engineering firms chose partners which were significantly larger; and both electronics (58 per cent) and software (72 per cent) showed the same predilection, whereas design firms tended to favour firms of a similar size.

Why collaborate?

Asked why they should wish to collaborate, the main reason given by three sectors was to gain access to technical knowledge. The exception was mechanical engineering, for which expanded production capacity and the fact that they were "paid to do so" were more important.

Fewer firms in mechanical engineering than in other sectors said they preferred to collaborate; more wanted to continue alone. Design firms expressed the opposite view; and other sectors were evenly divided. One interviewee said bluntly that his firm preferred to continue alone: "it's quicker and you don't have to share the profits".

Only half-way through the questionnaire, when researchers reckoned they had won the confidence of their interviewees, did they address the specifics of intellectual property management. "Do products, services or working practices depend on know-how or confidential knowledge?" Four-fifths of firms in design, electronics and software answered "yes". But half of those in mechanical engineering said "no".

Asked what they saw as a threat to their proprietory know-how, the same three sectors ranked the loss of key people as the greatest risk. As a perceived threat this ranks lower among mechanical engineering firms, which gave greater weight to the loss of know-how to customers, and through copying to their competitors. Loss of know-how to collaborating firms was cited by many software and design firms - sectors in which bespoke products prevail.

Understandable fears

Blackburn finds the fears of the SMEs in respect of loss of key people understandable. "They don't use terms like 'technology transfer' but they recognise its implications".

So how do SMEs try to minimise the threat of losing their know-how? Of the 400, 270 claim they have something worth protecting. A high proportion in all four sectors say they are prepared to rely on relationships to ensure that specialist knowledge is not stolen. But this is by no means the only strategy among SMEs:

- In software, lead time over competitors rates highly.
- Contractual undertakings rate highly in mechanical engineering and electronics.
- Using know-how to ensure that products are not easily copied rates highly in electronics.
- One ploy practised fairly widely in all sectors is to have a market niche not open to competitors.

Other strategies include the conspicuous display of copyright notices in the case of both design and software products. Licensing is used extensively by software firms. Patent use is less common among SMEs - less than one-quarter

> *"I find the fears of the SMEs in respect of loss of key people understandable. "They don't use terms like 'technology transfer' but they recognise its implications" –*
>
> *Dr Robert Blackburn*

put their faith in patenting. These were mainly electronics and mechanical engineering firms. Built-in barriers used in the products, such as encryption in software codes, are used by software and electronics firms.

Where does an SME seek advice on protecting its intellectual property?

Except for mechanical engineering firms, most turn to their legal advisers. In mechanical engineering, patent agents are the most important source of advice - followed closely by the customer.

Government advice unsought

What may surprise the government, given the attention it pays to SMEs, is how little its advice is sought on protection, whether from DTI itself, from Business Links, from TECs, or from other departments except for patent offices.

Most SMEs – nearly three-quarters of those questioned – have never resorted to legal action to protect IPR. But the figure was highest among the design firms, 39 per cent.

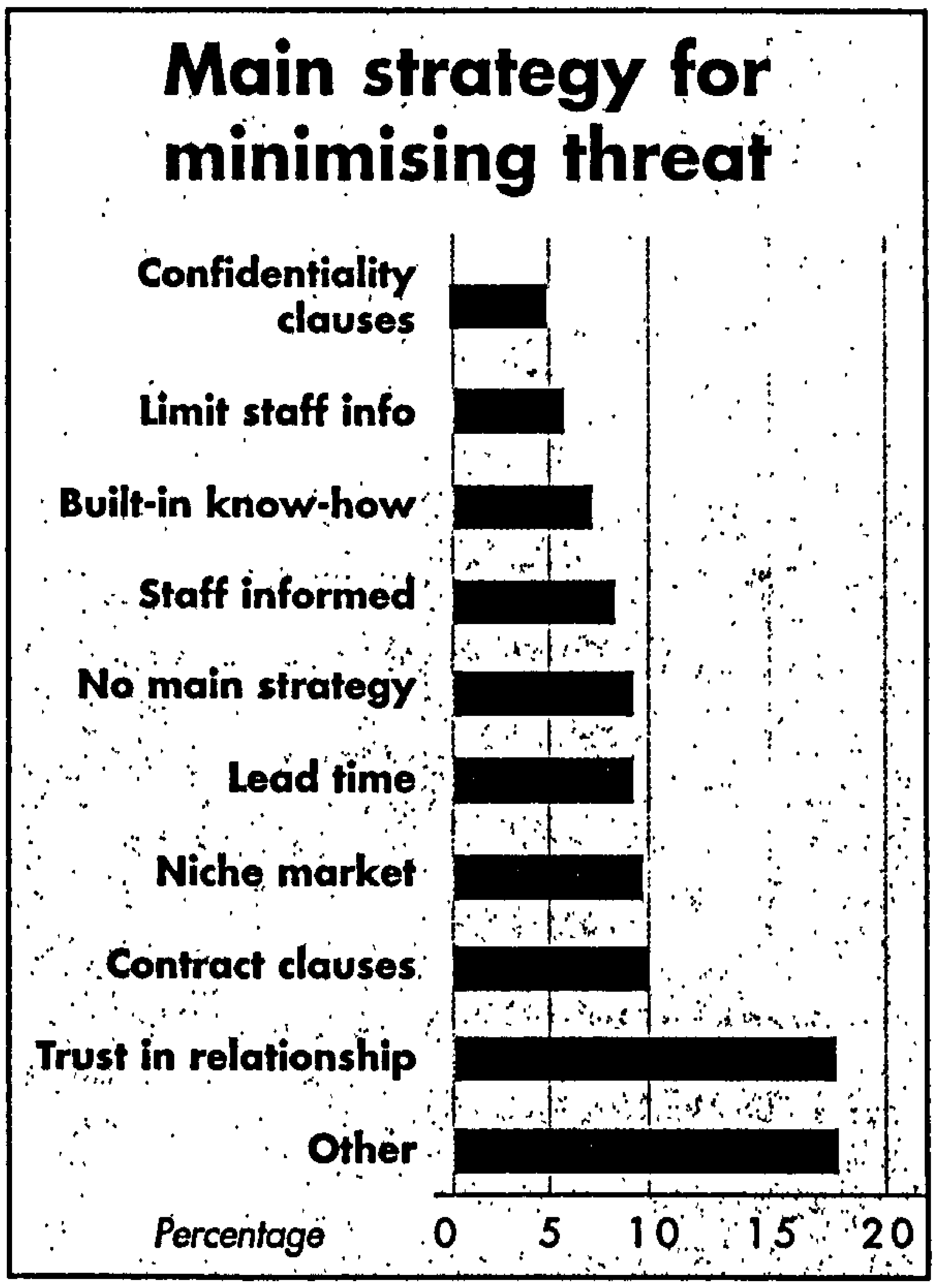
Those which said they had taken legal action had put their faith mostly in consultations with lawyers and legal threats against the copier. One-third of the cases had been settled out of court.

When asked about their approach to developing IPR, patent searches prove the most popular means, used by 20 per cent of the 400.

As for the consequences of formal methods of IP management, over three-quarters of the SMEs believed legal protection had no effect on them anyway. Only 13 per cent said it encouraged development in their firm. Some even thought that it discouraged development, says Blackburn.

Invited to comment on the effect of legal protection on their industry, however, only half said "no effect". Nearly a quarter believed it encouraged development in the industry - and 13 per cent thought it discouraged development.

Is there anything government can do to help you protect your IPR? was the final question. The answer came loud and clear: "make it quicker and cheaper to obtain and maintain".



Personal file

Robert Andrew Blackburn (40)

1979	BA, University of Hull.
1981	Schuman Scholarship to European Parliament, Luxembourg
1981	MA in Regional Planning, Coventry University.
1981-3	Research Assistant & Demonstrator, Nottingham Polytechnic.
1987	PhD, Dorset Institute.
1988	Researcher, Kingston University.
1995	Reader in Business School, Kingston University.
1996 –	Director, Small Business Research Centre, Kingston University.

References:

Programme reference L3004.

R Blackburn & J Beard (1997) Intellectual property and UK SMEs: A literature review and research agenda.

R Blackburn (1997) IP in SMEs: A survey in four industrial sectors.

Intellectual Property Initiative

RESEARCH PROGRAMME ON INTELLECTUAL PROPERTY

Director: Professor J.N.Adams 1998

2. *How big companies manage their intellectual property*

Duncan Matthews of Warwick University talks to David Fishlock

"Is it really worthwhile for industry to engage in time-consuming negotiations with universities over intellectual property rights when proportionately they yield so few patentable inventions?" asks Duncan Matthews.

Research Matthews has led into intellectual property protection in large science- and engineering-based British companies suggests that such negotiations are often largely irrelevant. Research contracts placed by such companies with universities are not of a kind or a size that is likely to lead to patents.

Matthews is a lecturer in intellectual property law at Warwick University, and a Visiting Fellow of the National Institute of Economic & Social Research (NIESR), the London "think-tank". His project has been assisted by three senior co-researchers: Professor John Pickering at Bath University; Dr John Kirkland, company secretary of NIESR; and Caroline Wilson, a research officer of NIESR. It is part of the Intellectual Property Institute's research programme on intellectual property (see also page 4).

The thrust of this research programme is to discover whether IPR is being taken seriously enough by those who are making industrial policy.

Matthews leads a project examining research contracts between universities and companies. Its aim is to discover what is considered good practice in the strategic management of intellectual property, and what are seen as the problem areas.

The project interviewed industrial liaison officers at five UK universities, and identified 17 UK companies which had placed research contracts. It then carried out about four interviews with each company, typically with a senior representative of R&D, marketing, commercial management, and university liaison. Mostly they were large multinational companies in the FT 100 index.

"Quite a few companies said past experience of missed opportunities had led them to take IP more seriously", says Matthews. Competitors had seized upon unprotected ideas or lapsed patents. Patenting is now their main technique for protecting IP.

The project finds most IP originates in the R&D base of the companies - "not in collaborations with universities, not in outsourcing, not

"Quite a few companies said past experience of missed opportunities had led them to take intellectual property more seriously" –

Duncan Matthews

in business clubs, etc." So sharing of rights is not a problem. The research also shows companies to be growing more focused on core businesses, less interested in "blue sky" research. As for university collaborations, their primary interest can range widely, from sponsorship of students to research likely to develop into patentable products.

Companies use patents, the project finds, to try to retain exclusivity for new products and processes. An effective patent life is often no more than ten years but products can sometimes be kept "evergreen" by further development and patents. Unwanted ideas may be licensed to generate income. Companies tend to monitor the R&D activities and patents of their competitors.

Laying minefields

A key stratagem, the research reveals, is to build up a portfolio of patents in a particular product area as a disguise, making it harder for competitors to pinpoint the key patents, or indeed even to engage in R&D in the area. Such a "minefield" of patents can discourage entry by competitors, while the company may try to keep its product evergreen with new patents.

How seriously do companies take their IP? "All companies we interviewed said it was an important part of company policy", Matthews reports. But the interviews show how they differ considerably in real staff commitment. "Where there's a high level of interest at board level, IP is taken seriously throughout the company".

Many companies have policy statements that set out corporate organisation and management of IP, and formal procedures on patenting policy, for instance. He finds such documents rank importantly with patent departments while R&D may not follow the procedures set out in them.

"Many companies realise it's not enough just to have a document." There must also be training and dissemination of information on IP, and instruction of new employees in IP policy. But he learned that managers sometimes sent juniors – even secretaries – to IP briefings. "That indicates a lack of commitment to us".

Generally speaking, says Matthews, career development does not depend on the number of patents granted. Nevertheless, patents are seen among peers – for example, in R&D – as important recognition of achievement.

The science-based companies do not reward inventors – pharmaceutical firms, for instance, see drug discovery as something they pay scientists to do. Engineering companies are more inclined to reward employees with "discretionary awards". In both cases, once patents are applied for, the inventor is encouraged to publish, resulting, says Matthews, in a greater number of publications than come from the academic world.

Who pays for corporate IP services? "Who pays has quite an important bearing on the IP strategy adopted", says Matthews. He finds the current vogue for devolved budgets is tending to make R&D departments financially responsible for IP services, and hence for the need for internal marketing of patent department services.

This is having some significant consequences, he says. R&D looks harder at whether patents should be applied for or renewed. "Particularly at the end of the financial year it's easy for R&D management to target patents for savings".

But he finds that many companies strongly committed to an IP policy have established safeguards: "sophisticated procedures and consultation before a patent is ever abandoned, for instance".

Fight for patent

Not every company interviewed was clear on the general principle that it should file for a patent only if it is prepared to defend its patent in law. But for some this principle means patents are not the preferred option in protecting IP. "Secrecy or speed of response may be thought more appropriate, particularly for SMEs", says Matthews. Sometimes a firm will publish deliberately in order to spoil a rival's chance of a patent.

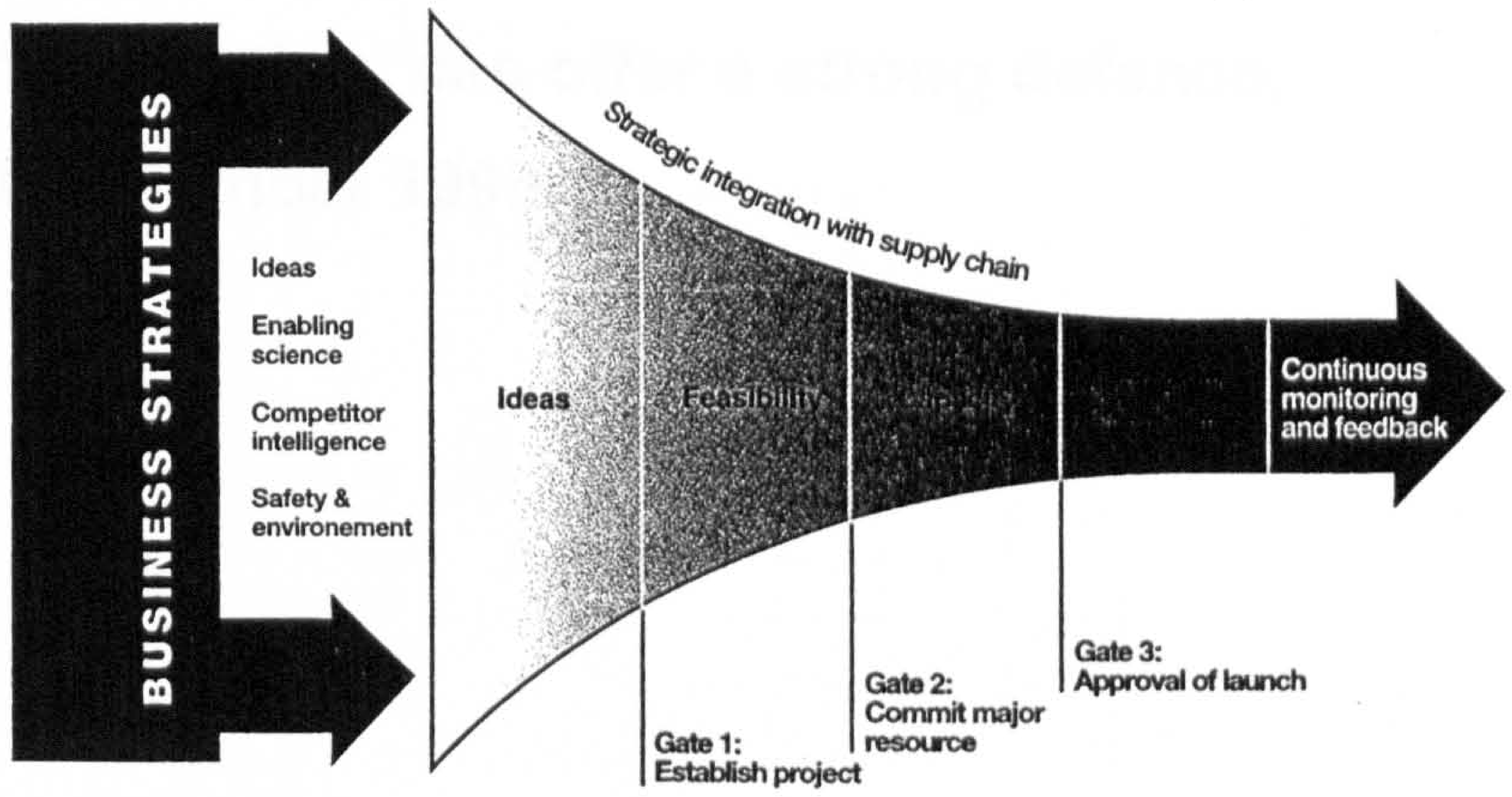
Matthews explores corporate attitudes towards external collaborations that might generate IP. Reasons offered for collaboration include access

Collaboration: how they compare

Universities	SMEs
LOWER COSTS	WORK NEAR MARKET
WIDER INTERNATIONAL LINKS	INDUSTRIAL EXPERTISE
MORE OPEN-MINDED APPROACH	HIGHER PRODUCTIVITY
RECRUITMENT & PR ADVANTAGES	COMMON OBJECTIVES
	MORE LIKELY TO DELIVER
	MORE DIFFICULT TO CONCLUDE AN AGREEMENT

to wider knowledge and expertise, fresh minds, international contacts, specialist equipment, and recruitment. Collaborations are forged mainly by company R&D staff, although "cold calling" by universities to academic liaison offices in companies is growing increasingly common. Companies tend to shy away from multiple-partner collaborations because of possible IP problems.

Innovation funnel with gates

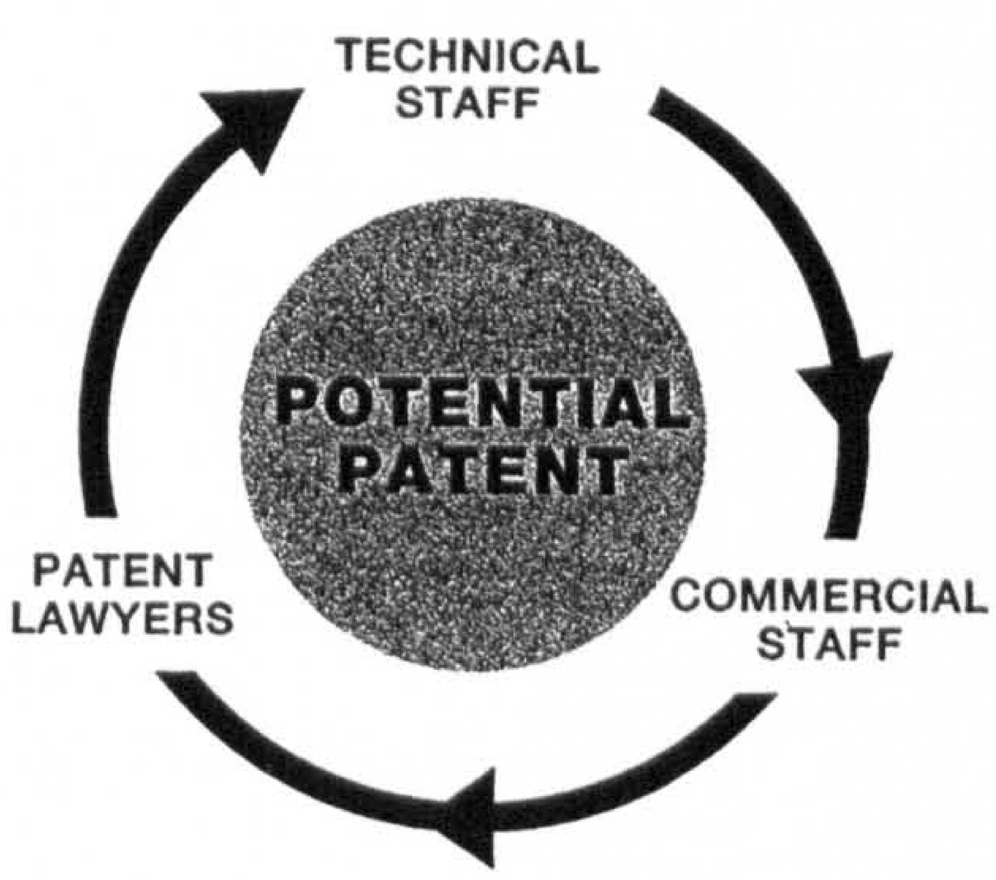


The box on page 2 contrasts the advantages seen by companies for two types of collaborator: universities and small and medium-sized enterprises (SMEs).

"Academics are seen as bad at meeting deadlines", Matthews comments.

Key features of industry's experience of university collaboration to emerge from these interviews include their modest size – generally less than £100,000 in value unless government is also involved. They tend not to be "near-market", but not "blue sky" either. Significant patents are not expected from them. But it is a relationship that is still maturing, he adds.

What we've learnt, says Matthews, is that technical staff have the ideas but commercial managers tend to take the decisions relating to corporate strategy on IP. They liaise with the patent lawyers, who in turn take responsibility for making technical staff aware of the importance of a potential patent. But technical staff do not run the activity themselves, which leads to the circle of responsibility illustrated below:



One of the most successful ways of making employees aware of the importance of IP proves to be the use of "innovation gates" (see sketch above). The R&D project proceeds through a number of phases separated by "gates" – decision points where certain closely defined criteria are weighed before it is allowed to proceed. IP issues are one such criterion, along with whether the project is getting the resources it needs. "We think this is a good way of ensuring that IP is part of the overall decision-making process", says Matthews.

Personal file

Duncan Matthews (32)

1986	BSc (Hons), Plymouth Polytechnic.
1987	MA, University of Warwick.
1987-90	Lobbyist, Eurofi Public Affairs Ltd.
1991	LLM, University of Exeter.
1991-5	Senior Research Officer, National Institute of Economic & Social Research.
1996	Jean Monnet Lecturer, Law & Politics of European Integration, University of Warwick.
1997 -	Research Fellow, ESRC Centre for the Study of Globalisation and Regionalisation, University of Warwick.

References:

Programme reference L3023.

J F Pickering, D Matthews, C Wilson and J Kirkland (1997): Determinants of intellectual property strategy in UK companies, London: NIESR Discussion Paper Series.

ANNEX 2:

Gourlay, R. How a 'big brother' can offer a strong defence, *Financial Times.* 21 November 1990

Protecting patents

How 'big brother' can offer a strong defence

Richard Gourlay reports on Renishaw, a technology high flyer

If David McMurtry had had his way 20 years ago he would probably not now have a personal fortune, a raft of awards and a reputation as one of the biggest names in metrology.

The foundations of the success of Renishaw, the company he helped found, lie in his invention of a device which measures machined parts called the touch-trigger-probe. But an early lucky break with patents and their subsequent fierce defence and extension coupled with a knack for creating new markets is as much a part of the story.

Renishaw provides a vivid example of the value to smaller companies of vigorously protecting products wherever possible with patents, and of having a financially strong "big brother" to defend them in the courts. It is also a reminder that patents must be nurtured, not ignored once in place, as they will expire.

McMurtry developed the original device in his living room one weekend when his employers at Rolls-Royce had run into problems machining parts with sufficient accuracy for the Concorde engine. Using a surprisingly simple concept, he came up with a device, a Kinematic location system, that helped measure machined parts to tolerances of ⅕ of a micrometer. It revolutionised measurement so that within 10 years his probes were as familiar on machine tools as electric kettles are in today's kitchens.

From its base in the sleepy Gloucestershire town of Wotton under Edge, Renishaw has achieved remarkable sales growth and enviable margins; in the past five years turnover has jumped by 300 per cent to £48m, on which it turned in profits of £13.4m.

McMurtry could have lost control of the technology, as many other inventors before him have done, had Rolls-Royce not refused to allow him to develop his probe alone. Instead, McMurtry and a colleague, John Deer, left to develop it under licence but took with them a crucial undertaking that Rolls-Royce would help protect the patent.

"If I had been on my own, bigger companies would have copied and told me to sue," McMurtry says, recalling a time when Renishaw almost certainly lacked the resources to fight a long patent battle. In 1976, it faced its first patent challenge which lasted for two years; but Rolls-Royce defended the patent and won.

With this early victory behind it Renishaw continued to maintain the kind of margins – as high as 50 per cent in the early years – it needed to spin off the cash for early research, development and growth without any serious calls on its bankers. By the end of the 1970s, its probe had become a recognised industry standard on co-ordinate measuring machines (CMM) for the inspection of machined parts.

Next, the probe was developed for computer numerically controlled (CNC) lathes and machining centres. The probes allow machine tools to set themselves up accurately and self-correct when things go wrong. They are now generally seen as essential for further development of flexible manufacturing systems (FMS) and fully automated manufacturing.

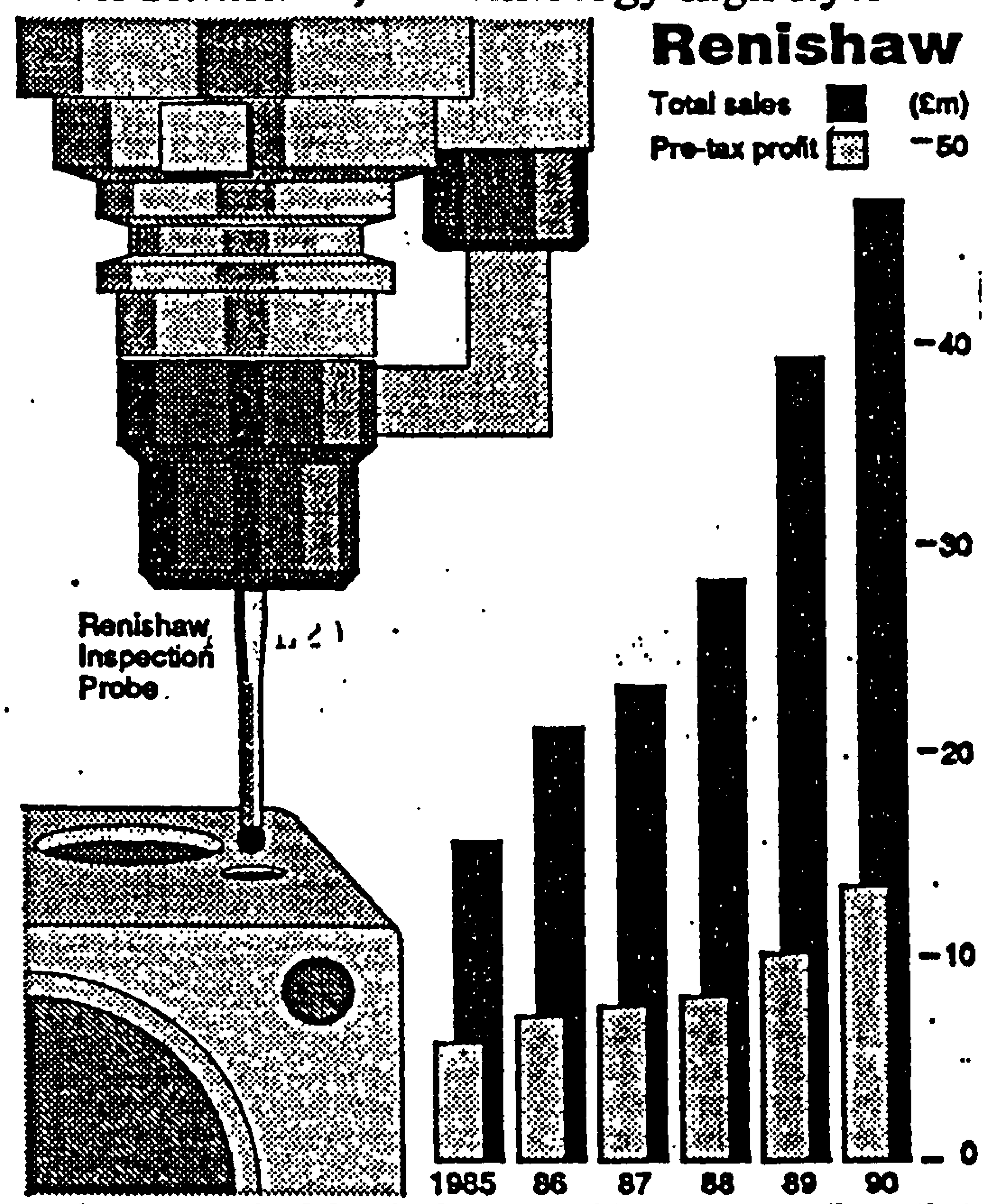
Various Renishaw probes are used by Transmanche Link to check pre-cast concrete segments on the lining of the Channel Tunnel; and they are in standard use to ensure necessary tolerances are observed in the manufacture of jet engine casings and blade tips.

After its early experience, Renishaw was fully aware of the value of patents, something that might appear obvious but has escaped many companies that too often take cheaper short cuts, according to British Technology Group, the state-owned technology transfer company.

However, patents expire. Renishaw has tried to beat this by creating add-on products – patented of course – for the original probes. "Our plan is to patent as we go along," says McMurtry. "Even if competitors are able to make our earlier probes these would not now be accepted in the market because we have better products which remain covered by patents."

It is as if boots had been patented before the invention of laces. By the time the patent expired, laces would have appeared and been patented. A newcomer would be able to make boots but who would buy them without laces?

Renishaw has concentrated on developing new products



such as motorised heads for probes, "flexible joints" from the machine head that allow the probes to measure from any angle and new, more sophisticated probes.

Although the patents on Renishaw's first probes start to expire in Europe within 14 months and in the US in six years, the company is banking on the patent thicket it has erected to give it effective cover for much longer.

Renishaw is also trying to develop new markets by enlarging the applications of the original probes. One development could reach a surprisingly wide audience for what is still a very specialised field.

This new product uses ordinary touch-trigger-probes and a simple PC programming package to trace the contours of an object, record it and reproduce it. For a few thousand pounds a design house can copy the design of almost anything – an attribute that has not escaped the numerous Hong Kong traders who have bought the product.

Its fastest growing product, the laser interferometer, exploits the fact that machine tools lose their precision during operation. Laser interferometers calibrate machine tools or machines that measure their accuracy and check the machine's movement.

Renishaw has also tried to increase the number of probes it can sell per CMM. Ten years ago each CMM would have one, worth £2,500 in sales to Renishaw; now each machine can be sold with up to eight probes, worth over £25,000. This means its sales are no longer directly dependent on the sales of CMMs, providing a useful hedge against an engineering recession.

Renishaw's progress from McMurtry's living-room floor to a leading player in metrol-

I Hartwell

ogy has not always been smooth. After Renishaw left the USM for the main stockmarket in 1984 the City began to worry about the acumen of a number of boffins-turned businessmen. There were some fears that Renishaw might be heading for a research and development binge or exciting, but unprofitable forays, into other high-tech areas using the cash it was spinning off.

In the event, Renishaw's research and development engineering budget has been held at between 10-15 per cent of turnover and its lessons in the acquisition classroom proved relatively cheap to learn.

In 1985, Renishaw spent £0.75m for 75 per cent of Micro Aided Engineering, a company making software that allowed computer-controlled machine tools to talk to each other, and promptly lost £400,000 in its first year. The business was closed. McMurtry recognises that the company made mistakes and is now wary of buying companies in order to acquire technology with which he and his team are not familiar.

Apart from the successful purchase of a French company to develop existing business lines, McMurtry says there are no plans to dig into Renishaw's £18m cash pile for acquisitions unless an absolutely golden opportunity arises.

Throughout this period, the constant protection of its patents by Rolls-Royce meant that, when confronted with the most serious challenge to its patents from the US company GTE-Valeron – which threatened Renishaw's biggest market in the US – a successful defence was mounted.

After a three-year battle in the US courts which drained cash and management effort, Renishaw not only emerged with its patent intact but with the opportunity to take over the customers that GTE-Valeron was no longer able to service. The £3.34m settlement reported in Renishaw's 1987 results, which did not reflect the amount due to Rolls-Royce, confirmed Renishaw's view that its legal department was a profit centre.

Most recently, Renishaw successfully defended the validity of its patents on touch trigger probes in Dusseldorf after an infringement by Zeiss and Heidenhain of Germany. It was the first patent case successfully fought by Renishaw without the background presence of Rolls-Royce, which sold to Renishaw last year its right to royalties to Renishaw.

ANNEX 3:

Extract from Renishaw Group Profile 1998

How it all began

David McMurtry

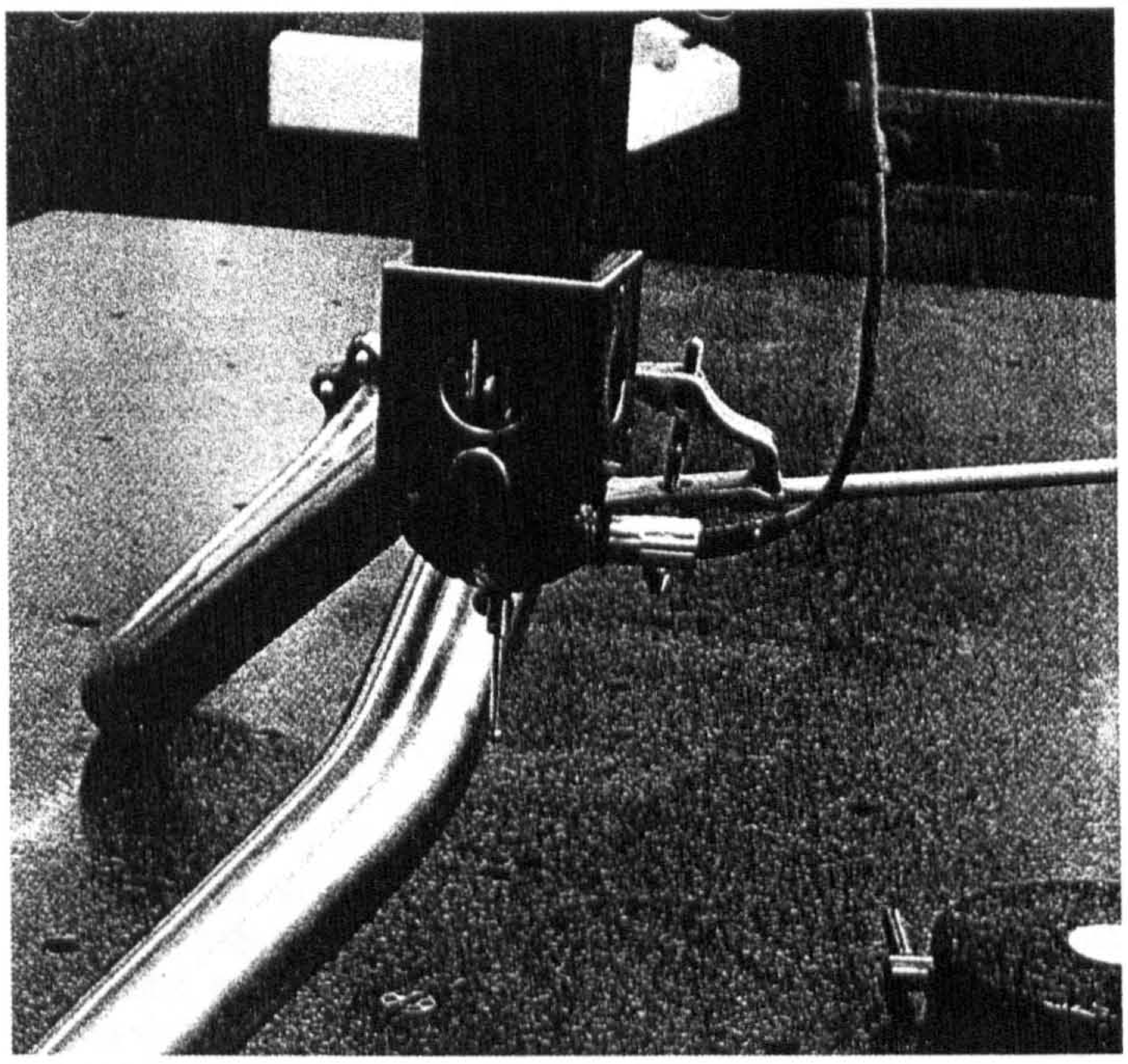
The first touch-trigger probe was invented to solve a specific inspection requirement, but went on to transform the design and revolutionise the use of Co-ordinate Measuring Machines (CMMs) for post-process inspection of manufactured components. The problem arose at Rolls-Royce plc in 1972, where David McMurtry, now Chairman and Chief Executive of Renishaw plc, was Assistant Chief of Engine Design of all Rolls-Royce engines manufactured at the Filton, Bristol works.

David was asked for his advice on a problem of measuring some complex pipe runs, of only .25″ diameter, for the Olympus engines used on Concorde. The pipes had to fit accurately between solid mountings, but the difficulty came in measuring them once they had been manufactured. David's team had already developed a system to define and measure points in space using a v-shaped probe which fitted over the pipe. The CMM used was one of the first Notsa machines, with a granite table, which was heavy to operate. Using the machine to measure these small diameter pipes was extremely difficult when using a solid probe because the pipes were deflected by the pressure of the probe making contact.

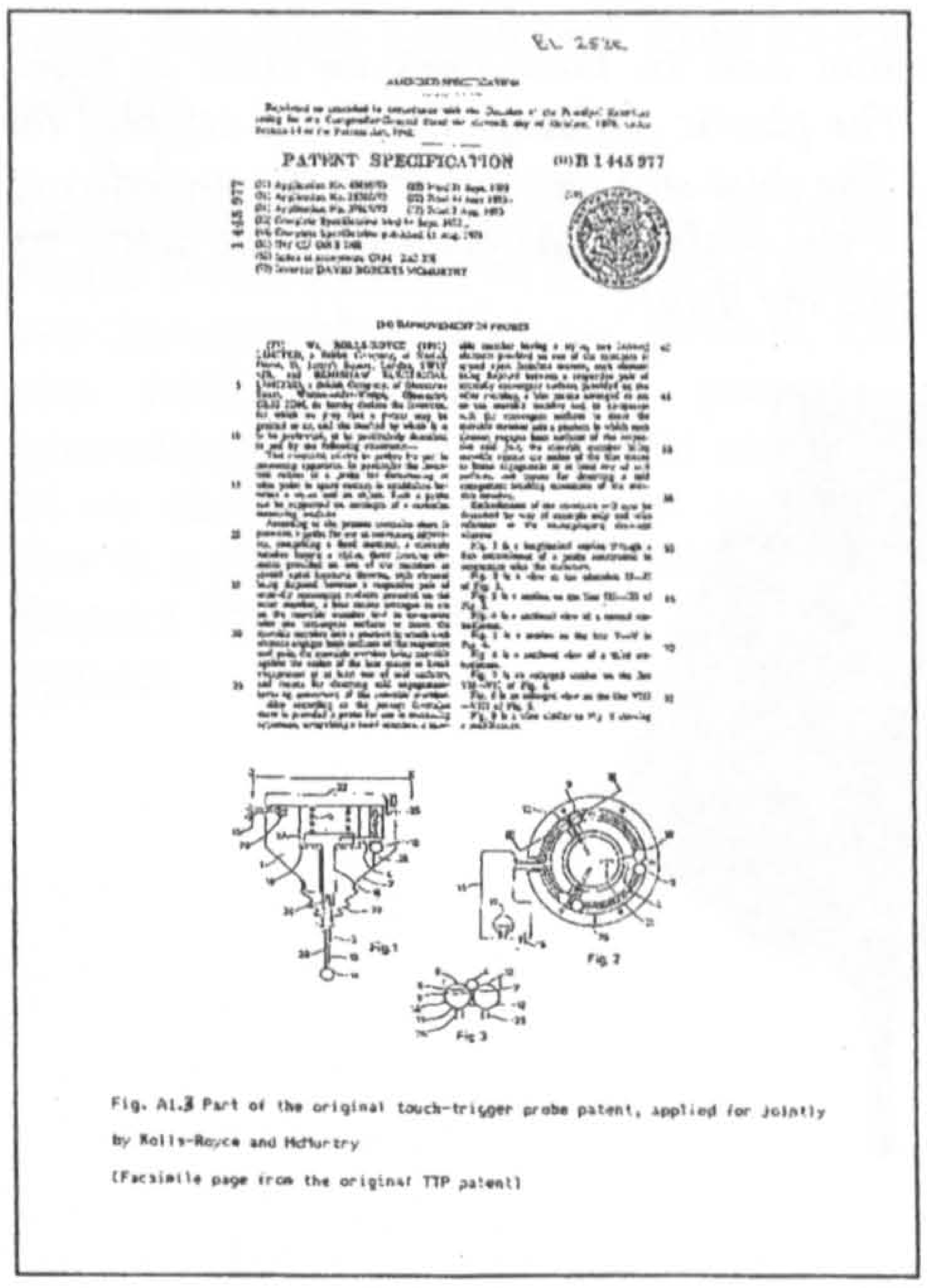
The job was urgent so David himself took a look at it. He decided that what was needed was an optical probe, or something else that did not deflect the pipe. Taking the problem home with him, he built the first touch-trigger probe over a week-end. The probe was quite a simple construction but because it employed fundamental kinematic location principles, it was sufficiently accurate for the task. That first probe was simply a switch where as the stylus touched the component and was deflected, contact was broken and froze the digital reading on the Notsa CMM. This was done quite simply with a battery in a circuit including a solenoid which took the place of the machine's normal foot switch.

David describes how he made the first probe. *"I drew a circle on a table and divided it into three with a pair of compasses, as any schoolboy knows. I put six ball bearings on the table at the three radii and embedded them in plastic padding. I soldered up the connections between the balls and built up the plastic padding to form a body. Then I made a crucifix and stylus on a Myford lathe. Next day I took it into the factory and it worked".*

Rolls-Royce took out a patent on David's original design, which was filed on 21st September 1972 with him acknowledged as the inventor.



An early touch-trigger probe taking pipe measurements on a CMM



PATENT SPECIFICATION (11) 1 445 977

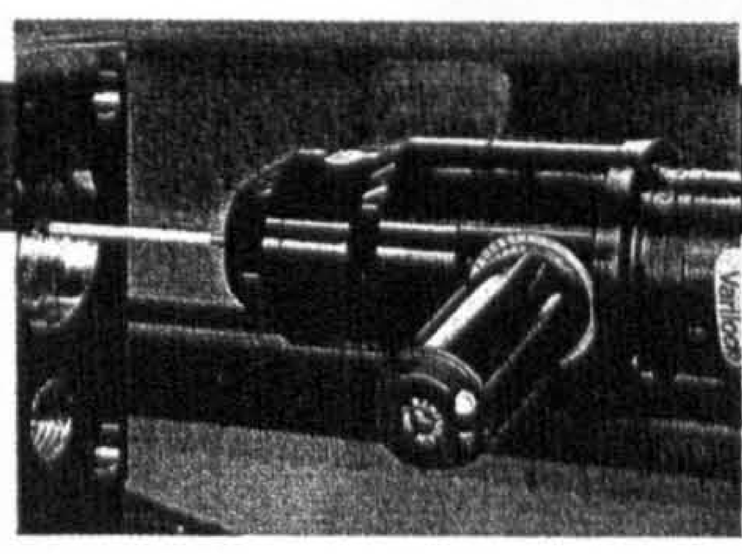
Fig. A1.3 Part of the original touch-trigger probe patent, applied for jointly by Rolls-Royce and McMurtry

(Facsimile page from the original TTP patent)

Patent specification

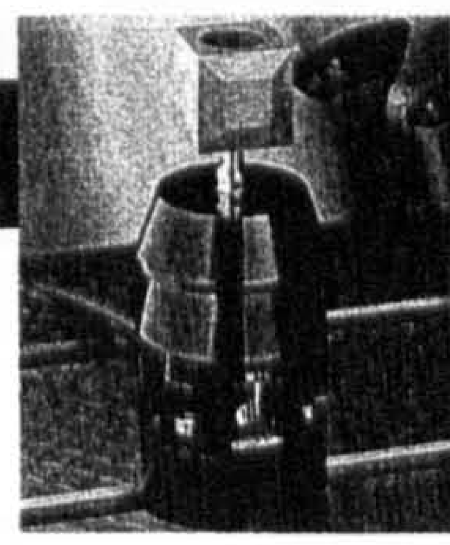
1980

MP3 probe with optical transmission



1980

MP4 toolsetting probe for milling machines



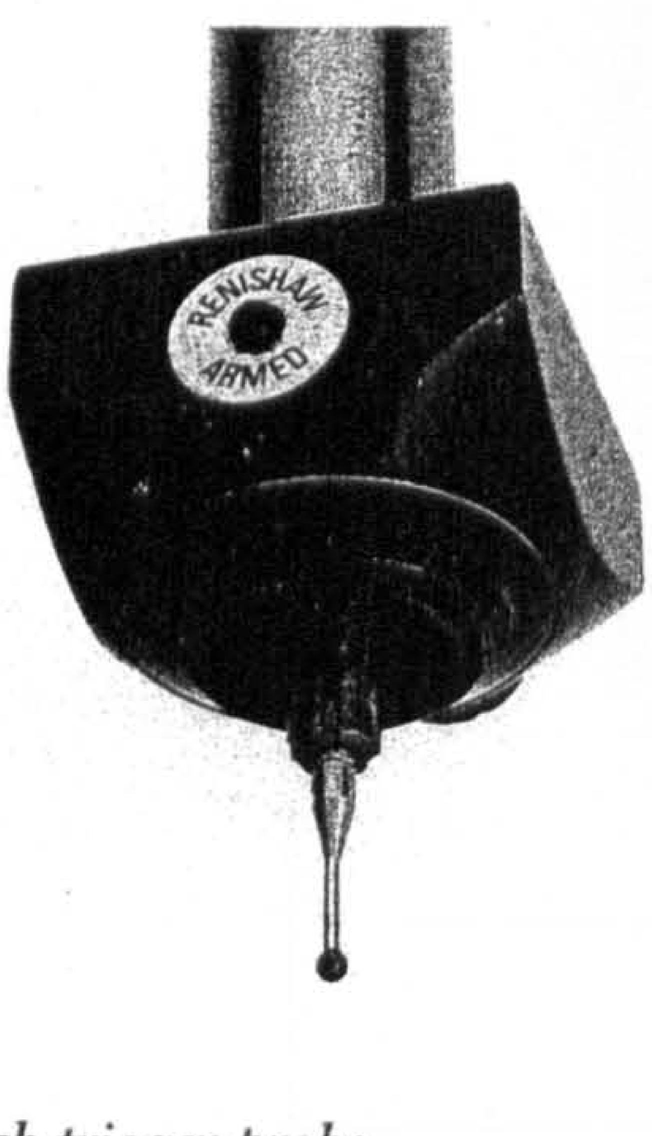
John Deer

Around this time David discussed the matter with John Deer, now Deputy Chairman of Renishaw plc, who was also working at Rolls-Royce, on power plant aerodynamics. John Deer had a background of machine shop engineering but wanted to have his own business. He had been approached to join his brother-in-law's business making and selling telephone answering machines, but had declined the offer as it was not really what he wanted to do.

John Deer takes up the story: *"We met in the Technical Library one day and David asked me what I was thinking of doing. I said that I wanted to do my own thing. David said he thought he had something of interest, which was his own design for an energy efficient central heating boiler. When we next met however, he did not mention this but took me down to the Notsa machine on which his probe had been fitted.*

Norman Key of Notsa, and later Chairman of LK, heard of David's invention and immediately realised its potential. We visited him in Derby and he gave us an order for ten probes. He required the shanks to be ground rather than turned and as we did not have ready access to such a facility, Notsa undertook this free of charge. The order was worth £3,333 to us!

We went into production and in those days we used to make everything ourselves. The plastic padding finish was stippled on and hand enamelled. The dust seal was cut from the underlay of one of David's carpets - you could see the progress of the probes we made from the line across the floor!"



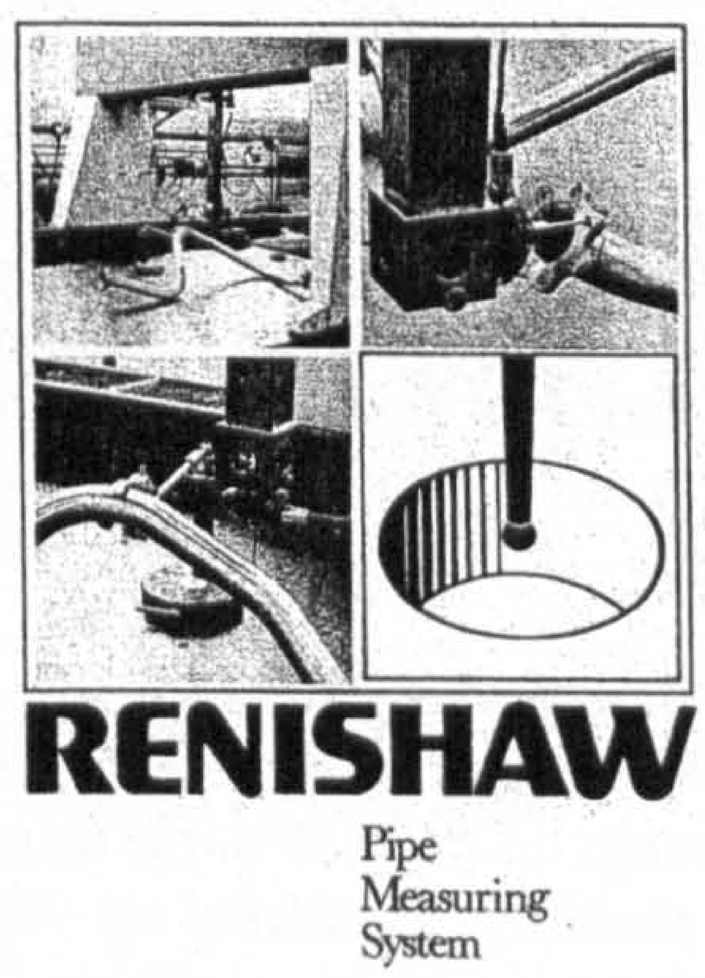
Early touch-trigger probe

Notsa showed the probe at an exhibition and it attracted considerable interest. John Deer then wrote to other CMM manufacturers and received follow-up enquiries from the UK and the USA.

The first Renishaw company, Renishaw Electrical Ltd, was registered on 4th April 1973, but the early probes manufactured in 1972 used the name S&A. Earlier, David McMurtry had formed, in his spare time, a small manufacturing operation with friend David Dring, which they called *Shepherd and Adams.* The name was derived from the maiden names of their spouses. They made components for some of David McMurtry's earlier inventions, together with a few jigs and fixtures which they sold to engineering companies. In those early days, it seemed sensible to use some of these facilities.

David McMurtry had invented the probe whilst an employee of Rolls-Royce, so the patent was held by them. To secure its position, S&A needed a manufacturing licence but it was commercial practice at Rolls-Royce only to negotiate such licences with companies having limited liability. An "off the shelf" company called Renishaw Electrical Limited was acquired from a Bristol firm which specialised in registering and selling companies, by Doug Elliot, a Round Table colleague of John Deer. Doug, who was Group Finance Director of United Transport, Chepstow, Gwent, provided them with financial and legal assistance in those early days. It was intended to change the company name but as David said, *"We never quite got round to it."*

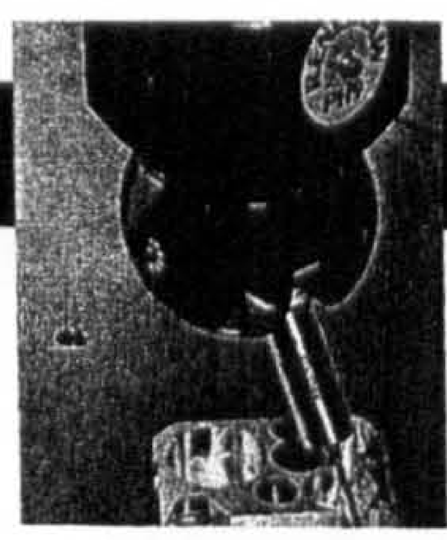
Renishaw Electrical Ltd entered into a licence agreement with S&A which continued until the agreement ceased in 1976. From that time, all probes carried Renishaw's trademark.



Early promotional literature

1980

PH9 motorised head for CMMs

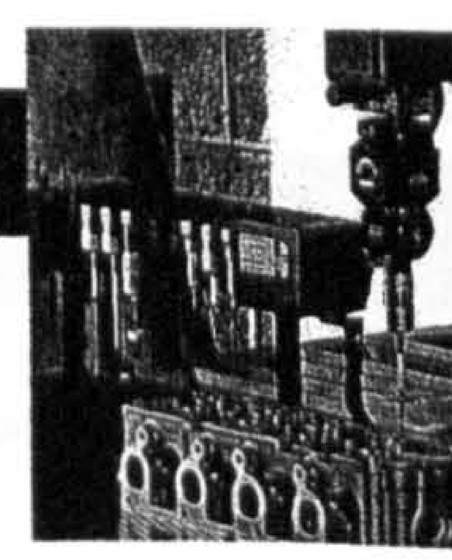


1981

LP1, LP2 probes for CNC lathes/turning centres

1984

PH9A motorised head, ACR1 probe Autochange system for CMMs



Incidentally, Renishaw also happens to be the name of a village in Derbyshire. Renishaw Hall is the home of the Sitwell family who are well known for their literary works and eccentricities!

By 1974, Renishaw's business had grown to such an extent that John Deer finally decided to leave Rolls-Royce and work full time for Renishaw. By 1977, David McMurtry had been promoted to Deputy Chief Designer but negotiated to become a consultant to Rolls-Royce on a two-day week basis, giving him more time to devote to Renishaw's expanding business. It was not until 1979, however, when he had completed his responsibility at Rolls-Royce for the RB401 "Quiet Engine" project, that he joined Renishaw full-time. The test engine was donated to David McMurtry in 1996 and will become part of Renishaw's "Historical Collection".

During David's employment at Rolls-Royce, he produced a number of different probe designs which were patented by Rolls-Royce themselves. Although not many of them were marketed by the new Renishaw company, the effect of these patents made it very difficult for competitors to find a design which could compete effectively without infringing one or more of the patents.

An important milestone in the history of the company was the establishment of joint proprietorship with Rolls-Royce of David's original patents. John Deer had been studying a book on patent law and found a section which explained that a co-patentee could not licence a third party without the permission of the other partner. He realised that Renishaw was itself only a licensee and could not be safe from the possibility of Rolls-Royce licensing other companies to manufacture probes, unless it obtained co-ownership status.

John approached Rolls-Royce in 1976 and was successful in persuading the company that joint ownership of the patents was in the best interests of both parties; Renishaw being provided with added security and encouragement to develop the business, Rolls-Royce enjoying a high and increasing royalty income from a single source.

The first benefit to Renishaw from this new relationship with Rolls-Royce came quickly when in 1978, DEA, Renishaw's largest customer at that time, introduced its own small diameter probe. This probe worked on the same principles as those devised by David McMurtry and Rolls-Royce agreed to take action against DEA for patent infringement in Italy. The case was eventually settled by a licencing arrangement which was satisfactory to all three parties.

Rolls-Royce made it clear, however, from this time, that although prepared to provide assistance from their Patent Department, any future conflict over patent matters would have to be funded solely by Renishaw. In view of this situation and because there were signs of competing probes coming on the market, Renishaw negotiated a significant reduction in royalties.

Renishaw's business was again threatened when, in the early 1980s, GTE Valeron in the USA began to market its own touch-trigger probe. This had to be confronted because the competitor's strength could have made serious inroads into Renishaw's market worldwide. A law suit followed and resulted in a court trial in the USA. It cost about $1 million before Renishaw and Rolls-Royce finally obtained an injunction forbidding the manufacture and sale of this probe, together with compensation of a substantial sum which the company agreed not to disclose.

David McMurtry said that Renishaw's US lawyers warned him to expect legal costs of around $250,000. He added, *"We were lucky that our lawyers underestimated, because if they had originally told us that the legal costs would be in the region of $1 million, we might never have fought the case"!*

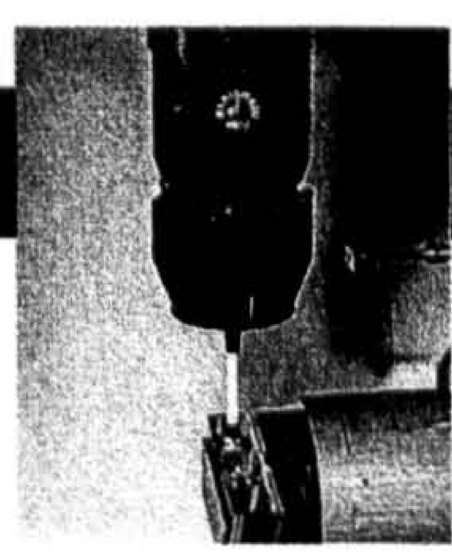
Since that time, successful patent actions have been taken against several competitors in Japan, USA and Germany.

The relationship with Rolls-Royce terminated in 1987 when Renishaw purchased Rolls-Royce's 50% share in the patents.

Following further legal action in Spring 1997, The United States District Court of Michigan handed down its decision late Summer that Marposs' probes, subject to litigation, do not infringe Renishaw's patents. The Group has accordingly lodged an appeal and the outcome is awaited. In an earlier law suit against another company, Renishaw was in a similar position, having lost the original case in a District Court in the USA, but subsequently winning on appeal.

1985

MP7/8/9 compact probes with optical transmission for CNC machine tools



1985

OP2 laser probe for CMMs

1985

MCG machine checking gauge for CMMs

ANNEX 4:

Baker, A. Torotrak, *Automotive Engineer.* June/July 1996

TOROTRAK

After a long spell of focussed technical development the Torotrak toroidal traction-drive transmission is approaching the crossover point from working concept to actual manufacture. Alan Baker reports on the developments since it was covered in the February/March 1990 and June/July 1991 issues of *Automotive Engineer* that have lead to a number of important licensing agreements.

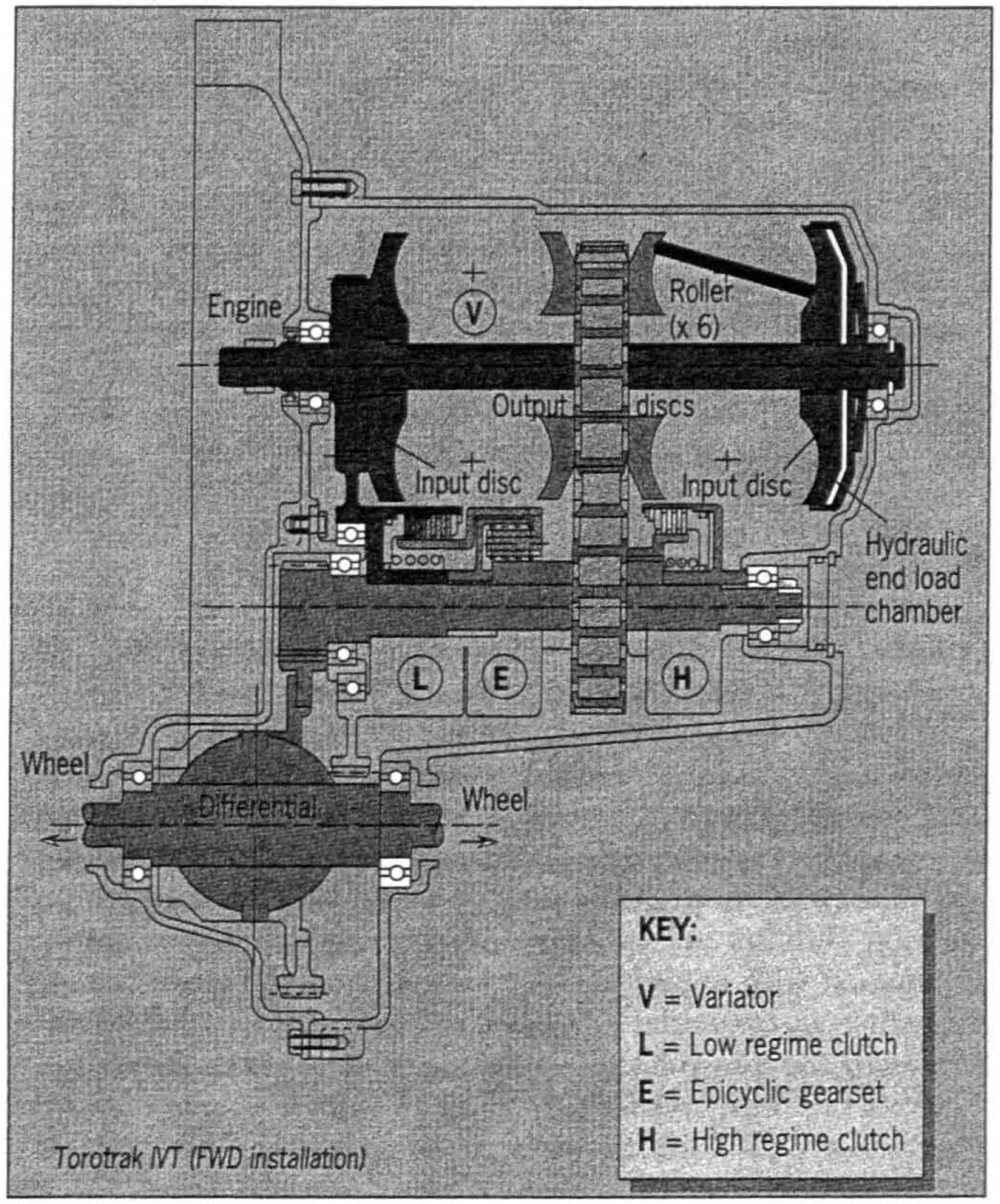
Following its privatisation in 1992, when it was transformed into a technology transfer company from being a supporter of lame-duck inventions the British Technology Group, floated as BTG plc on the London Stock Exchange, is now a fully commercial and international with offices in Philadelphia and Tokyo as well as in London.

The Torotrak (Development) Ltd subsidiary is based at Leyland, Lancs and was initially within the Leyland Vehicles complex – a carry-over from the development programmes of the mid-1980s. Recently, though, it has moved into new ~emises which reflect the ,wth of business from the vehicle industry. Its Technical Director is ex-Leyland Chris Greenwood, the engineer who played a large part in those programmes which successfully ran trucks and buses fitted with the Leyland CVT – a forerunner of the Torotrak IVT. The system, however, is now referred to as an IVT rather than a CVT since infinitely variable is a more accurate description than continuously variable.

Design progress

On the technical front, the period since those earlier AE reports has been devoted to consolidation and refinement rather than radical advances. While the basic disc-and-roller variator mechanism is now familiar enough to need no recapitulation it is worth summarising the previously reported major improvements that have markedly enhanced the transmission's competitiveness. Operational efficiency has in fact been so much improved that Torotrak is claiming a 15 per cent lower average fuel consumption than with a conventional manual gearbox together with an average emissions reduction of 30 per cent. Additionally so effective has the mechanical simplification been that independent assessment puts manufacturing costs significantly below those for the equivalent normal epicyclic-plus-torque-converter four-speed automatic.

The basic Perbury double-toroid format is unchanged but axial length has been reduced by combining the output members into a



Torotrak IVT (FWD installation)

single medial unit. Actuation of the three tilting discs for each toroid is now hydraulic (via double-acting pistons and forked carriages) thus ensuring that they share the load equally and the hydraulic pressure also provides the end-thrust necessary for achieving optimum traction.

Perhaps the most significant change of all, though, is in the control medium. The control parameter is no longer roller position (ie ratio) but instead is the reaction torque between input and output: any change in this torque that leads to relative changes in engine and vehicle speeds will cause the rollers to steer into a new precession angle to reflect the alteration in ratio. This system is very much quicker-acting than the original mechanical control, the whole ratio spectrum being covered in only half a revolution, independent of engine speed.

The present dual-range configuration (see drawing) has evolved from the Leyland days because of the need for a larger ratio spread than could be achieved through simple roller tilting within the toroids. By utilising the mechanical summing property of epicyclic gearing, the set that furnishes the lower range was harnessed to provide a 'geared neutral' that obviated the need for any sort of starting-up device – torque converter or clutch – to the benefit of simplicity, compactness, lightness, minimal power loss and reduced cost as well as giving operational justification to the 'infinitely variable' label. Thanks to the sophisticated electronic and hydraulic control, too, any desired 'creep' can be built-in, up to that needed to hold a vehicle indefinitely on a 25 per cent gradient, this requiring an input from a typical car engine of around 8 kW — a figure that compares very favourably with the power loss in a torque converter on a similar gradient.

Development areas and the competition

AE reported earlier on the development of front-drive designs in addition to the rear-drive kind that had featured from the start. Following the popularity of four-wheel drive vehicles, the current programme covers transmissions for this category as well. Smaller sizes are also on the menu because the Torotrak has no adverse scale effects and promises higher efficiency and better driveability in small cars than do its competitors in the automatic field — an aspect to which I shall return shortly.

The traction fluid is of course a highly critical component of the transmission and one in which several of the major oil companies are taking a keen interest. Shell in particular has done a great deal of experimental work and is understood to be developing a 'new generation' fluid having enhanced torque-transmission and in-service properties.

Dr Geoff Soar, who was with the old NRDC in the project's early stages and is currently Torotrak's Marketing & Licensing Director, regards the so-called 'half-toroidal' variator as having its main advantage — higher efficiency at the roller contact points — more than outweighed by greater complexity and weight, plus the need for thrust bearings. In the double-toroidal Torotrak, of course, all loadings are in balance. Hydrostatic systems, too, can be discounted for ordinary vehicle usage despite their suitability for a number of specialist applications.

The Van Doorne pushed-belt CVT, already used by Ford, Fiat and Rover among others, has recently been accepted by Nissan and Honda and shown itself to be more efficient for the smaller car than the conventional four-ratio auto with torque converter. The Torotrak, though, could more than match it in small car applications and, as already indicated, has no disadvantageous scale effects. There was a big question mark within the industry, said Geoff, against the practicability of increasing the belt size beyond that necessary for powerful engines of 2-3 litres, at which capacity the CVT might be no more efficient than a modern stepped automatic.

It follows from the foregoing that, for supermini-plus cars, Torotrak's biggest competitor is the orthodox four/five-speed automatic. The limitation here, though, is in the scope for future improvement. These transmissions have been around so long that the progress curve is approaching the asymptotic whereas Torotrak is still on the steep initial portion of its curve and yet already substantially more beneficial.

Licensing arrangements

The all-round progress made over the last few years has borne fruit with three major companies having taken out licences: Ford in July 1994; FFD-Ricardo in July 1995; and Toyota two months later. Since then a fourth licence has been agreed with an un-named European tractor manufacturer with a wide size spectrum of products.

Ford's licence is known to embrace manufacture as well as development. As part of a £2 million integrated powertrain programme (with some EU funding) it has already made 15 pre-production Torotrak units which are being installed in Mondeos for evaluation with regard to fuel consumption and emissions performance in particular. Toyota has announced its intention of assessing the transmission on test rigs in Japan and of building a number of prototypes for testing on vehicles — the terms of the agreement with Torotrak includes the option of a full manufacturing licence. AE

Annex 5

Coughlan, A.
Safeguarding Britain's mother of invention
New Scientist. 31 August 1991.

The future of a unique British venture is in limbo this summer as the parliamentarians who must decide its fate relax on holiday. But the scene is set for a fierce battle in October. This is when members of the House of Lords meet again to debate the controversial privatisation of the British Technology Group, the organisation that specialises in taking ideas and inventions from universities, polytechnic and research councils and commercialising them.

The group hold more than 8000 patents and last year returned royalties worth £13 million to British academics who had forged licensing deals through the BTG. The group's most notable triumphs include marketing the hovercraft and magnetic resonance imaging (MRI), a non-invasive way of "seeing" inside the human body. Other successes include pyrethrin insecticides – natural pesticides that kill insects but nothing else – and powerful antibiotics called cephalosporins. The BTG has also bared its teeth in legal disputes. In its most celebrated case, over infringement of the hovercraft patent, the BTG took on and beat the Pentagon.

So the group, with net assets worth £60 million vested almost entirely in intellectual property, has given excellent value to tax payers and academics alike. Over the years the BTG has won the trust of its patrons in the scientific community in Britain.

But this profitable partnership looks destined to change as privatisation looms closer. While the government says the move to the private sector with improve the BTG's fortunes, opponents argue that both the group and academia will suffer.

BTG board members had hoped that the privatisation bill would be passed by parliament before the summer recess. But they missed the boat and must now wait until 15 October when the Lords give the bill its third and final reading. Protagonists from both sides of the debate agree that – barring a change of government – the most likely outcome is that the bill will be enacted. But opponents still hope to delay the process by persuading the Conservative peers – some of whom oppose the government's plans – to break ranks and vote for new amendments. The bill would then be forced back to the House of Commons for MPs to debate the alterations.

The government could pre-empt this move by inserting new passages in the bill to satisfy the misgivings of dissenting Lords. But such a move is unlikely because the government wants to avoid creating legal precedents.

The first hint of change at BTG can be traced to the mid-1980s and the appointment as chief executive of Ian Harvey, an ambitious young businessman who was brought in to guide the group towards privatisation.

"I would not have joined BTG unless it was to be privatised. The logical place to put a body acting as a private sector organisation is in the private sector," he says. Harvey is so committed to privatisation that he has intimated that he will leave if the privatisation fails. This would be a shame, say even his sternest critics who, in private, acknowledge the energy with which he has reshaped the organisation and made it more efficient.

He complains about having to deal with "a new minister every month" at the Department of Trade and Industry, which is responsible for the group. He also says ties to the government create mistrust in potential overseas partners, who fear possible ulterior motives and inefficiency.

Events have grown more fraught and complex since the turn of the year when the government first announced to the public its intention to privatise the BTG.

Gordon Brown, Labour's industry spokesman, reacted fiercely: "The privatisation is based on dogma and nothing else." He said in a debate on the group last February. "The bill has not been pursued because the government believes in British Science, technology or industry but because they believe in privatisation. It is the ultimate in short-term measures from a government dominated by a short-term approach."

Outside government, support for privatisation is confined to the BTG boardroom. The group's 175 staff – a mixture of administrators, technologists, lawyers and patent agents – have made it clear through their union, the Institution of Professionals, Managers and Specialists, that they oppose privatisation. Their chief argument is that moving out of the public sector will destroy the trust they have built up with academia.

The academic community has also voiced misgivings, fearing that a privatised BTG will abandon its "impartiality" when dealing with different projects. They believe it will shun long-term schemes which are unlikely to make money for years in favour of the projects that will yield the short-term profits that are popular with shareholders. Several inventors, responsible for some of the BTG's most successful enterprises have also criticised moves to privatise the group.

Despite these fears, plans for privatisation have continued unabated. As a result, the debate has shifted towards the pragmatists who have worked to insert as many safeguards as possible into the bill to ensure that the nature of the BTG does not change after privatisation.

All groups involved in the debate – even Harvey's board – have tried to persuade the government that the BTG will not succeed as a privatised entity unless its "integrity, independence and impartiality" are preserved intact. Unless the BTG retains these attributes, inventors and academics will not entrust the BTG with the stewardship of their ideas and inventions. The other universally accepted prerequisite for success is that the group retains the specialised talents of its staff and the breadth of its intellectual assets.

Harvey also agrees with others over the biggest threats facing a new-look BTG. The most feared outcome is that corporate predators will buy into the group, wrest control of it and sell off the profitable activities while closing down the unprofitable projects, or those which need time to nurture. Equally threatening is a controlling bid by a big single-business manufacturer – a drugs company, for example. Such a "trade-deal" would allow a manufacturer to suppress inventions that compete with its own products and sell off potentially profitable concerns in which it has no interest.

The government has been slow to respond to pleas to protect the BTG from these hazards. It has moved some way but, according to opposition politicians, it has resisted measures which would protect unequivocally the future of the BTG.

The problem is that the government refuses to write the safeguards into the bill itself. Instead, clauses have been inserted in the 'articles of association'. These lay down the constitution and regulations of a registered company and no company can legally exist without them. But opposition politicians and academics alike argue such safeguards are worthless because shareholders can vote to change them.

Opponents want government to retain control over the company even after privatisation so that it can veto any deals or activities that might jeopardise the BTG. Even Harvey's board would prefer the protection to be written into the statute book, but has resigned itself to the government's wishes. The government itself argues that it has never retained control over a company it has privatised and that to do so would defeat the point of the exercise. In the most recent debate on the BTG, on 22 July, Lord Reay, the government's industry spokesman, was assailed from all sides with pleas for the government to make an exception and enshrine the safeguards in the bill.

But he refused to acknowledge that the BTG was unique because of the long-term nature of its business and the intellectual basis of its assets. "BTG cannot be considered privatised if Parliament retains the power indefinitely to intervene in the company's business" he said.

Lord Flowers, an independent peer and chairman of the House of Lords Select Committee on Science and Technology said that despite the best efforts of the bill's opponents inside and outside Parliament, "ministers have been unbending". It seems that the government wishes to legislate by article [of association] and not by bill, and that, they cannot do.

Flowers warned that unless the government took heed and put the safeguards "on the face of the bill" academics would lose faith with the BTG and make technology transfer arrangements of their own. "A rival BTG will develop within the research community itself, probably in a university, and since that will have the confidence of its potential customers it will attract away not only the business but also the staff of the existing BTG. That would be a shameful waste."

Other Lords said that it was unacceptable for the government to have published the articles of association after the bill had negotiated its passage through the Commons. and so deny elected MPs the opportunity to debate whether the safeguards were adequate.

Lord Williams. the Opposition industry spokesman, hopes the government will relent and include the most important safeguards in the bill before the third reading takes place. That way, he says, the Opposition would not press its amendments but allow privatisation to proceed without further fuss Otherwise, he and other peers including Flowers. have vowed to "fight very hard" on 15 October to force their amendments through.

Meanwhile, the BTG is continuing its preliminary negotiations with potential shareholders, including large pension funds, foundations and institutes. The difficulty says the group's management, is that the government has not yet produced a prospectus, so potential buyers do not know what is on offer. Moreover, uncertainty over the sale of the BTG is creating business difficulties'. a problem compounded by falling profits and growing awareness that the group's highest-earning patents have, or are about to, run out.

Also, the Committee of Vice-Chancellors and Principals has been busy assembling a onsortium that would bid for a university-controlled stake in the BTG, though a spokesman for the committee expressed fears about whether universities can spare the money in the current financial climate.

But perhaps the final word should go to an inventor who has benefited from BTG's enterprise and is deeply mistrustful of the proposed changes. Peter Mansfield, at the University of Nottingham, who developed MRI, says he is angry that inventors have been ignored. "Unless we the inventors are involved in the process and our opinions sought. then that's the end of it."

He fears that even a respectable medical charity which owned a large slice of the BTG might be enticed into bartering the group's assets in return for services, such as cheap scanners. This type of deal could cheat inventors of their royalties.

He adds: "I'm concerned that young inventors have a safe and trustworthy place to put their ideas and not have to lodge them with a fly-by-night organisation that might be gone tomorrow."

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ANNEX 6

Extract from the Torotrak Listing Prospectus

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PART II DETAILS OF THE TOROTRAK GROUP AND THE RIGHTS ISSUE

Introduction

The Torotrak Group is a powertrain engineering group, specialising in the design, development and licensing of an infinitely variable transmission system ("IVT") for production by vehicle or transmission manufacturers. Torotrak's IVT is aimed primarily at the automotive market and is intended to supersede conventional automatic transmissions.

Since its formation by BTG, the Torotrak Group has focused on the creation and protection of intellectual property rights relating to the Torotrak IVT technology together with the design, development and prototyping of infinitely variable transmissions for customers in the automotive industry. In 1960 BTG acquired the rights to the Perbury Engineering Limited patent portfolio. In the 1970s the IVT technology was licensed by BTG to Rover and Lucas who developed the related auxiliary drive transmission for the Harrier jet fighter. In 1987 the technology was purchased by the Torotrak Group from Rover and Lucas, and the entire Leyland IVT engineering team transferred to the Torotrak Group.

The concept of using a Toroidal Variator as the basis of an automotive transmission has been known for many years and attempts to apply it were made in the 1930s and 1950s. However, all the elements required for a successful IVT have only recently become available. Advanced technologies, such as electronic throttle control, together with recent developments in materials and traction fluids, are the principal reasons why Torotrak has been able to produce a working IVT where others have failed.

The Torotrak IVT functions as part of the powertrain and, through integrated computer control of the engine, the Directors believe it will enable fuel economy savings of at least 20 per cent. and a corresponding reduction in carbon dioxide emissions compared to powertrains incorporating conventional automatic transmissions. Further details of Torotrak's IVT are set out in the section headed "How the Torotrak IVT Works" below.

Torotrak's initial research and development work on IVT technology led, in the early 1990s, to the incorporation of a Mark I transmission in a Rover 820i car and subsequently in a Ford Orion. This enabled the Torotrak Group to test and evaluate certain new inventions and to conduct preliminary marketing to potential licensees. By 1994 Ford had commissioned a more advanced (Mark II) transmission for incorporation in a Ford Mondeo. This was delivered to Ford in 1996. The Mark II transmission, together with other variations of this design using other vehicle platforms designed and developed since 1994, has enabled Torotrak and its licensees to carry out detailed assessments of the fuel economy savings, and the driving and performance characteristics of the Torotrak IVT. It has also enabled Torotrak to develop the transmission management system further. During this period Torotrak has experienced and overcome certain technical issues relating to the Torotrak IVT. These include variator instability problems, difficulties with the coupling plate connecting the Mark II transmission to the engine and hydraulic control problems with the Mark II transmission. This experience gives the Directors confidence in Torotrak's ability to resolve technical issues.

Fuel efficiency tests were conducted on behalf of Torotrak in 1993 and in 1996 and 1997 by certain licensees. These tests were carried out on the Ford Mondeo, Ford Orion, Rover 820i and Toyota Cressida using internationally accepted fuel economy test cycles, including the US Federal Test Cycle and the West German Federal Duty Cycle, as their benchmark.

All of these tests were carried out independently of Torotrak and measured the performance of Torotrak's IVT within a test car compared to a standard car. The Ford Mondeo and Ford Orion tests were carried out by Ford. The Rover 820i test was carried out on behalf of Torotrak by Engineering Research Applications Limited, a government accredited laboratory. The Toyota Cressida tests were carried out by Toyota. The results of these tests have led to the Directors' belief that the Torotrak IVT will enable fuel economy savings of at least 20 per cent. compared to powertrains incorporating conventional automatic transmissions.

The Directors believe that since early 1998 the Torotrak IVT has been "concept ready", meaning that no further inventions to the Torotrak IVT are essential to deliver the functions required for effective operation in vehicles. Nevertheless significant further work remains to be done to bring the Torotrak IVT to production readiness. The Mark III transmission is now being designed by Torotrak with this objective in mind (see "Torotrak Group Strategy and Use of Rights Issue Proceeds").

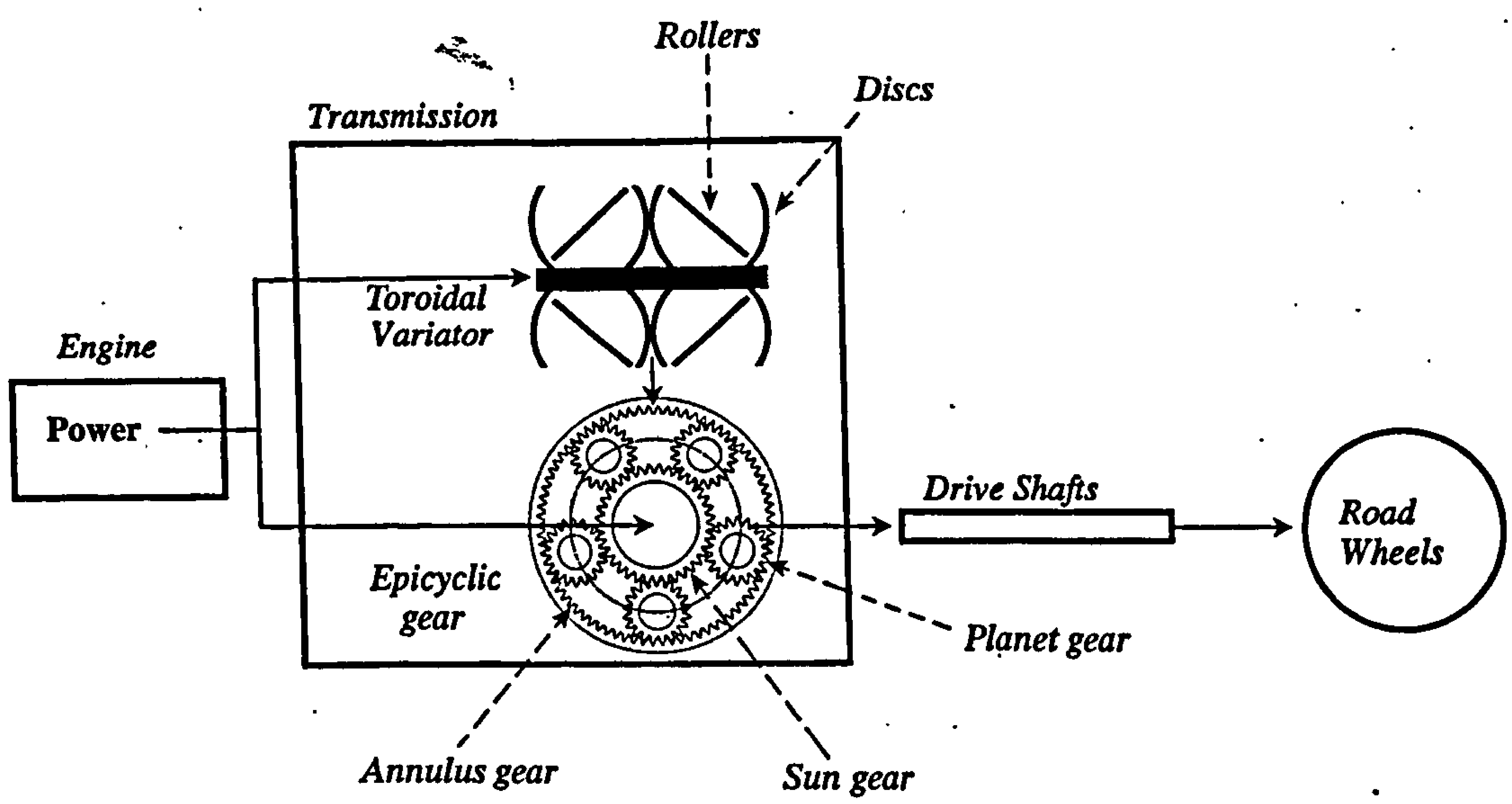
The Technology

All automotive internal combustion engines derive power by burning fuel. The efficiency of the process depends, to a large extent, upon the speed of the engine. Efficient engine operation is achieved by running the engine slowly at open throttle. This reduces friction and energy losses as it minimises the pumping of combustion gases. The range of powers and speeds required at the wheels of a vehicle do not directly match the power output characteristics of internal combustion engines. This mismatch is addressed, to some extent, through the use of a transmission system containing a range of ratios which may either be selected by the driver in a manual gearbox or in an automatic gearbox by sensors which measure driver demands and vehicle performance. To operate with open throttle at all speeds requires a transmission with many ratios and the ability to shift automatically and imperceptibly between them. The Torotrak IVT provides an infinite number of ratios. Several transmission companies have developed automatic gearboxes with a larger number of fixed gear ratios, up from four to five or even six. However, to approach the same level of operation as the Torotrak IVT up to eight or ten gear ratios would be required which would be impractical on grounds of transmission size, cost and vehicle driveability.

How the Torotrak IVT Works

The mechanical system

To give an appreciation of how the Torotrak IVT works the following simplified diagram illustrates how the mechanical part of the Torotrak IVT is arranged.



There are two basic mechanical elements:

The Toroidal Variator – this is a set of toroidal discs between which two sets of rollers (the disc roller assemblies) are squeezed by hydraulic pressure. The tilting of the rollers between the discs changes the ratio in a continuous progression. The two sets of disc roller assemblies provide an equilibrium of forces within the variator unit whilst producing an infinite number of ratios. The function of the variator is to alter its output speed by taking the engine input speed and then varying it up or down as required. The discs and rollers transfer traction at the rolling contact areas via a purpose designed fluid which also serves to lubricate and cool the transmission.

The epicyclic gear set contains three principal parts: the annulus gear; the sun gear; and the carrier and planet gears. Typically, the sun gear is driven directly by the engine, while the annulus gear is driven at the variable output speed of the variator. These two speeds and powers from the engine and the variator are added together by the epicyclic gear and the output is sent to the road wheels via the drive shafts, producing one of three results (considering the inputs and outputs as rotational speeds):

- if the result is positive the vehicle will move forward;
- if the result is zero the vehicle will remain stationary; and
- if the result is negative the vehicle will move backwards.

The engine is able to run at speeds independent of the wheels because the transmission can assume an infinite number of ratios to 'balance' the speeds.

This mechanical arrangement also allows the Torotrak IVT to operate without a separate launch device such as a clutch or torque converter. These devices are a major cause of energy loss in conventional automatic transmissions and, therefore, an engine fitted with these devices is less fuel efficient.

Transmission management system

In a vehicle with a conventional automatic transmission, the electronic management system controlling the powertrain receives instructions from the driver via the throttle pedal. As a result the engine's speed increases or decreases and the transmission reacts accordingly. Thus the transmission is passive, reacting to the engine and seeking to make the appropriate choice of fixed gear for the requested performance.

In the Torotrak IVT, the transmission is controlled by Torotrak's transmission management system which operates the electronic and hydraulic systems which form part of the IVT system. The Torotrak IVT is an active system, and it is the transmission management system which receives the driver's instructions via an electronic throttle pedal and calculates the optimum engine speed and throttle setting sending instructions to the engine to deliver the required power. The Torotrak IVT then controls the delivery of that power to the road wheels. One of the key features of Torotrak's IVT is that the transmission is not ratio controlled, it is torque controlled to provide the required power to the wheels. This means, for example, the Torotrak IVT can keep the engine on its maximum economy control line or, depending on driver preference, its maximum power line for performance. The powertrain is thus controlled and tuned by the Torotrak software: the driver decides what he or she wants, and the Torotrak transmission management system controls the vehicle's powertrain to deliver that performance.

Principal Benefits of the Torotrak IVT

The principal benefits of the Torotrak IVT compared to a conventional automatic transmission stem from the ability of the Torotrak IVT to run a vehicle engine at close to optimum speed for performance or fuel economy as desired for a greater proportion of its operating range. Furthermore, the Torotrak IVT does not need a separate launch device. These benefits lead to:

- significantly improved fuel economy;
- corresponding reduction in carbon dioxide emissions;
- improved acceleration and improved driving characteristics; and
- the ability to customise the driving characteristics of a vehicle to individual driver requirements.

In addition, the production process for the Torotrak IVT will utilise existing materials and manufacturing processes without the need for high precision tolerancing beyond what is required by normal automotive standards for similar components. All of the components are capable of being sourced from existing automotive suppliers and are typical of existing components. The variator itself utilises existing bearing technology. Consequently, the Directors believe that the production costs for the Torotrak IVT will be competitive with those of conventional automatic transmissions.

Furthermore, the Directors believe that the Torotrak IVT will be suitable for any type of vehicle which requires a transmission regardless of engine power and can be packaged to fit within most existing vehicle platforms. These are the bases for the Directors' belief that, over time, the Torotrak IVT has the potential to become the automotive industry standard for automatic transmissions.

Intellectual Property

In developing the Torotrak IVT, the Torotrak Group has generated a broad portfolio of intellectual property including patents, know-how, design rights and copyright. This has attracted the interest of major vehicle and transmission manufacturers, and forms the basis of the licence agreements.

The approach adopted by the Torotrak Group in making patent applications has been to seek protection in respect of each development as it is made. Currently the Torotrak Group has 53 inventions protected by 222 granted patents and 168 patent applications filed in 35 countries. It is the Torotrak Group's policy to expand and refresh the portfolio by maintaining development leadership with new inventions and further patents. Continued investment in research and development and work relevant to OEM customer contracts continues to stimulate the creation of new technology and therefore IPR. Each new patent potentially extends the revenue-earning life of the technology and widens the protection afforded to the Torotrak Group as market penetration develops. Each licensee currently has an agreement with Torotrak pursuant to which new technology they may develop which is core to the IVT technology is either licensed or assigned to the Torotrak Group and thus can be made available to all other licensees.

The patent strategy employed by the Torotrak Group is to ensure that the patent portfolio as a whole is robust by subject and by territory. By subject, the portfolio of patents covers the Toroidal Variator, transmission packaging, transmission management systems, control systems and software. By territory, cover is provided by filing in the major territories of the world where transmissions and automotive vehicles are currently manufactured or sold, e.g. in the United States, Europe and Japan, as well as in areas which the Directors consider are potential growth areas for automotive transmissions, including China, India, Brazil and South Africa.

Part IX of this document contains the Independent Patent Agent's report by Urquhart-Dykes & Lord which sets out the Torotrak Group's patent portfolio.

The Directors believe it is not possible to produce a commercially viable IVT without some associated control software. The Torotrak Group has therefore developed considerable expertise in developing and writing such control software for use in conjunction with IVTs which are based on its technology. The first version of such software is normally written by employees of the Torotrak Group and, since such software needs to interact closely with the engine management system of the vehicle in which the Torotrak IVT is fitted, the software is largely bespoke. Furthermore, such software is frequently rewritten by the Torotrak Group, by the relevant licensee or by both of them.

The Torotrak Group is the owner of copyright in control software written by employees of the Torotrak Group and either owner or joint owner of copyright in software written jointly by employees of the Torotrak Group and others. However, the Directors consider that little value subsists in the individual software programs themselves (as copyright works) compared to both the know-how upon which the development of such software is based and patents licensed, or proposed to be licensed, in the licence agreements. The Directors believe that the know-how is protected by appropriate confidentiality obligations in the licence agreements.

Licence Agreements, Contracts and Strategic Alliances

Licence agreements

The Torotrak Group has entered into licence agreements with seven vehicle or transmission manufacturers which allow them to develop and exploit or exercise their option to develop and exploit the Torotrak IVT technology and a summary is set out below:

Name	Operative Date	Business
Ford Motor Company	1 June 1993	Vehicle manufacturer
Toyota Motor Corporation	1 June 1995	Vehicle manufacturer
Getrag	1 December 1995	Transmission manufacturer
LG Cable & Machinery	1 July 1996	Specialist vehicle manufacturing division of Korean conglomerate
Ricardo-FFD	1 June 1995	Transmission manufacturer
Major European tractor manufacturer	1 April 1995	Agricultural vehicle manufacturer
Major European truck manufacturer	1 April 1997	Commercial vehicle manufacturer

Whilst none of the licensees is under an obligation to manufacture the Torotrak IVT, all of the licence agreements allow the licensees either to exploit, or to exercise their option to exploit, the Torotrak Group's patents and to use the Torotrak know-how, including the relevant technical information and software relating to the patents. The licences granted under the licence agreements terminate on either the expiry of the option period or the later of the expiry of the patent portfolio (which may be extended where the licensee accepts new patents as Torotrak develops its technology) or upon the occurrence of another event (for example, a number of years from the date of first manufacture of the relevant products or a number of years from the operative date). As is typical with licences over technology in this stage of development, the licence agreements can also be terminated by the licensee on between 1 and 6 months' notice or may be terminated by Torotrak in certain circumstances. The licence agreements provide for Torotrak to receive licence income in the form of cash down-payments, or payments to maintain options, and this is received from the licensees at agreed stages. For the three years ended 31 March 1998, Torotrak received licence income totalling £1.2 million. The terms of the licence agreements require each licensee to pay royalties on each IVT unit they produce. The terms governing these royalties vary from licence to licence; in one instance the royalty rate will be determined by reference to fuel economy results in the future and in another agreement on the royalty rate has been deferred by Torotrak until further evaluation of the Torotrak IVT technology has been completed.

The following summarises the Directors' view of the current status of projects with the existing licensees:

- Ford: The IVT Mondeo vehicles (incorporating the Mark II transmission) have reached an advanced stage in driveability, having already demonstrated significantly improved fuel economy over a range of test cycles. Ford has agreed to make the second stage down-payment on the licence in 1998. During 1997, responsibility for the project was reallocated from Ford UK to Ford US. Evaluation work is ongoing.

- Toyota: The contract work for Toyota commenced in 1995 with the initial requirements being to (i) design and build two variator test rigs, (ii) design, build and develop five Torotrak IVT units and (iii) install transmission units into two vehicles supplied by Toyota. Once work commenced, Toyota and Torotrak realised that the scope of work should be significantly increased, partly to cope with integrating the Torotrak IVT into a rear wheel drive application. Toyota and Torotrak have worked closely together and made significant progress. Following completion of the Cressida project work in October 1997, Toyota has commenced an in-house programme to design and develop its own version of the transmission. Torotrak is providing engineering consulting and research services and has agreed to provide resources in the form of people and specialist test equipment to support Toyota's programme. The Directors believe that Toyota will be capable of product launch in 2002.
- Getrag: Getrag is a transmission manufacturer which supplies the majority of its output to BMW. Transmissions designed for evaluation in the BMW 7 series have been assembled by a joint Getrag/Torotrak team and are now being evaluated and developed at Leyland and in Germany.
- LG Cable and Machinery: LG is applying a Torotrak design to an agricultural tractor application and has started a second generation prototype. It has asked for Torotrak to supply engineering consultancy services to assist in its development work and made a third down-payment in 1998 under its licence agreement.
- Ricardo-FFD: Ricardo-FFD has a licence for the application of the Torotrak IVT to certain classes of rallying vehicles. This has not yet led to the commencement of specific development work.
- Major European tractor manufacturer: The project is at the prototype development phase. Two tractors and a number of test rigs are running at Leyland and at the licensee's own premises. Torotrak is writing bespoke versions of its software which will provide additional functions required by the user. The two test vehicles are undergoing simulated ploughing tests.
- Major European truck manufacturer: The first prototypes are fully tested and Torotrak is negotiating the next phase of product development.

Contracts

The Group has also undertaken research and evaluation contracts for licensees and potential licensees. These include:

- Daimler-Benz: The first stage of development work of Torotrak's IVT for the 'S' class Mercedes was completed late in 1997. This showed that the Torotrak IVT could be packaged to fit in the 'S' class Mercedes with either 8 or 12 cylinder engines. Development work on the transmission's cooling capabilities to enable the transmission to cope with theoretical extremes of operation at very high continuous power is ongoing, as a prerequisite for the commencement of the second stage of development work.
- General Motors: Torotrak has agreed to manufacture two variator test rigs which will be delivered during 1998. Negotiations are continuing regarding transmission and vehicle projects and a licence agreement.
- Koyo: Torotrak has supplied a variator test rig and related control software to Koyo. Koyo has supplied bearings to Toyota for many years. Koyo is also a bearing and component supplier to other major Japanese OEMs.

Contracts have also been completed with Shell, Renault, Peugeot and Honda. The Directors believe that further contract work may arise with one or more of these companies in the near future. Project work of this type has in the past and may in the future lead to new licence agreements.

In addition, active discussions regarding a licence and project work based on the Mark III transmission are in progress with the bus and truck division of Mitsubishi.

Strategic alliances

The Torotrak Group has developed informal strategic alliances with Shell, INA Bearings, Busak and Shamban and British Steel, all of which are working on the design and development of products and or materials for use with Torotrak's IVT system in the following specialist areas:

- Shell: Shell has been using its extensive lubricants expertise, including the application of advanced molecular modelling, to design fluids that combine high traction coefficients with wet-clutch performance, gear protection and viscometric characteristics necessary to realise the full potential of the IVT system. In September 1997, Shell announced that it had developed a new generation of advanced traction fluids for use in traction drive systems such as the Torotrak IVT. Shell continues to work on improving the fluid. Shell maintains a direct relationship with some of Torotrak's licensees and customers. Shell is not the only company researching and/or developing traction fluids for use in IVT systems. Several companies in Japan, including Idemitsu, are working in this area.
- INA Bearings: INA supplies variator discs and rollers to Torotrak.
- Busak and Shamban: The association with Torotrak has been established for several years and has led to the development of oil seals to work in the Torotrak IVT.
- British Steel: British Steel is investigating material specifications for discs and rollers used in the Torotrak IVT to improve durability and reduce costs.

Academic and Other Studies

Torotrak is working with the following UK universities which are investigating specific areas relating to the Torotrak IVT:

- Leeds University: The tribology group at Leeds University will be investigating variator contact lubrication and wear in a research project due to start in October 1998. Leeds University will develop a wear model of the variator contact to enable assessment of contact performance over a wide range of operating conditions, including higher rates of slip. The project is to be run in association with Professors Duncan Dowson and Chris Taylor.
- Imperial College of Science and Technology University ("Imperial College"): Professor Richard Sayles at Imperial College is running a project to develop a "new life model" for the variator rolling contact, taking into account surface roughness, relative motion at the contact, tangential traction, lubricating film thickness and other factors thought to affect traction contact life. The objective is to improve understanding of the factors which influence variator contact life and enable more efficient future design, development and manufacture of components.
- Bath University: Bath University is currently running two projects with Torotrak's involvement. The first is an investigation of vehicle powertrain control, concentrating on the interaction between driveability, economy and emission levels. Ford and the Engineering and Physical Sciences Research Council are funding this work, with Torotrak acting in an advisory role. The second project will examine the use of lean burn and increased exhaust gas recirculation on engine fuel economy and emissions. The two projects are complementary and are both being supervised by Dr Nick Vaughan in the Mechanical Engineering Department.

In addition to this specific research carried out on behalf of licensees or for its own use, Torotrak is aware of academic research into, or other projects of a more general nature in respect of, the IVT technology. Some examples of these are summarised below:

"Automotive Traction Drive CVT's – An Overview", Lubomyr O. Hewko, SAE paper 861355, 1984.

Lubomyr Hewko's review of work on the full toroidal traction drive at General Motors highlights the potential benefits of the technology and also the critical technical issues at the time of publication, being cost and high tolerance manufacturing due to ratio control of the transmission. The Torotrak IVT is torque controlled and the Directors believe that Torotrak has overcome the principal critical issues highlighted in this report.

"The rheological properties of elastohydrodynamic lubricants. Regimes of traction in elastohydrodynamic lubrication", C.R. Evans and K.L. Johnson, Proc I Mech E, Vol 200, No C5, 1987 and "The influence of surface roughness on elastohydrodynamic traction", C.R. Evans and K.L. Johnson, Proc I Mech E, Vol 201, No C2, 1987.

Professor K.L. Johnson of Cambridge University continued his earlier traction investigations with J.L. Tevaarwerk when he combined with Dr C.R. Evans to produce these two landmark publications in the field of fluid rheology.

"Recent Developments in High Pressure Rheology of Lubricants", Scott Bair, Leeds Lyon Symposium, Elsevier Science, 1995.

S. Bair and W.O. Winer of the Georgia Institute of Technology ("GIT") have been carrying out similar work in the US, but using a high pressure viscometer rather than an actual rolling contact to study fluid properties. Recent work, some reported in this paper, suggests that GIT is close to a breakthrough in fundamental understanding of fluid traction.

"Versatile numerical procedures – based on speed and force pole offsets – for prediction of efficiency of rolling contact type CVTs", M. Magi, VDI Berichte 1207, October 1995.

Professor Magi at Chalmers University in Gothenburg has studied rolling contact efficiencies and kinematics for some time. This paper reports on a highly computationally efficient method of contact analysis.

"Dynamic Modelling and Validation of the Regime Change Characteristics of a Split Power, Infinitely Variable Transmission", Dr Iain James and Nick Vaughan, Advanced Vehicle Transmissions, I Mech E, September 1997.

A general study of control aspects relating to geared neutral IVT. The work is general in nature, but is based on full toroidal traction drive. One of the authors (Dr I.B. James) now works at Torotrak.

The Thermie Report

This project was commissioned by the European Commission (Directorate-General for Energy). The objective was to show that the Torotrak IVT could produce fuel savings of 15 per cent. when compared to manual equivalents of the same vehicle on the European test cycle. Torotrak was to design, build and commission the transmissions; Ford was to build, test and monitor the engines and vehicles used in the study.

The Thermie project started in 1993 and the collation of data finished in early 1997. The Directors believe that the Company benefited from working with Ford during the course of the project. Although the report highlights certain issues, the Directors believe that the principal concerns identified have either been dealt with or are the subject of Torotrak's research and development programme. Torotrak's medium-term strategy addresses the need for the customer appraisal exercise to take place prior to market launch.

BTG and Ford have submitted a draft report on the Thermie project to the European Commission. An extract from the summary section of the draft report is reproduced below:

"The Thermie project exceeded the target 15% fuel economy benefits and has been demonstrated in a package with commercial levels of driveability that will be demonstrated to EU representatives in the near future. However, the initial intention to build a small fleet of development vehicles to demonstrate both fuel economy and customer acceptability was not achieved.

The key elements in this outcome resulted from an underestimate of the task and the emergence of a number of concerns that had to be investigated in depth before the project could progress to the customer appraisal stage. Therefore part way through the project the emphasis changed from a customer appraisal exercise to a technology demonstration exercise where the benefits of the technology would be assessed within the parameters of a small number of captive vehicles. This change in direction was discussed with the EU representatives to ensure they understood the issues. Within this new context the claimed benefits for the technology were demonstrated although some open issues remain regarding durability, emissions and a number of specific functional concerns such as judder under heavy braking, hesitation on high power downshift and the improvement required to the synchronous change performance.

Since the completion of the project, Torotrak has continued to work in these specialised areas. There is now increased understanding of the issues identified and there is high confidence that further improvements will result from further development and that there is no generic issue that will prevent the delivery of this technology and its acceptance in the marketplace."

It should be noted that detailed test data contained in the confidential part of the draft report will not be made public by the European Commission, Ford or BTG.

Market Outlook

Automotive

The Directors believe that increasing legislative pressure in the United States and political pressures there and elsewhere are driving automotive manufacturers to look to new technology to improve fuel economy and to reduce harmful carbon dioxide emissions. In 1996 (the last year for which in depth information is available) LMC International Limited ("LMC"), a leading economic consultancy, estimated that the total worldwide market for new cars and trucks was approximately 50 million vehicles. In the last 10 years, the proportion of vehicles fitted with conventional automatic transmissions as opposed to manual transmissions has increased both in Europe, where the proportion of cars fitted with automatic transmissions is relatively low, and in other parts of the world. The Directors believe this trend will continue and that the proportion of vehicles fitted with conventional automatic transmissions will continue to increase.

In the United States, under the US Energy Policy and Conservation Act of 1975 (as amended), current CAFE standards for cars manufactured in model year 1990 onwards are set at an average of 27.5 miles per US gallon and at 20.7 miles per US gallon for light trucks manufactured in model year 1996 onwards. The majority of the increasingly popular SUVs are currently included within the light truck definition but the Directors believe SUVs will be included within the CAFE standards for cars. The Directors believe that SUV manufacturers will thus need to improve the fuel economy of SUVs to ensure they meet the CAFE standards for cars.

The Directors believe the OEMs are coming under increasing political pressure to reduce harmful carbon dioxide emissions. The recent Earth Summit in Kyoto has also led to increasing demands for a reduction in carbon dioxide emissions from vehicles.

The Directors consider that the Torotrak IVT will significantly assist OEMs to address the pressure to improve fuel economy and reduce carbon dioxide emissions without reducing vehicle performance.

Non Automotive

The Torotrak IVT is suitable for a range of other applications requiring variable speed control through a mechanical transmission system such as marine drives and industrial machine tools. However, the Directors consider that the automotive industry offers the most significant royalty income opportunities for the Torotrak Group and do not propose to address other markets until significant progress within the automotive industry has been achieved.

Torotrak Group Strategy and Use of Rights Issue Proceeds

The Torotrak Group's principal long-term strategy is to generate substantial royalty income by licensing the Torotrak IVT technology for volume manufacture.

The Torotrak Group has developed its strategy recognising that OEMs are generally slow to adopt major new technologies and, in general, require a product to be fully validated before committing to production.

The Directors recognise that there is a continuing need for the Torotrak Group to refine the Torotrak IVT to a stage where it can be considered to be production-ready. In addition, the Torotrak Group is seeking to target initially the development of the technology in the SUV market, particularly in the US, and the luxury car market. The Directors believe that the Torotrak IVT will have the greatest competitive advantage in the SUV and luxury car markets for the following reasons:

- in the United States these markets are the most threatened by tighter CAFE standards;
- these markets generally carry high margins and are better able to bear the initial cost of a new technology;
- OEMs generally seek to introduce new technologies in their more prestigious vehicles, before introducing the technology into smaller cars; and
- competition from other emerging transmission technologies is less at the larger end of the vehicle market.

The Directors believe that following initial launch in the SUV and luxury car markets, the Torotrak IVT will spread throughout other sectors in the automotive market.

The principal elements of the Torotrak Group's medium term strategy are:

(i) *Design and development of the Mark III transmission*

This will be a specific design for the SUV market and will be the principal product to be tested in the fleet trial programme. The development of the Mark III transmission is expected to be completed in 1999. There are a number of projects in progress or planned, the costs of which are part of the overall research and development programme described below;

(ii) *Fleet trials*

These will involve the testing of the Mark III transmission and subsequent evolutions thereof in a variety of driving conditions and are expected initially to involve up to 100 vehicles covering an aggregate of up to 10,000,000 miles. The trials will involve the collection and analysis of test data, the refinement of the transmissions in response to the test data and the verification and presentation of results to licensees. A key element in the design of the trials will be to collaborate with licensees on what they would expect to see in the outcome, including the important aspect of customer acceptance of driving characteristics and vehicle performance. It is the Torotrak Group's intention to involve the licensees in the detailed planning by December 1998. Procurement for the fleet trials is expected to take place during 1999. The trials themselves are expected to commence in 2000 and are likely to take up to 18 months. The operating expenditure relating to the fleet trials includes the cost of vehicles, transmissions, instrumentation and running costs and is expected to amount to approximately £14 million over the next three years;

(iii) *Pilot trials*

Assuming successful completion of the fleet trials, Torotrak intends to discuss with licensees the possibility of pilot trials to test market acceptance. The Directors expect that the pilot trials will involve sales in small volumes to test market acceptability. These are planned to continue for 18 months and to commence in 2002. Successful pilot trials are expected to be a prerequisite to full scale market launch which is unlikely to be achieved, therefore, before 2003. Any costs relating to pilot trials are expected to be borne by licensees;

(iv) *New facility*

The Torotrak Group has recently purchased a four acre site on which it intends to build a new facility which will be capable of housing all of the Group's activities including research and development, product engineering and transmission assembly which the Directors believe will be capable of producing up to 200 transmissions per week. This is the capacity required to provide the quantities expected for fleet trials and for prototypes and pilot trials by OEMs. Quality control targets of ISO 9000 and Ford Q1 capability will be used. In addition, Torotrak will develop parallel production and production engineering expertise to support licensees and customers. The initial phase of construction is expected to be completed by September 1998. The cost of the freehold site and construction is expected to be approximately £5 million. In addition, other plant and equipment including computer hardware and software is expected to amount to a further £5 million; and

(v) *Research and development*

The Torotrak Group will continue with its research and development programme for specific problem resolution, to develop and test further inventions and enhancements and to develop the Mark III transmission. In addition to the Mark III transmission development projects, there are currently 33 projects under way examining various parts of the Torotrak IVT and its componentry. The costs of the research and development programme are expected to amount to approximately £4 million per annum. Torotrak's research and development programme is currently focused on the following areas which have arisen during development work:

- Hydraulics and control: the interaction between the Toroidal Variator, its hydraulic and electronic control system and traction fluids at a range of temperatures, viscosities, lubricity and aeration levels.
- Engineering models: the use of a combination of empirical testing and developing techniques combined with modelling techniques using Matlab software to refine the engineering models and test and evaluate them.
- Variator tribology: a number of projects are in progress which together have the objective of optimising the full Toroidal Variator in terms of durability, efficiency and cost of production. In addition Torotrak is working closely with Shell on the effect of improved traction fluids and the effect of variator dynamics is also being investigated. The approach to these projects uses a number of Torotrak's new test facilities including the measurement of wear in the disc/roller contact patch related to various slip rates and traction fluids. These tests are conducted with flat discs to represent the discs and rollers.
- Torque transfer: the use of mathematical modelling techniques to simulate from first principles the action of the transfer of torque between disc and roller contact patch and determine theories for wear rates and durability. This work is being supported by similar theoretical studies being conducted at Leeds University and Imperial College in projects funded by Torotrak.
- Torotrak is also conducting a range of investigations to exemplify the use of existing automotive technologies within the IVT and derive design rules for the specification of componentry such as seals and sprags.

The Directors are confident of successfully completing the 33 projects underway, due to the success of the Company in resolving previous technical issues and the experience of the employees of the Torotrak Group.

In addition to the costs described above, expenditure on capital items including testing equipment, hardware, software, instrumentation and other equipment is expected to amount to approximately £10 million, the majority required in the next two years, and establishment costs including administration and finance are expected to amount to approximately £3 million per annum.

The Torotrak Group intends to fund its strategy principally from the proceeds of the Rights Issue, which is expected to raise approximately £45.4 million, net of expenses, and its existing cash resources. Further funds are expected to be available through contract income and down payments on existing and new licence agreements. The Torotrak Group estimates that its net funding requirements over the next two years will be approximately £35 million which will be met from the resources described above.

The Company's existing and potential customers are typically large international corporations. Consequently there is no variation in the Company's strategy across the expected major markets for the Torotrak IVT. The Company does not intend to conduct volume manufacture of the Torotrak IVT. The Torotrak Group may in the future consider either a joint venture or a strategic alliance with a tier 1 automotive supplier. The Directors believe this would help to establish credibility in respect of high volume production. The Directors have not ruled out any strategic options going forward at this stage.

Investment Policy

The Company intends to appoint independent investment managers to advise and implement a low-risk strategy for the investment of unutilised net cash from initial cash resources and the proceeds of the Rights Issue until it is required by the Torotrak Group's operations. This strategy will seek to maximise the interest income received from bank deposits of this unutilised net cash.

Competitive Environment

The Directors consider that the main competition for the Torotrak IVT currently comes from conventional automatic transmissions. Conventional automatic transmissions are an established product with over 40 years of product development. Their principal disadvantage is that, whilst they have become more refined, particularly through the application of microprocessor control, they have little scope for further improvement in fuel economy.

Variable transmission systems are becoming increasingly accepted by the market. In particular, Belt CVTs are already used in small car automatics and are now being introduced in medium-sized cars (around 2 litres). Belt CVTs need to retain a separate launch device such as a clutch or a torque converter and thus the Directors believe that Belt CVTs will be less competitive in terms of fuel economy and carbon dioxide emissions performance than Torotrak IVTs. In addition the Directors believe Belt CVTs could have difficulty in delivering the higher power required by larger vehicles. Nevertheless, Belt CVTs may pose a significant competitive threat to Torotrak's IVT in the small and medium-sized car market.

In addition, there are a number of other technologies, listed below, that are or may be capable of being used in the vehicle transmission market:

– Antonov plc has developed a relatively simple mechanically controlled stepped ratio automatic which is well suited to small car applications but retains a clutch as a launch device and is similar to existing automatics. The Directors do not believe the Antonov transmission has entered volume production. The Directors believe that the Antonov transmission will be unlikely to replace the existing automatic transmissions produced for high powered vehicles;

– transmissions utilising hydrostatic principles are not currently, and are unlikely to be, used in cars because of their noise and inefficiencies, but they are currently operating in tractors and other non-automotive applications; and

– half toroidal CVTs are being promoted by NSK and a number of OEMs have them under assessment. However, half toroidal CVTs are not yet in volume production. This system uses similar traction drive principles to Torotrak's full toroidal transmission, but still incorporates a separate launch device. The Directors believe it will be unable to deliver powertrain efficiencies and benefits comparable to using the Torotrak IVT.

Automated manuals are another recent development. These are stepped ratio transmissions which incorporate a clutch as a starting and gear changing device. The clutch is operated automatically by the electronics in the system as opposed to being manually operated by the driver. The Directors believe that automated manuals have been developed as an interim product for European markets for manual drivers who are resistant to automatic transmissions. Accordingly, the Directors believe automated manuals have a limited market.

For the reasons stated, the Directors do not believe that any of the technologies described above pose a significant threat to the commercialisation of the Torotrak IVT, particularly for high powered vehicles. The small car market is likely to remain more competitive.

Other developments in improved fuel economy such as weight reduction programmes, alternative fuel technologies such as gas or fuel cells or gasoline direct injection ("GDI") are, in general, complementary to Torotrak's IVT technology. The use of these technologies in conjunction with the Torotrak IVT is likely to result in enhanced benefits.

Financial Record

The summarised historical information set out below for the three years ended 31 March 1998 has been extracted without adjustment from the Accountants' Report in Part VI of this document. Investors should read the whole document and not just rely on the summarised historical information set out below.

	Year ended 31 March		
	1996	1997	1998
	£000	£000	£000
Licence income	97	717	386
Contract income	1,611	2,589	1,326
Total Turnover	1,708	3,306	1,712
Development expenses	(1,544)	(2,104)	(2,603)
Administrative expenses	(397)	(468)	(834)
Net interest (payable)/receivable	(22)	(4)	12
Profit/(loss) before taxation	(255)	730	(1,713)

The Torotrak Group has not generated significant turnover during the last three years and its financial record is uneven due to the timing of relatively large, irregular payments made where milestone achievements have been reached. Turnover comprises contract income from customers requiring specific work on Torotrak's IVT technology and licence income. The majority of contract work is carried out for licensees with the Ford and Toyota contracts accounting for approximately 50 per cent. of turnover over the three year period. The initial Toyota contract finished in October 1997 and significant payments under this contract contributed to the increase in turnover for the year ended 31 March 1997. Contract work with existing and potential licensees is driven by their individual needs and is essentially open ended. Licence income in 1997 was also substantially higher than 1996 or 1998 due to the timing of down payments. The Directors are unable to predict future turnover for the next few years as the Torotrak Group is dependent on its customers agreeing to development work being carried out and to a decision being taken to put the Torotrak IVT into volume production. Seasonal variations did not have a material effect on the Torotrak Group's turnover.

The costs of contract work relate to the engineer technical man-days and component costs. Generally these have resulted in an element of overhead recovery.

As the number of employees in the Torotrak Group has increased, the amount of development work that could be undertaken on its own behalf has also increased. Administrative expenses have risen to meet this growth. A significant expansion in the number of employees took place in the year ended 31 March 1998 (from an average of 27 employees in the year ended 31 March 1997 to 52 at 31 March 1998) as a result of the investment of some of the proceeds of the placing by BTG in May 1997. The full year effect of these costs was not reflected in the results for the year ended 31 March 1998 as a number of the new employees joined the Torotrak Group late in the financial year. In addition the implementation of the Torotrak Group's strategy and resulting spend will result in significant increases in the Torotrak Group's development and employee costs. These are unlikely to be offset by increased turnover. As part of the 1987 acquisition of IPR from Rover, £1.65 million of deferred consideration is due to be paid to Rover out of future licence revenues.

The Torotrak Group has been funded by intercompany loans from companies within the BTG Group. As a result it has no bank facilities in place. The pro forma net assets statement of the Torotrak Group set out in Part VII of this document shows that the Torotrak Group had pro forma net assets, taking into account the proceeds of the Rights Issue, at 31 March 1998 of approximately £52.9 million.

Millennium Compliance

The millennium compliance problem concerns the inability of information systems, primarily computer software programmes, to recognise and process date sensitive information properly as the year 2000 approaches. The software included in the Torotrak IVT, however, is not date sensitive and is therefore not affected by the millennium compliance problem.

The Torotrak Group, however, has many other computer reliant technologies and systems. Consequently the Directors have supervised a review of the Torotrak Group's computer systems, other operating equipment and service providers. As a result of this review, certain software was identified as not being millennium compliant and has been replaced. All new software and hardware acquired by the Torotrak Group is accompanied by a certificate from the relevant licensor or supplier confirming that it is millennium compliant. However, there can be no absolute assurance that the Torotrak Group's computer systems and equipment providers and service providers will not encounter unforeseen millennium compliance problems. Accordingly, there can be no assurance that the Year 2000 problem will not have a material adverse effect on the Torotrak Group.

Dividend Policy

The Torotrak Group has neither declared nor paid any dividends to date. In the medium term, the Torotrak Group intends to retain any future income to finance the development of its business and accordingly does not currently anticipate paying any dividends on its ordinary share capital in the foreseeable future. In the long term, the Torotrak Group expects to adopt a dividend policy of paying out a substantial proportion of any distributable profits.

PART III RISK FACTORS

Prospective investors should be aware that an investment in Torotrak involves a high degree of risk and should be made only by those with the necessary expertise to appraise the investment. In addition to the other information in this document, the risk factors set out below should be considered carefully in evaluating any investment in Torotrak. The risk factors set out below should be read in conjunction with the Independent Expert's and Independent Patent Agent's reports in Parts VIII and IX of this document.

Early Stage of Commercialisation

The Torotrak Group is at an early stage in the commercialisation and marketing of the Torotrak IVT technology. The Torotrak Group has not yet commenced profitable trading and the strategic goals envisaged by the Directors may not be achieved. There can be no assurance that the Torotrak IVT will be commercially successful or that the Torotrak Group will ever achieve significant revenues.

Technology

Whilst the Directors believe that no further inventions to the Torotrak IVT are essential to deliver the functions required for effective operation in vehicles, there are a number of outstanding technical issues which currently result in inadequate performance in some aspects of the operation of the Torotrak IVT. These include, but are not limited to, variator polishing, cold starting and the behaviour of traction fluid at low temperatures, durability testing, driveline dynamics and hydraulic control, noise, optimisation of componentry and design for production. In addition, contract work deriving from the successful design and development of the Mark III transmission will be dependent on these issues being resolved.

Whilst solutions to these issues are being developed, there can be no guarantee that they will be resolved or that further technical issues will not arise in the future. Failure to resolve any such technical issues may have a material adverse effect on the Torotrak Group and could impair its ability to carry out planned development work.

Management of Growth and Expansion

The Torotrak Group's recent expansion has resulted in substantial growth in the number of its employees and the scope of its operating and financial systems resulting in increased responsibility for management personnel. The Torotrak Group's ability to support the anticipated growth of its business will be substantially dependent upon, among other things, continued development of financial and management controls and information technology systems, and the hiring and training of new employees. Balancing the needs of these licensees within the resource constraints of the Company will be one of the challenges facing the management of Torotrak. There can be no assurance that the Torotrak Group will be able to manage any future expansion successfully, and any inability to do so would have a material adverse effect on the Torotrak Group. In particular, the Torotrak Group has had no prior experience in either the design and implementation of fleet trials or in producing Torotrak's IVT in the numbers envisaged by the Torotrak Group's strategy.

Loss of key licence

The Directors believe that the loss of either the Toyota or Ford licences would be a significant event which could delay the time of launch and volume production of the Torotrak IVT and lead to a significant reduction in the amount of future royalty income. At this stage the Directors believe that Ford and Toyota do not have any intentions of terminating their licence agreements with Torotrak.

Timing of contract and licence revenue

While the Torotrak Group has licence agreements and development and evaluation contracts with several vehicle and transmission manufacturers there can be no assurance that these licences will be maintained by the licensees or that contract and licence income will be received at the levels and in the timescale envisaged by the Directors. The Torotrak Group may face delays in volume production being started and slow adoption among car manufacturers. This may be due to lack of confidence in IVT or because the manufacturers may be seeking adequate returns on existing investments.

Collaboration with Shell

The Torotrak Group has chosen to rely on Shell for the supply of traction fluid and the continued improvement and development of new traction fluids for the future. If for any reason Shell ceased to collaborate with the Torotrak Group, the Torotrak Group would have to seek alternative supplies from one or more oil companies, which are known to be pursuing similar developments. This may result in a delay to the initial launch and/or additional cost to the Torotrak Group.

Requirement for additional funds

Torotrak's future capital requirements to continue the development of the business and the development and commercialisation of its current and future IVT technologies will be substantial and may require further fund raising. The level and timing of expenditure will depend on a number of factors, many of which are outside the control of Torotrak. There can be no assurance that, when required, further funds will be available to Torotrak. If additional funds should be raised by issuing equity securities, dilution of existing shareholdings may result.

Risks associated with overseas trade

Sales in Torotrak's markets are subject to risks inherent in international business activities, including, in particular, general economic conditions in each relevant country, overlapping of differing tax structures and unexpected changes in regulatory requirements. Other risks associated with overseas trade in general include import and export licensing requirements, trade restrictions and changes in tariff and freight rates. While Torotrak currently is not subject to material risks of the foregoing nature in the countries in which it has licensees, specifically the US, Japan, Germany and Italy, there can be no assurance that such risks do not, or will not, exist in other countries in which Torotrak may have licensees in the future or that such risks will not have a material adverse effect on Torotrak's business, financial condition and results of operations.

Costs of production

The successful take-up of Torotrak's IVT by the licensees is dependent on an acceptable cost of production. The production process utilises existing materials and manufacturing processes without the need for high precision tolerancing beyond what is required for normal automotive standards for similar parts. All components are capable of being sourced from existing automotive suppliers. The variator itself utilises existing bearing technology. However, until the Torotrak IVT is in volume manufacture the exact costs of production will not be known and may be material to the financial condition and results of operations of Torotrak.

Dependence on key personnel

Torotrak's future success depends in large part on the continued service of its key management, sales, product development and operational personnel and its ability to continue to attract, motivate and retain highly qualified employees. In particular, the loss of the services of any of the executive Directors or of Torotrak's other senior management or technical personnel could have a material adverse effect on Torotrak's business, financial condition and results of operations. There can be no assurance that Torotrak will continue to be successful in attracting, retaining or motivating professional, technical, managerial, sales and marketing and customer support personnel it requires to conduct its operations successfully. The inability to hire and retain qualified personnel or the loss of the services of key personnel could have a material adverse effect upon Torotrak's business, financial condition and results of operations.

Licence Agreements and reliance on OEMs

The successful commercial exploitation of the Torotrak IVT is dependent upon Torotrak negotiating and entering into favourable commercial agreements with licensees with the potential for generating significant revenue from licence fees and royalty payments. There can be no assurance that Torotrak will be able to enter into favourable commercial agreements in the future or that such commercial agreements will be successful. In calculating the potential royalties that Torotrak might receive from its licensees, Torotrak has relied on assumptions about the business development plans, and the royalty rates to be paid by, its licensees. However, such assumptions may be subject to certain risks and the actual performance of the existing licensees could differ materially from the assumptions used. There can be no assurance that such licensees will be able to exploit commercially the Torotrak IVT by incorporating it into their existing or new products and attain market share successfully. Neither can there be any assurance that licensees will not incur further difficulties in manufacturing products containing the Torotrak IVT which may result in unanticipated costs and delay the time for the receipt of royalties under the various agreements.

Competitors or potential competitors may have filed patent applications or may have been granted patents which could affect the freedom of licensees to use Torotrak's technology. If patents are granted to other parties that contain claims having a scope that is interpreted to cover any of the Torotrak Group's products, there can be no assurance that the Torotrak Group will be able to obtain licences to such patents at reasonable cost, if at all, or be able to develop or obtain alternative technology.

Driver acceptability

The success of Torotrak is dependent on drivers of vehicles fitted with powertrains that incorporate the Torotrak IVT being satisfied with its performance. The majority of drivers are unlikely to object to the different drive characteristics of a vehicle including the Torotrak IVT. However, there can be no assurance that drivers will accept the change to Torotrak's IVT technology and thus Torotrak's IVT may not achieve market acceptance.

Uncertainties inherent in patent protection

Torotrak is heavily dependent upon its proprietary technology. The Torotrak Group's success will depend, *inter alia*, on its continuing ability to establish, protect and enforce proprietary rights relating to its technology. There can be no assurance that any intended patent application will be successfully filed, that any filed applications will mature into granted patents or that existing patents or patents which may be obtained in the future will adequately protect the Torotrak Group's products and technology. The Torotrak Group cannot be certain that granted patents will be enforceable.

There can be no assurance that the present or future issued patents will protect the Company's technology lead. The Torotrak Group's patents that have been obtained or applied for will expire during the period from 1998 to 2018. The Torotrak Group also relies upon know-how and software to maintain its technology lead. However, there is no assurance that this information can be completely protected.

There can be no assurance that the Torotrak Group's patents or patent applications will not become involved in opposition or revocation proceedings instituted by third parties. If such proceedings were initiated against the Torotrak Group's rights, the defence of such rights could involve substantial costs and the outcome could not be predicted with certainty.

There can be no assurance that third parties will respect Torotrak's patent rights. If Torotrak takes action against third parties it believes are infringing its patent rights, such proceedings could involve substantial costs and the outcome could not be predicted with certainty. Such litigation activity must be expected.

Patent applications and granted patents may be challenged on the grounds that the applications or patents do not fulfil the legal requirements of the jurisdiction in which those applications or patents apply. For instance, the application or patent may be challenged on the grounds that a previously published document, or other information in the public domain, discloses the invention described in the application or patent. Torotrak cannot therefore give an assurance that no Torotrak patent will be successfully challenged in the future.

An additional risk, peculiar to the United States, is the possibility that another inventor may claim priority of invention based on their own record of inventive activity, which may not be in the public domain, prior to the patent application date. Known as "interference" proceedings, these are not uncommon and may be expensive to defend.

Availability of Transmissions

As the Torotrak Group does not intend to manufacture the Torotrak IVT in volume, there is a risk that the OEMs will not be prepared to manufacture or procure manufacture in sufficient volumes to satisfy initial demand for the Torotrak IVT.

Competition

The Torotrak Group is not aware of any company with directly competitive technology which has performance characteristics similar to Torotrak's IVT. However it is possible that competitors may develop more effective technologies than, or may produce products superior to, those of the Torotrak Group.

Withholding Tax

Much of Torotrak's income is expected to comprise licence and similar income from overseas jurisdictions (e.g. Japan and US). Many such jurisdictions currently impose a withholding tax ("WHT") on payments of such income although this will often be reduced (e.g. in the case of Japan to 10 per cent.) or removed (e.g. in the case of US) by virtue of an applicable double taxation treaty. Such WHT would give rise to a cash flow cost for Torotrak. In some cases WHT is imposed at the full domestic rate pending the obtaining of clearances under the relevant double taxation treaty with a refund of the whole or part of such WHT following, often many months, later. In other cases where a double tax treaty exists the WHT is only reduced rather than removed. In the latter case, although Torotrak will obtain a UK tax credit for the WHT, this may represent an acceleration of tax of between 9 and 21 months.

Newly-Formed Group

As a newly demerged entity, the Torotrak Group has no operating history as an independent public company. Historically BTG has financed the Torotrak Group's operations and capital and other expenditures. After completion of the Demerger, the Torotrak Group will have to meet all of its cash requirements from the proceeds of the Rights Issue and through funds generated internally from operations and external borrowings, which may be more costly.

No Listing Prior to Demerger

Shareholders should note that prior to the Demerger there will have been no prior trading market for the Ordinary Shares and there can be no assurance as to the price at which they will trade or the degree of volatility in the trading price. The price at which the Ordinary Shares trade will be determined in the public trading market and may be influenced by many factors, including the depth and liquidity of the market for the Ordinary Shares, investor perceptions of the Torotrak Group and its businesses, general economic and market conditions and, at least in the short-term, the investment preferences of BTG Shareholders.

US regulatory approval

In order to commence pilot trials of the Torotrak IVT in the US, Torotrak will require clearance under the Federal Motor Vehicle Safety Standards regulations. In obtaining such approval, Torotrak may require the co-operation of an existing US automotive manufacturer.

ANNEX 7:

Scope and Advantage Details for the Torotrak Patent Portfolio

(entries are arranged in order of increasing earliest filing date)

EP 0 306 272 (earliest filing date: 02.09.87)

Protected Solution(s):

independent claim 1:
A continuously-variable-ratio transmission capable of operation in at least first and second regimes, and adapted for use in a vehicle having first and second laterally-displaced rotary driving members and steered by differential rotation of such members, comprising:
first and second variators **(CVTs)**, that is to say ratio-varying units, having first and second rotary output members rotatable about first and second output axes respectively;
associated **first and second epicyclic gear sets** each having first and second input axes by which they are connected to the first and second rotary output members respectively and each having sun, carrier and annulus components, a first such component of the first and second epicyclic gears being connected respectively to the first and second driving members;
characterised in that **(+) the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.**

independent claim 8:
A continuously-variable-ratio transmission capable of operation in at least first and second regimes, and adapted for use in a vehicle having first and second laterally-displaced rotary driving members and steered by differential rotation of such members, comprising:
a transmission input adapted to be driven by a prime mover of the vehicle;
first and second variators **(CVTs)**, that is to say ratio-varying units, each having an input connected to the transmission input, and an output;
first and second epicyclic gear sets each having three inputs/outputs
characterised in that **(+) in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.**

Description of Prior Art and Advantage(s):

column 1, line 51-60:
'The invention also applies especially to CVTs which include two variators and which are thus specially suitable for use in a tracked or other vehicle which has first and second laterally-displaced rotary driving members, and which is steered by the differential rotation of those members. Such a CVT is described in patent specification US-A-4718299 (*1), and an object of the present invention is to provide an efficient yet simpler two-variator CVT' **(=improved efficiency, reduced cost)**

column 3, lines 50-59:
'Potential advantages of the CVT include great economy in the number of components used **(=reduced cost)**, compactness and neatness **(=reduced size)** inherent in the coincidence of the operating axes of the variators and epicyclics ...., **identical steer performance in high and low regimes**, and no problem for the engineer skilled in the art to choose ratio ranges for variators ... and epicyclic rations for gear sets ... so as to **permit synchronous change between high and low regimes.**'

(*1 – US'299 is taken to correspond to the preamble of both independent claims)

EP 0 354 013 (earliest filing date: 04.08.88)

Protected Solution(s):

independent claim 1:
In or for a transmission of the toroidal-race, rolling-traction type **(=for a CVT with input and output discs and roller therebetween):**
a hydraulic ram comprising a cylinder, and a piston moveable within that cylinder so that the piston and cylinder define between them a working space of variable volume, the space being bounded at one axial end by the piston and at the other by an axial end wall of the cylinder;
means to connect the piston to at least one roller of the transmission, whereby the angular orientation of the roller is related to the axial position of the piston within the cylinder **(=roller control system);**
inlet and outlet ports to the working space, the inlet port being connectable in use to a source of hydraulic fluid under pressure and the outlet port to exhaust;
in which **the inlet and outlet ports are both formed in the axial end wall of the cylinder, and in which the outlet port lies axially proud of the inlet port**, whereby as the piston approaches the end wall it tends firstly to increase the flow resistance of the outlet port and secondly to contact it and so be prevented from further axial movement **(=hydraulic end stop effect)**, without substantially obstructing the inlet port.

Description of Prior Art and Advantage(s):

column 1, line 26 ff.:
'In both of the patent specifications just recited [GB-C-2 023 753, EP-A-0 133 330), means are also provided to set up a "hydraulic end stop" effect, to resist and arrest further movement of the ram piston, should the transmission encounter a driving condition in which the rollers tend to overshoot their normal range of attitudes and so be in danger of running off the edges of the toroidal discs. ... Aims of the present invention include simplifying the ram, facilitating both the adjustment of the piston and the means of connecting it to the rollers **(= reduced cost)**, and providing an improved end-stop mechanism.

WO90/02277 (earliest filing date: 16.08.88)

Protected Solution(s):

independent claim 1:
A hydraulic control circuit for a CVT including a first ratio-varying component of variable orientation (**= CVT of the toroidal-race rolling-traction type***), and + at least one second **engageable component having variable capacity to transmit torque when engaged** and in which:
a hydraulic ram means comprises a piston moveable over a predetermined stroke within a cylinder, and the piston is connectable in use to the first ratio-varying component so that the location of the piston within its stroke reflects the orientation of the first component , and the cylinder includes inlet and outlet ports for hydraulic fluid;
the outlet is arranged within the cylinder so as to be restricted when the piston overshoots its predetermined stroke **(+ hydraulic end stop effect)**, so raising circuit pressure upstream of the ram means, and
+ control means are responsive to that raised upstream circuit pressure and operable, in use of the CVT, to reduce the torque-transmitting capacity of a said second component.
(* although the claim only specifies 'a first ratio-varying component of variable orientation', it is considered that a toroidal-race rolling traction type of CVT is implicit)

independent claim 7:
A CVT of the toroidal-race rolling traction type, in which hydraulic end loading means maintain the appropriate torque-transmitting contact between rollers and discs, which includes a hydraulic control circuit according to claim 4, and in which the higher of the two circuit pressure upstream of the two cylinder inlets is applied also to the hydraulic end loading means.
(In view of the interpretation of independent claim 1 as a Protected Solution to a 'CVT of the toroidal-race rolling traction type', claim 7 has been interpreted as being dependent thereon).

independent claim 8:
A CVT of multi-regime type, including a hydraulic control circuit according to claim 1, in which at least one regime is engaged by the operation of a said second engageable component.
(In view of the interpretation of independent claim 1 as a Protected Solution to a 'CVT of the toroidal-race rolling traction type', claim 8 has been interpreted as being dependent thereon).

Description of Prior Art and Advantage(s):

Page 2, line 19ff.:

'The aim of the present invention is to provide a potentially quicker and more direct change in hydraulic pressure within a ram cylinder, to oppose the overshoot of the piston in ... abuse or overload conditions'
(Note: the Protected Solution does not contain the features necessary to achieve this advantage. Consequently it is not included in the diagram)

Page 2, line 25ff.:
'... to provide the facility for using the increased ram chamber pressure to modulate the degree of engagement of ... a clutch'
(Note: the Protected Solution does not contain the features necessary to achieve this advantage. Consequently it is not included in the diagram)

Page 8, line 7ff. explains the functioning of the features of the Protected Solution:
'While it is desirable that traction should not suddenly fail and should therefore initially be maintained in overload / abuse conditions, it is also important that the raised end load and consequent higher forces of reaction between discs and rollers should not overstress those parts **(=improved lifetime)**. The higher forces should therefore be of brief duration. The high pressure feedback to control valves 56,57 by way of line 58 is arranged so as to achieve this. When piston 35 starts to restrict one of the outlets 52 or 53, the effect of the enhanced feedback pressure is to ... reduce the pressure .... That reduced pressure then passes by way of switching device 63 to whichever of clutches 25 or 26 is engaged. The capacity of that clutch will therefore be reduced. Since the variator can only be put under load by a torque transmitted across whichever regime clutch is engaged, a continuously applied overload ... will in general cause the pressure at the engaged clutch to reduce until clutch slip occurs.

WO90/05860 (earliest filing date: 21.11.88)

Protected Solution(s):

independent claim 1:
A roller control system for a CVT of the toroidal race, rolling traction type in which a roller assembly comprises a carriage and bearings mounted thereon and a roller mounted to spin in those bearings, in which the roller contact and transmits traction between coaxial rotatable discs presenting input and output races conforming to different parts of the surface of a single torus and in so doing is subjected to traction forces at the disc/roller contacts **(='Roller Control System for a CVT with input and output discs and roller therebetween')**, in which an operating mechanism is reciprocable over a predetermined stroke of operating movement and is operable to apply a predetermined control force to the carriage, and in which the operating mechanism and carriage seek an equilibrium position in which the resultant of the control force and of the traction forces experienced by the roller assembly in a plane at right angles to the axis of the discs is zero **(='of the force-balance type' – see discussion of prior art below)**, and in which

the carriage includes rigid structure relative to which the roller axis and the roller centre are fixed, and which contacts the operating mechanism at a location displaced from the roller axis;

the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism.

independent claim 10:
A CVT of the toroidal race, rolling traction type according to claim 1 including a fixed casing structure and a roller control system according to any of the preceding claims (*), in which at least part of the operating mechanism is mounted on the fixed casing structure.

(* - the double dependencies of this claim - to both claim 1 and also to 'any of the preceding claims' - is a drafting error. A claim should only contain one reference)

Description of Prior Art and Advantage(s):

page 3, line 20ff.:
'in GB-A-1395319, both the tangential shift and the resulting pivotal movement are facilitated by mounting ball ends at opposite extremities of the carriage'

page 5, line 6ff.:
'a fundamental feature of variators of the type just described in outline, and described in greater detail in patent specification GB-A-1395319 for example, is that they are of "force-balance" type. That is to say, one of the conditions that must be fulfilled for equilibrium of the transmission at any given ratio value is

that the torque reaction force and the hydraulic force acting upon the carriage piston must be in balance'

page 13, line 28ff.:
'the invention seeks to provide a roller control system which is considerable simplified compared with many known systems' **(= reduced cost)**

WO90/07660 (earliest filing date: 06.01.89)

Protected Solution(s):

independent claim 1:
A driveline for a wheeled vehicle, comprising:
an engine having an output member rotatable about an output axis,
a CVT - that is to say, a transmission of continuously-variable ratio - having an output member and at least one input and including a differential unit and a ratio-varying unit or variator presenting an output axis of rotation, and having the (+) capability of a "geared neutral" state in which for a predetermined variator setting the output member is stationary in response to a driven input,
a slipless driving connection between the output member of the engine and at least such one input of the CVT;
two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts,
in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation.

independent claim 13:
A wheeled vehicle containing a driveline according to any of the preceding claims.

Discussion of Prior Art and Advantage(s):

page 2, lines 12 to 33:
'Where the transmission is a CVT however, and especially a CVT of the toroidal-race rolling-traction type, a transverse engine presents a special problem. It is customary to locate the engine and the transmission in-line with their principal operating axes coincident, but the combined length of a typical engine and CVT may exceed the available transverse space in a road vehicle. One object of the present invention is to provide an alternative layout of engine and transmission which enables them to be accommodated together within a smaller transverse vehicle dimension. (= **reduced size [of engine and transmission]**) Another feature of a driveline according to the present invention is the opportunity it offers to provide a reasonable clearance between each of the driven wheels and the adjacent engine or transmission structure, so that the half shafts which are directly connected to the wheels may be of efficient length, and may be substantially equal in length. In some known transverse-engined vehicles the disposition of the engine and transmission structure dictates half-shafts very unequal in length. This has several disadvantages, including larger angular displacements at the shorter end from suspension movements, and unequal torsional stiffness unless the latter is avoided by increasing the diameter of the longer half-shaft.' (= **half shafts of equal and efficient length**)

WO91/06791 (earliest filing date: 03.11.89)

Protected Solution(s):

sole independent claim:
A continuously-variable ratio transmission (CVT) including a double-acting hydraulic ram comprising a piston and a pair of opposed hydraulic cylinders, and in which the fluid contents of both cylinders are connected to physical displacement means operable by a human operator, characterised in that the **CVT is of the toroidal-race rolling-traction type**, in that the ratio transmitted by the traction-transmitting rollers is determined by the position of the piston, and in that the **(+) physical displacement means comprise separate physical displacement members connected hydraulically and respectively to the opposed hydraulic cylinders of the ram whereby by simultaneously depressing one member and releasing the other, the operator changes the transmitted ratio by displacing the ram piston by which that ratio is determined.**

Discussion of prior art and advantage(s):

page 2, line 34 - page 3, line 15:
'A hydraulically-operated CVT ... is described in more detail in patent specification GB-C-2023753 as well as in US-A-4662248. ... A vital component in such a CVT is of course a high powered pump ... It is an aim of the present invention to adapt and simplify **(=reduced cost)** such a hydraulically-controlled CVT for use where no such power driven pump is available and where less exact pressure balances will suffice.'

page 3, lines 19-31:
'The CVT according to the invention is therefore to be distinguished from the kind of CVT shown for instance in patent specification GB-A-1494128, in which an operator-controlled lever is directly connected to a piston/cylinder unit forming part of a hydraulic circuit within the CVT. However, the ratio transmitted by the CVT is determined by a quite separate connection - between the lever and those parts of the CVT whose relative movement causes the ratio to change. In GB-A-1494128, the hydraulic circuit serves essentially as part of a feedback system, to give to the operator by way of the lever a reaction which provides some "feel" for the ratio-changes that he has brought about by way of the direct mechanical connection.'

WO91/08405 (earliest filing date: 01.12.89)

Protected Solution(s):

sole independent claim:
A variator for a transmission **(CVT) of the toroidal-race rolling-traction type comprising (+) at least two input discs and at least two output discs arranged alternately in coaxial sequence,** characterised in that **(+) all discs except the first and last in the sequence are formed with part-toroidal races on both faces of the disc, thereby defining a sequence of at least four clearances where an input and output race confront each other across an imaginary torus, and including:**
a separate set of rollers of adjustable orientation arranged to transmit traction across each successive clearance between the respective input and output races;
means to coordinate all the rollers of each separate set so that they adopt the same orientation;
and means to transmit drive from the output discs to at least one rotatable output member.

Description of Prior Art and Advantage(s):

page 5, line 14:
'Assuming that those discs and the associated chains and sprockets are only normal, small-sized production components, between them they have transmitted a total torque that would have required a component of much larger size had a single output disc been required to transmit the total torque.' **(= reduced size)**

<u>WO91/08406 (earliest filing date: 01.12.89)</u>

<u>Protected Solution(s):</u>

sole independent claim:
A continuously-variable-ratio transmission (**CVT**) capable of operating in two regimes **(= + multi-regime gearbox - *1)** and comprising the arrangement in succession of a ratio-varying unit **of the toroidal-race rolling-traction type** having an operating axis and a rotary output and input both aligned with that axis, **(+) a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit** <u>characterised in that</u> **(+) the said driving connection includes a rotary member displaced from but parallel to the operating axis and lying radially outboard of the speed reducing gear unit relative to that axis.**

(*1 – this abbreviation added to facilitate inclusion into figure K of the diagram).

<u>Discussion of Prior Art and Advantages:</u>

page 1, line 24 – page 2, line 15:
'Sometimes it is desirable to arrange all the major components of such a transmission as nearly as possible coaxial with the operating axis of the variator (*2). ... in a two-regime transmission this has in the past posed two points for particular consideration ... it has been found necessary to use different gearing combinations for the two gear units which follow the variator. This naturally adds to the complexity and expense **(i.e. cost)** by increasing the total number of parts used in the transmission as a whole, and it has frequently – as in patent specifications GB-B-02150240 and EP-B-0149892, for example – required the use of a compound epicyclic gear with double planets for one of the gear units. The present invention aims to provide a simpler design, potentially with less parts, for a transmission of the concentric type already described.'

(*2 – in the absence of any more specific information, this has been taken as the advantage for the diagram entry for the known solution of EP-B-0149892)

page 3, line 23ff.:
'Certain features of this transmission will be particularly apparent: Firstly the absence of any drum-like output member connected to variator output disc 8, which would surround the downstream input disc 4 and make access difficult to components such as the rollers ... **(= simplified manufacture = reduced cost)** Secondly, the identical structure of the components of epicyclic gear units 10 and 15. **(= reduced part count = reduced cost)** Fourthly, ... there is no need, in order to obtain the appropriate directions of rotation of output shaft 17, to use double planets in either unit. **(= reduced part count = reduced cost)**

WO91/11637 (earliest filing date: 30.01.90)

Protected Solution(s):

independent claim 1:

A rotatable disc formed with a coaxial part-toroidal race and suitable for use as the input or output disc or the variator for a transmission of the toroidal-race rolling-traction type **(= CVT of the toroidal-race rolling-traction type)**, in which **(+) the torus radius of the race**, that is to say the radius of curvature of the race measured at a chosen point on the race and in a plane including the disc axis, **decreases as the distance of that point from the disc axis diminishes.**

independent claim 5:

A variator for a transmission of the toroidal-race rolling-traction type, including two complementary rotatable discs (input and output) according to any of the preceding claims.

Description of Prior Art and Advantage(s):

page 4, line 25f.:

'... a net gain in fatigue life can be obtained because life is inversely proportional to a high power of stress ...'

WO91/14116 (earliest filing date: 16.03.90)

Protected Solution(s):

sole independent claim:
A hydraulic control system for a continuously-variable-ratio transmission **(CVT) of the toroidal-race rolling-traction type** in which the mechanism for positioning a roller includes a double-acting ram to which the roller is connected, and **(+) in which the two opposed faces of the ram are exposed in normal use to the pressures of two separate lines of fluid, each such line being pressure-controlled by separate means located downstream of the respective ram face, in which the outputs of the pressure control means combine in a common region connectable by valve means with each line, and in which a preset difference in fluid pressure between a line and the common region causes the valve means to open to allow fluid to pass from the common region to that line.**

Discussion of prior art and advantage(s):

page 2, line 22ff.:
'The present invention arises from appreciating that ... this pressure difference may be used to trigger the transfer of fluid to the upstream, low pressure side. The tendency to fluid starvation on the low pressure side is therefore diminished, and with it the maximum flow rate demanded of the source and so the size and expense of the source itself **(=reduced size, reduced cost).** Means for effecting such transfer are quite absent in prior publications such as patent specification EP-B-0133330 and the related EP-B-0078125 where the outlets of the respective control valves - identified by reference 23 in both specifications - lead only to tank or exhaust, and there is no means of connection between those outlets and the upstream regions of the hydraulic circuitry.'

WO92/01175 (earliest filing date: 13.07.90)

Protected Solution(s):

independent claim 1:
A variator for a transmission of the toroidal-race rolling-traction type in which each of a set of rollers transmitting traction between an input disc and an output disc is positioned hydraulically by means of an attached and double-acting piston working within a hydraulic cylinder **(CVT of the toroidal-race rolling-traction type)**, characterised in that **(+) all the cylinders lie to the same side of a common plane including the axis of the discs.**

Discussion of Prior Art and Advantage(s):

page 1, line 8 - page 2, line 12:
'Variators of this type are well known in the art, and patent specifications GB-A-1 395 319, GB-B-2107009, EP-B-0078125 and EP-B-0133330 are some of many in which such a roller positioning system is illustrated and described ...

... Furthermore each cylinder has to be connected to input and output hydraulic leads. Those leads, and their connections to the cylinders, must be substantial in order to withstand the fluid pressures to which they will be subjected, and the symmetrical disposition of the cylinders around the transmission axis means that the leads also will be disposed all around the circumference of the transmission, for example cast within the transmission casing, or even possibly exposed. This creates a number of problems. For instance the cost of forming complex passages within a cast casing **(= reduced cost)** ... the protection from damage of those parts if any of the passages are exposed ... **(= improved reliability)**

... The present invention is based on appreciating that ... it is possible to modify the disposition of the three mechanisms so that they all lie generally to one side only of the common axis of the discs, so potentially alleviating several of the problems already referred to.'

WO92/03671 (earliest filing date: 17.08.90)

Protected Solution(s):

sole independent claim:
A continuously-variable-ratio transmission **(CVT)** with coaxial input and output and capable of operating in at least two regimes **(multi-regime gearbox)** and comprising the arrangement in succession of a ratio-varying unit **of the toroidal-race rolling-traction type**, and a gearing arrangement comprising both a speed-reducing gear unit and a mixing gear unit, the latter being of the epicyclic type, in which the **mixing epicyclic gear unit is so arranged that its components are locked-up** (that is to say, rotate as one) **in at least one of the regimes and in which the speed-reducing gear unit effects a reduction in speed but no reversal of direction between its input and its output.**

Description of Prior Art and Advantage(s):

page 3, lines 2 to 9:
'Hitherto it has been customary, in the art, to achieve both the reversal and the speed reduction within unit G itself. This happens, for instance, within the speed-reducing unit shown in figure 4 of patent specifications GB-A-2023753 and GB-A-2100372. The inevitable consequence of this combination of requirements has been to reduce somewhat the potential efficiency of unit G, which like unit M may be of epicyclic type'

page 3, lines 12 to 19:
'One aspect of the invention is illustrated by ... Figure 2 ... In that CVT the two necessary features of ... speed reduction and direction reversal – are separated, so enhancing the efficiency of the speed-reducing unit'

WO92/08912 (earliest filing date: 16.11.90)

Protected Solution(s):

independent claim 1:
A variator for a continuously-variable-ratio transmission (CVT) of the toroidal-race rolling-traction type, in which each roller spans the toroidal clearance between its respective input and output discs diametrically, and in which the centre of each roller is capable in use of limited movement back and forth along the centre circle of the toroidal clearance **(=CVT of the toroidal-race rolling-traction type)**, characterised in that **stop means are mounted adjacent both the outer and inner edges of the part-toroidal races on the discs, to prevent the roller from running off those edges.**

Discussion of Prior Art and Advantage(s):

page 3, line 15ff.:
'The present invention arises from the fact that with a more modern hydraulic mounting and control of the rollers, as described in WO90/05860 for instance, substantial change of roller orientation is much more rapid, and can occur within as little as a small fraction of a revolution of the input disc or discs. The possibility of the rollers changing orientation rapidly and unpredictably, and even running off the input and/or output races, within a single backward revolution of the input shaft, for instance on engine shut down or following a false start, therefore becomes a real one and should be guarded against.' **(= improved reliability)'**

page 4, line 29ff.:
'As taught in many prior publications of hydraulic roller control systems ... the hydraulic circuit by which the position of the roller carriages and thus of the rollers is controlled during drive conditions contains "hydraulic end stop" features which come into play when the pistons approach the ends of their permitted strokes, whereby to ... oppose further piston movement towards and beyond the stroke end. However when hydraulic power is released, for instance when the engine is shut down at the end of a run or fails to fire when started, such hydraulic stops will not operate. Furthermore, if on such occasions the engine output shaft turns backwards by even a small amount - say even less than half a revolution - then the combination of quick roller response and the unpredictable roller movement caused by reverse input rotation may cause at least some of the rollers within the variator to change orientation so violently that they are in danger of running off the edges of the races. According to the present invention, that risk ... is countered by providing physical fences.' **(= improved reliability)**

WO92/10697 (earliest filing date: 11.12.90)

Protected Solution(s):

sole independent claim:
A continuously-variable-ratio transmission **(CVT) of the toroidal-race rolling-traction type**, capable of operating in "low" and "high" regimes with synchronous change between those regimes, and including a variator - that is to say a ratio-varying component - and an associated gearing set of which the components are capable of being set in different combinations for the high and low regimes, in which the output of the gearing is connectable to the output of the CVT as a whole, and the gearing has first and second inputs connected with the variator output and engine output respectively **(= + multi-regime gearbox)**, characterised in that **(+) in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.**

Discussion of Prior Art and Advantage(s):

page 1, line 29 to page 2, line 34:
'Examples of such two-regime CVT's of the toroidal-race rolling-traction type are to be found described in Patent Specification GB-A-1078791 ... in the second or high regime, there has in effect been a direct driving connection between the engine and the CVT output ... The present invention arises from appreciating the possibility of reducing the maximum torque reaction in high regime within the variator of a two-regime CVT by avoiding direct drive in high regime ...'

page 3, line 5ff.:
'... the invention thus offers the prospect of a variator with components of smaller size than would have been necessary if direct drive had been used **(= reduced size)**, and economy of design **(= reduced cost)** may be achieved by maximising the number of gearing components that are used in both regimes, and minimising the number that are used in only one regime.'

WO92/11475 (earliest filing date: 21.12.90)

Protected Solution(s):

sole independent claim:
A roller control system for a CVT of the toroidal-race, rolling-traction type in which a roller assembly comprises a carriage including rigid structure and bearings mounted thereon and a roller mounted to spin in those bearings, in which the roller contacts and transmits traction between coaxial rotatable discs presenting input and output races of toroidal form and in so doing is subjected to traction forces at the disc/roller contacts **(='Roller Control System for a CVT with input and output discs and roller therebetween')**, in which an operating mechanism includes fixed and moveable parts and is in contact with and operable to apply a predetermined control force to, the carriage, in which the operating mechanism and carriage seek an equilibrium position in which the resultant of the control force and of the traction forces experienced by the roller assembly in a plane at right angles to the axis of the discs is zero **(='of the force-balance type' - SEE LATER NOTE), in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism** characterised in that **(+) the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.**

Description of Prior Art and Advantage(s):

page 5, line 29ff.:
' The following are among the prospective advantages of roller control systems according to the present invention. Firstly a hinge - e.g. items 7 in Figures 1 to 3, and the hinge about axis 45 in figure 4 - can be cheaper and package better than joints allowing relative rotation about more than one axis, as shown in some of the embodiments in publication WO90/05860, for example'
(=reduced cost)

page 5 , line 35ff.:
'Secondly the hinge or swivel joints (about axes 8,45), just described, ensure that the associated pistons (11,12,35) of the operating mechanisms will rotate in their cylinders whenever the roller centre is displaced along axis 20, and the CVT therefore changes ratio. This may be important because that rotation, when taking place under any powerful forces exerted from the roller, will tend to break any '"stiction" between the pistons and their respective cylinders and thus promote smooth operation and true equalisation of force between all the rollers, each supplied in parallel from source 17, that are transmitting traction between any one input disc and its corresponding output disc."
(=improved smoothness of operation)

page 6, line11ff.:
'Thirdly conventional seals for the control pistons (11,12,35) can be used, because these pistons are subject neither to tilting nor to large displacements"
(=reduced cost)

WO93/21031 (earliest filing date: 16.04.92)

Protected Solution(s):

independent claim 1:
A driveline comprising a control system subject to operator demand, and a continuously-variable-ratio transmission (CVT) that includes a variator - that is to say a ratio-varying component - and is drivable by a prime mover or other engine, and having an output connectable to a point of use, the energy input to the engine being subject to variable regulation by the control system, in which optimum relationships between the engine torque and speed are predetermined over a range of values of those two quantities, in which means are provided to sense and correlate appropriate speeds, torques and ratios of the CVT whereby the driveline seeks a state in which such an optimum relationship is fulfilled, characterised in that the variator is of torque-controlled type and the control system is operable to regulate the reaction torque experienced within the variator.

independent claim 8:
A driveline comprising a control system subject to operator demand, and a continuously-variable-ratio transmission (CVT) **(= with CVT)** driven by a prime mover or other engine, and having an output connectable to a point of use, **the energy input to the engine being subject to variable regulation by the control system,** in which the CVT includes a variator - that is to say a ratio-varying component - of torque-controlled type and in which **the control system is operable to regulate the reaction torque experienced within the** variator, in which the variator is **of the toroidal-race rolling-traction type,** and the control system regulates the variator reaction torque by controlling the operating force applied to the variator rollers, in which the roller operating force is exerted hydraulically, the hydraulic control pressure being regulated by the control system, characterised in that **(+) the control system is adapted continually to compute the variator reaction torque with relation to alternative calculations based on the transmission input and output torques respectively, and in that the system chooses for operation the calculation yielding the lesser value of variator reaction torque and applies a related hydraulic control pressure.**

Discussion of prior art and advantage(s):

page 1, line 20 - page 2, line 27:
'In a contemporary vehicle driveline including a variator of the toroidal-race rolling-traction type, the key component can be expected to be a computerised control system, programmed to receive inputs of two kinds. ...

... The result of the many input signals, of these two kinds, that the control system receives, will in practice be only two essential output signals. One of these will be used to control the fuel supply to the engine, and the other to control the transmission.' The object of this invention is generally to improve a driveline of such type, and in particular to promote two improvements. Firstly, to operate the control system when the drivers demand changes so as to effect a smooth and rapid change from one steady state ... to another when demanded by the operator. Secondly, to translate the driver's demand into either a demand for a transmission output torque (over the lower part of the transmission ratio range) or a demand for an engine power i.e. torque and speed) over the higher part of the range) and to effect an automatic and imperceptible transition between the two modes of operation of the control system.'

page 7, lines 1-7 and 23-28:
'A second aspect of the present invention relates particularly to the programming of the control system ... This aspect of the invention applies to a driveline including any torque-controlled variator, but especially one where the variator is of the toroidal-race rolling traction type ...

... Thus the control system must interpret driver demand in two different ways: over a lower part of the ratio range it must produce a desired level of transmission output torque and, over the higher part of the range a desired level of engine torque (or power). The transmission between these two control modes must be automatic and undetectable.*' **(= improved smoothness of operation)**

(* - It will be noted that the advantage of the 'second aspect' is actually the same as the object of the invention per page 2, lines 15-27. It will also be noted that the characterising portion of claim 1 does not correspond to the above advantages - this is discussed in more detail in the main thesis document.)

WO94/01718 (earliest filing date: 03.07.92)

Protected Solution(s):

independent claim 1:
In or for a continuously-variable-ratio transmission of the toroidal-race rolling-traction type in which the roller carriages are connected to hydraulic piston-and-cylinder units by operation of which the orientation of the pistons and thus the transmitted ratio is controlled, a roller-control unit **(='Roller Control System for a CVT with input and output discs and roller therebetween, of the force-balance type')** comprising a cylinder mounted on fixed supporting structure, a piston, and a connection between that piston and the carriage of the associated roller, in which the piston is constrained to move within the cylinder so that the axes of the cylinder and pistons are coincident at all times, and in which **the piston and the roller carriage are connected by a pivotal joint located within the body of the piston,** characterised in that the piston is double-acting and in that the locus of contact between piston and cylinder constitutes the only locus through which the roller carriage makes contact with the fixed supporting structure **(= the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism)**

independent claim 10:
A CVT of the toroidal-race rolling-traction type including a roller-control unit according to claim 1.

Description of Prior Art and Advantage(s):

page 2, line 5ff.:
' ... in most of the embodiments described in publication WO90/05860 the sealing ring of the piston has a part-spherical outer face, allowing the piston to tilt slightly within the cylinder without losing sealing contact with it. Such a design, although practicable, requires more careful manufacture and assembly than a simple piston, and in particular requires a special seal where the piston rod passes through the cylinder end, to accommodate the wobbling of the rod which results from the tilting of the piston."

page 5, line 24ff.:
'Among the advantages of the construction are firstly the simplicity of the jointing of the link shaft 14 to the centre of the piston core 32.'
(= reduced cost)

page 5, line 27.:
'Thirdly, the lack of need for any great accuracy in the finish of the solid piston core 32, because the accuracy can be provided by the much lighter sleeve parts 33,34 which are then fitted over it.'
(- reduced cost)

WO94/04849 (earliest filing date: 13.08.92)

Protected Solution(s):

sole independent claim:
A continuously-variable-ratio transmission (CVT) having a rotatable input for connection to a prime mover and a rotatable output for connection to a driven member, in which the input is connected to a **(+) starting device capable of slip, (+) in which an output from the starting device is connectable both to** a variable ratio component **(CVT) and to a fixed ratio component and a first one-way clutch**, and in which the outputs of those two components are both connected to the CVT output.

Discussion of Prior Art and Advantage(s):

page 1, lines 10 – 18:
'The steplessly-variable ratio varying units (variators) of many known types of CVT are incapable of achieving zero ratio ... This has led many designers to include within the CVT, in addition to the variator, a starting device typically in the form of a torque convertor or other hydrokinetic coupling. When the prime mover is started from rest, it is connected to the driven wheels by way of the device and a gearing unit, and the variator is disconnected from the drive train.

page 1, line 33 - page 2, line 14:
'... Patent specification GB-B-2025545 describes a transmission of this kind. However, because there are two concentric input shafts to the transmission ... the location of the principal components is constrained. This can present a problem, particularly when a variator of the toroidal-race rolling-traction type is used in place of a belt because of its greater axial length. In addition it is not easy to adjust the ratio of a belt to that the variator can take over the drive from the fixed ratio gearing without shock. A toroidal-race variator, on the other hand, will move automatically to a ratio which is synchronous with that of the gearing and the two can thus be used in parallel ... Flexibility of installation is thus improved: for instance the axial sequence of the principal components (coupling, gearing, variator) can be changed.' **(= improved flexibility of installation)**

WO94/16244 (earliest filing date: 18.01.93)

Protected Solution(s):

sole independent claim:
A continuously-variable transmission capable of geared neutral **(+ geared neutral arrangement)** and of operating in at least two regimes **(+ multi-regime gearbox)**, and including a ratio-varying component **(CVT)**, a power-recirculating epicyclic, an input epicyclic the input of which is connnectable to a prime mover, and a final drive shaft connectable with the variator by way of one of two alternative drive shafts characterised in that (*1) **(+) the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.**

Description of Prior Art and Advantage(s):

*1 – in using the two-part form, the combination of features of the preamble are acknowledged as belonging to the prior art. The description itself does not describe such prior art, although it does separately acknowledge both 'geared neutral' and 'multi-regime' arrangements as being well known in the art.

page 2, lines 8-18:
'The present invention seeks to provide a CVT of the toroidal-race rolling-traction type, capable of geared neutral and of operating in at least two regimes, with a **specially convenient facility for incorporating extra regimes in both forward and reverse**, and also with the facility to limit the power passing through the variator, particularly at or close to the geared neutral condition. This power limitation can offer the prospect of providing substantial advantages, including **reduced variator size**, particularly in vehicles such as excavator trucks which are often required to deliver high torque when moving at low or zero road speed'.

page 6, lines 17-20:
'The maximum power which a toroidal-race variator must transmit is a key factor in determining the size and cost **(=reduced cost)** of such a variator, so there are clear advantages in minimising that maximum power.'

WO94/24462 (earliest filing date: 15.04.93)

Protected Solution(s):

sole independent claim:
A continuously-variable-ratio transmission **(CVT) comprising a** ratio-varying unit ("**variator**"), and an epicyclic unit having three outputs arranged concentrically and comprising first and second epicyclic gears so arranged that two of the components of one of the sets are each commoned with a component of the other to constitute two of the outputs of the epicyclic unit, these two outputs being connected respectively in fixed ratio to opposite ends of the variator*,**(= + geared neutral arrangement)** in which the said two outputs of the epicyclic unit are connectable to an output shaft by way of a plurality of ratio combinations, in which a plurality of clutches are provided to engage the outputs and ratio combinations in different ways whereby the CVT can operate in a plurality of regimes **(= + multi-regime gearbox)**, and in which the **(+) epicyclic and variator ratios are chosen so that the changes between those regimes are all synchronous and that at a first given variator ratio all epicyclic components rotate at the same speed , whereby alternate regime changes occur at that first given variator ratio.**

(* - page 2, line 21ff. explains that '... the two elements of the variator are respectively connected to different output members of the epicyclic unit. This arrangement of the variator is chosen, according to the present invention, so as to ensure a CVT that is capable of using variators, such as those of the toroidal-race rolling-traction type, which are unidirectional in operation and which cannot reach zero output speed'. Other filings in the portfolio (e.g. WO94/16244) explain that such an arrangement an arrangement is known as 'geared neutral' - it is also referred to on page 2, line 4 and page 7, line 7 of the description. Accordingly, this term is used in the summary)

Discussion of Prior Art and Advantage(s):

page 1, lines 1-19:
'This invention relates to continuously-variable ratio transmissions including, as basic components, a ratio-varying member, a gearing unit capable of splitting and recirculating power, and a plurality of clutches alternatively engageable to connect the combined output of the variator and unit by way of further gearing to a final output shaft of the CVT as a whole ... Providing more than one alternative clutch/further gearing combination to transmit the drive to the CVT output creates a "multi-regime" system in which the full variator range may be utilised in each of the regimes, so that the ratio range of the CVT as a whole is extended, and can approximate to the ratio range of the CVT, raised to the power of the number of regimes.'

page 7, lines 7-8:
'... the condition known in the art as "geared neutral"...'

page 3, lines 7-10:
'Hydrostatic variators tend to work with best efficiency when one unit is stationary. The present invention seeks to provide a neat **(= reduced size)** and economical **(= reduced cost)** construction potentially suitable for CVT's using variators that may not have this characteristic.'

page 5, line 19ff.:
'... a further feature of the invention, which contributes particularly to the economy in the total number of components **(= reduced cost)** and especially in the need for only the three gear trains ...'

WO95/09996 (earliest filing date: 01.10.93)

Protected Solution(s):

independent claim 1:
A method of controlling a vehicular driveline including an engine or other prime mover, a continuously-variable-ratio transmission (**= driveline with CVT**) and a final drive, in which (+) **over a working range of engine speed the engine is constrained to work to a performance "map" correlating each value of that speed with a particular value of engine torque,** characterised in that (+) **driver demand for a rise in engine speed is programmed to initiate a response in three successive stages** as follows:-
Stage 1: **initial engine speed rises quickly to a predetermined value** ("engage speed") **without any substantial rise in final drive speed;**
Stage 2: **both speeds then continue to rise and to be related by a predetermined function until engine speed reaches a value ("limit speed") commensurate with the driver's demand, and**
Stage 3: **limit speed is then maintained during any further change in final drive speed.**

independent claim 8:
A vehicular driveline controlled by a method according to any of the preceding claims.

Description of Prior Art and Advantage(s):

page 3, line 5ff.:
'The present invention aims to modify the mutual control of the engine and CVT so that although the engine can still operate to an optimum-efficiency control line ... the engine note and the acceleration are correlated in a manner more familiar to a driver used to conventional manuals and automatics' (= **conventional variation of acceleration with engine note)**

WO95/17621 (earliest filing date: 20.12.93)

Protected Solution(s):

sole independent claim:
A continuously-variable-transmission ("CVT") **of the band-and-sheave type** including control means operable by a driver or other operator, a ratio-varying component comprising at least one band in driving contact with two pulley units presenting parallel but separated axes of rotation but sharing a substantially common radial plane, in which each pulley unit comprises shaft means and two sheaves mounted thereon, the axial separation of the sheaves being variable whereby to alter the radius of contact between the band and that pulley unit and so alter the transmitted ratio, **(+) in which there is a torque-sensitive connection between at least one of the pulley units and its shaft means capable of generating an axial unit/shaft means force that is a function of the magnitude and direction of the torque the pulley unit is transmitting and in which loading means operate on the pulley units to urge their sheaves together with a loading force** characterised in that **(+) the input of power to the variator by way of a shaft means on either of the two axes has the effect, by way of the torque-sensitive connection, of tending to cause the axial separation of the sheaves of a unit on that shaft means to increase relative to that of the sheaves of the corresponding unit on the other shaft means.**

Description of Prior Art and Advantage(s):

page 1, line 1.:
'This invention relates generally to ... CVTs of the band-and-sheave type.'

page 3, line 24ff.:
'One such proposal appears in Paper 730003 ... presented at the International Automotive Engineering Congress ... in January 1973. In the variator described in that proposal one of the two pulley units exhibits some torque-sensitive capacity due to the capacity of one of the sheaves to move spirally relative to the shaft on which it is mounted ...'

page 4, line 20ff.:
'The present invention arises from appreciating how a CVT of the band-and-sheave type may be improved by becoming torque-controllable to the degree that it is required by a modern automotive vehicle, and that is more comparable with the controllability of the toroidal-race CVT's already mentioned.'

WO96/28668 (earliest filing date: 16.03.95)

Protected Solution(s):

sole independent claim:
A variator for a continuously-variable-transmission (CVT) of the half-toroidal traction roller type, in which ratio change results when a roller exercises first freedom of movement by rotating about a first or precession axis and in which the roller mounting has a further freedom of movement about a second or tilt axis, in which (+) the precession axis is inclined at an angle to a plane lying normal to the axis of the races, and in which each equilibrium value of the ratio angle correlates with a unique angular orientation of the roller about the tilt axis.

Description of Prior Art and Advantage(s):

page 1, line 1.:
'This invention relates ... to variators of the so-called 'half toroidal' type in which the rollers are positioned inwardly of the centre of the cavity defined by the part-toroidal races formed in the input and output discs.'

page 1, line 25ff.:
'... in US-A-3008337 ... the carriage of each of the rollers ... spanning the toroidal cavity between the input and output discs is mounted to rotate not only about a precession axis as already described, but also about a second or 'tilt' axis lying parallel to the common axis of the discs"

page 2, line 15ff.:
In US-A-3008337 there is '... no unique correlation between each equilibrium ration of the transmission and a particular orientation of each roller about its tilt axis ... This mode of operation may result in disappointing characteristics of response and especially stability.'

page 2, line 19ff.:
'The present invention arises from appreciating the possibility of a different geometry, leading to a tilt-controlled CVT of potentially better response and stability in which each equilibrium ratio angle of each roller correlates with a unique orientation of that roller about its tilt axis.'

WO97/01718 (earliest filing date: 28.06.95)

Protected Solution(s):

sole independent claim:
A roller control system for a continuously-variable-ratio transmission **(CVT of the toroidal-race rolling-traction type) (+of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism*)** including (+) **an operating mechanism having a first part operable to control the position of the roller centre along the torus centre circle but incapable of defining the tilt angle adopted by the roller, and a second part comprising a mechanical link connected to the roller bearings and operable to control the tilt angle, in which the link lies substantially parallel to the plane of the roller and is constrained to pass through a predetermined single point.**

(* - these two features considered to be implicit given discussion of prior art below)

Discussion of prior art and advantage(s):

page 1, lines 12-22:
'Such a variator has been found to work efficiently in a so-called 'torque controlled' CVT **(= force-balance type)** where a pressure generated hydraulically (by means not shown) in cylinder E exerts a force on piston D ... In other words, each equilibrium tilt angle of the roller is uniquely defined by just three points, namely the locations of contact of the roller A with races F and H and the location of the centre of the piston D **(= in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism).** Such a variator, and the CVT of which it is part, is described and shown in more detail in Patent EP-B-0444086 (note: = WO90/05860).'

page 2, lines 1-12.:
'... as is typical in the prior art, the axis of movement which applies the reaction force (the piston D) and the axis of tilt (the rod P) coincide at the third of the three points by which each angular setting of the roller is uniquely defined. This coincidence imposes constraints upon the location and orientation of certain components, particularly the cylinder E, and thus on the overall dimensions of the variator. For example, because the axis of cylinder E is inclined to the transverse mid-plane M by the castor angle L, the radius at which the cylinder is located relative to the disc axis N exceeds the radius of the discs themselves. If it did not, a corner of the cylinder would be at risk of fouling the disc J. According to the present invention such constraints are diminished, thus providing greater freedom to locate the equivalent of cylinder E so as to minimise the overall dimensions of the variator **(= reduced size)**

WO97/18982 (earliest filing date: 20.11.95)

Protected Solution(s):

independent claim 1:
A position servo system comprising a driven mechanism, a first rotary actuating member by which operative control is normally applied to that mechanism, and a continuously-variable-transmission ("CVT") of the variable-ratio-epicyclic type, and in which there is a first connection between a component of the CVT and the first actuating member, and a second connection between a component of the CVT and the driven mechanism, characterised in that **(+) the CVT has a rotary input from a prime mover separate from the actuating member, in that the CVT is disposed coaxially with the first actuating member, and in that an error between the positions of the driven mechanism and the first actuating member - indicative of the application of a substantial driving effort - results in a power output from the CVT, tending to apply torque to the driven mechanism so as to diminish the error.**

independent claim 21:
An automobile or other apparatus including a position servo system as claimed in any preceding claim.

(Note: independent claim 21 is not included in the diagram for the reasons specified in the main thesis document)

Description of Prior Art and Advantage(s):

page 1, line 19ff.:
'The present invention is to be distinguished from the embodiment of JP-A-63 291 770 principally in that in the system described in that prior publication, the CVT does not generate and transmit any power to assist the steering effort provided by the operator. Instead, the function of the CVT appears to be to vary the manual steering ratio, between the steering wheel and the steering rack to which it is connected, so that quite separate means to generate power assistance receive relative strong signals at low vehicle speeds and weak ones at high speeds'

page 6, lines 12-19:
'The following potential advantages of the embodiments of the invention shown in all the Figures of drawings should be particularly noted. Firstly that because the entire CVT rotates in common with the members from which it receives its input and to which it delivers its output, there are no problems associated with the fact that while the shaft can rotate through over three revolutions, the power steering effect should come into operation when there is only a small angular error - say 2 degrees - between shaft 3 and tube 20. Secondly, that the variator

naturally rests with rollers at a 1:1 ratio when stationary, thereby avoiding any tendency to steer.'

(Note: Neither of these advantages are relative to the prior art. It is not evident how either can be reduced to more basic principles. Since there is only one entry, it is sufficient to leave the advantage unspecified)

WO97/37156 (earliest filing date: 01.04.96)

Protected Solution(s):

independent claim 1:
A roller assembly for use in a toroidal-race rolling traction variator **(= CVT of the toroidal-race rolling-traction type)**comprising a roller mounted in a carriage and **+ ducting for introducing flows of cooling liquid to the roller thereby to remove heat from the roller during operation of the device, in which the ducting includes at least two mutually opposed outlets positioned for directing cooling liquid onto opposing portions of the roller.**

independent claim 13:
A roller assembly for use in a toroidal-race rolling traction variator **(= CVT of the toroidal-race rolling-traction type)**comprising a roller mounted in a carriage operably connected to a double acting piston of a roller control cylinder, said control cylinder including a stem connecting the piston to the carriage and having a passage therethrough for the transportation of cooling fluid to the roller, **(+ hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith)**; said **+ the [cylinder] stem having an end face exposed to a pressurising effect of the cooling fluid and the double acting piston having a confronting surface also exposed to the pressurising effect of the cooling fluid, such that any axial load on the stem is at least partially counteracted by an opposite effect on the confronting surface of the double acting piston.**

Discussion of Prior Art and Advantage(s):

page 1, line 26ff.:
'British patent application number GB-A-2282196 discloses a roller assembly for the above type of variator in which cooling fluid is provided to the roller surface via a hollow roller support arm. The fluid is passed through a single outlet positioned opposite the roller outer surface and bathes the roller in cooling fluid. It is an object of the present invention to provide an improved apparatus for the cooling of such rollers.'
('Improved apparatus for cooling' is interpreted to mean 'improved cooling' which translates into **improved lifetime**. Unfortunately, the filing contains no other advantage information)

WO97/40292 (earliest filing date: 19.04.96)

Protected Solution(s):

independent claim 1:
A variator assembly comprising a variator of the toroidal-race rolling-traction type having input and output discs, hydraulic piston actuated rollers positioned between said discs and operative to transmit traction therebetween **(=CVT with input and output discs and roller therebetween)** and end loading means **for biasing the discs into engagement with each other,** characterised by (+) **hydraulic control means operative to vary the end load in sympathy with changes in the force exerted by the roller-control piston so as to maintain the traction coefficient at the roller-disc interface consistently below the limit at which traction would be lost.**

independent claim 15:
A valve characterised by first and second chambers and a double-headed piston having a first head within the first chamber and a second head in the second chamber, said first head acting to divide the first chamber into two portions, the first of which has an inlet for receiving hydraulic fluid from a first source and the second chamber having a second inlet for receiving hydraulic fluid from a second source, said second head being operably connected to the first head by a joining member and being moveable therewith, said second. chamber having a first inlet for receiving hydraulic fluid from a source, an outlet for supplying hydraulic fluid at pressure to another apparatus , and a third obturable outlet, the arrangement being such that the pressure of the hydraulic fluid in the second chamber varies in sympathy with the net pressure in the first chamber.

Discussion of Prior Art and Advantage(s):

page 1, line 8ff.:
'CVT using this type of variator is described in detail in patent specifications GB-A-2023753 and GB-A-1078791for example. The variator in this case comprises two input discs or rotors both of which rotate with an input shaft driven by a prime mover. One of these two discs is fixed to the shaft while the other is splined to the shaft so that the disc has freedom for limited displacement in an axial direction. ... In addition to its function as an input member, the axially displaceable end disc also serves as a piston operative to exert an end load on the variator. This is required to generate the necessary contacting forces between the rollers and the discs to transmit drive. If the variator is subjected to excessive end load efficiency will be low and component life short whereas, if it is inadequate, unacceptable slipping can occur at the roller-disc interface which will result in a loss of traction, a clearly undesirable effect.'
(it follows that the advantage associated with 'end loading means' is 'improved traction')

page 9, line 14 ff.:
'It will be noted that the variator control system of the present invention compares very favourably with that of GB-A-1 600 974 because as a result of there being no effective trailing pressure in the roller-control pistons in this prior arrangement, any low pressure applied there for end load compensation will increase the operating traction coefficient with the attendant danger of exceeding the limiting value, and the undesirable consequences already outlined above' (see * below)

*: see page 1, line 18 ff.:
'if the variator is subjected to excessive end load efficiency will be low and component life short' **(=improved efficiency, = improved lifetime)**

N.B. No discussion in filing of prior art relating to valve.

WO97/40296 (earliest filing date: 19.04.96)

Protected Solution(s):

independent claim 1:
(CVT of the toroidal-race rolling-traction type – see reference to 'variator rollers' below) + A control system for a multi-regime continually-variable-transmission **(= multi-regime gearbox)** driven by a prime mover and providing an output drive, the control system comprising first and second regime change clutches and means for initiating engagement of the otherwise unengaged clutch during regime change, said control system further including: **(control system comprising – see reference to 'control system' above) first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers (*1),** characterised in that (+) **the first and second control means are operable independently of each other thereby to achieve active control of the regime change.**

(*1 – control means for clutch and variator assumed to be implicit in 'multi-regime gearbox' arrangement and thus not prefixed by '+')

independent claim 12:
A method of operating a control system **(=control system)** for a multi-regime **(= multi-regime gearbox)** continually-variable transmission **(= CVT)** having first and second regime change clutches, the method comprising the steps of:
firstly, during regime change, initiating engagement of the otherwise unengaged clutch before the variator reaches synchronous ratio such that the engine load created by the transmission varies and thereby induces a change of regime;
secondly, completing regime change by disengaging the clutch associated with the regime from which the transmission has been changed and completing engagement of the clutch under engagement.

independent claim 16:
A hydraulic control system for a multi-regime **(= multi-regime gearbox)**continually variable transmission driven by a prime mover and providing an output drive, the transmission having hydraulically actuated first and second regime change clutches and a variator having ratio varying rollers each associated with a respective hydraulic ram **(=CVT of the toroidal-race rolling-traction type)**, the system having, at any particular moment in time, a higher and a lower source of hydraulic pressure, **(+ a control system comprising – see reference to 'control system' above) supply means for causing the supply of hydraulic fluid to each clutch to vary between the fluid at the higher pressure and the fluid at the lower pressure and the supply of hydraulic fluid to the hydraulic ram to be such that the rollers respond to the differential pressure.**

Description of Prior Art and Advantage(s):

page 1, line 5:
'Transmissions are known which use a variator of the toroidal-race rolling-traction type to give the continuously-variable-ratio performance and clutches to move the transmission between one or other of two operating regimes.'

page 3, line 1ff.:
'In these latter circumstances, hard-filling of the clutch will occur at a significant transmission ratio error and this results in a noticeable mechanical shock on the change from one transmission regime to the other. It is an object of the present invention to reduce and possibly eliminate the problems associated with the above-mentioned arrangement **(i.e. improved smoothness of operation)**

WO99/34133 (earliest filing date: 24.12.97)

Protected Solution(s):

sole independent claim:
A variator transmission apparatus comprising an input shaft, one or more input discs mounted on the shaft for rotation therewith, an output disc assembly, the input disc or discs and the output disc assembly defining between them one or more toroidal cavities, a plurality of rollers located in the cavity or cavities **(=CVT of the toroidal-race rolling-traction type)** and means for applying an end load pressure to maintain the rollers in contact with the respective disc or discs in order to transmit drive **(=end loading means for biasing the discs into engagement with each other*)**, characterised in that **(+) one of the discs is mounted on the shaft by means of an intermediate relatively flexible member.**

* terminology as already used in WO97/40292

Discussion of the prior art and advantage(s):

page 1, line 29ff. with reference to 'infinitely-variable-ratio transmission apparatus of the toroidal-race rolling friction type':
'The drive ... exerts a transverse load onto the shaft and at high power transmission levels can cause the shaft to flex. The degree of flexing is relatively small but has the potential of causing a significant effect on the position of the two output discs which can cause the load on some of the rollers to be increased, i.e. a crushing effect will be applied, whilst the load on some of the remaining rollers will be decreased, thereby not allowing the drive to be transferred efficiently from the input to the output discs.'

page 5, line 25ff.:
'The increase in load on some of the rollers may be unacceptable in that unduly high stresses are caused within the rollers **(= improved lifetime)**, whilst the decrease in load on the remaining rollers is likely to reduce efficiency of the drive between the input and output discs because slipping may occur between the input and output discs' **(= improved efficiency)**

WO99/34134 (earliest filing date: 24.12.97)

Protected Solution(s):

sole independent claim:
'A variator transmission apparatus **comprising a housing, an input shaft, two input discs mounted on an auxiliary shaft for rotation therewith, an output disc assembly, the input discs and the output disc assembly defining between them two toroidal cavities**, a plurality of rollers located in the cavities **(=CVT of the toroidal-race rolling-traction type)** and the apparatus being subjected to an end load to maintain the rollers in contact with the respective discs and disc assembly in order to transmit drive **(=end loading means for biasing the discs into engagement with each other*)**, characterised in that **(+) the input shaft is arranged to drive the auxiliary shaft and the output disc assembly is supported from the housing.**

* terminology as already used in WO97/40292

Discussion of the prior art and advantage(s):

page 1, line 7ff.:
'In such [known but unspecified] apparatus there is employed a main shaft which takes drive from an engine ... to two input discs which are mounted on the shaft. Two output discs are mounted back to back between the input discs and are free to rotate relative to the shaft.'
(This corresponds to the preamble of claim 1. No prior art document details are given.)

page 1, line 21ff.:
'The drive ... exerts a transverse load onto the shaft and causes the shaft to flex. The degree of flexing is relatively small but has the potential of causing a significant effect on the position of the two output discs which can cause the load on some of the rollers to be increased, i.e. a crushing effect will be applied, whilst the load on some of the remaining rollers will be decreased, thereby not allowing the drive to be transferred efficiently from the input to the output discs.'
(note - same text as used in WO99/34133 above)

page 4, line 4ff.:
'The increase in load on some of the rollers may be unacceptable in that unduly high stresses are caused within the rollers **(= improved lifetime)**, whilst the decrease in load on the remaining rollers is likely to reduce efficiency of the drive between the input and output discs because slipping may occur between the input and output discs' **(= improved efficiency)**
(note - same text as used in WO99/34133 above)

page 5, line13ff.:

'It will be appreciated that the load exerted by the drive from the output discs on the support structure will not cause any flexing of the input shaft nor the auxiliary shaft. Instead, the load will be taken by the cradle. As both the input shaft and the auxiliary shaft are isolated from the load exerted by the drive from the output discs the toroidal cavities will not be distorted and the load on the rollers will not be affected by the load exerted by the drive from the output discs.

WO99/54646 (earliest filing date: 22.04.98)

Protected Solution(s):

sole independent claim:
A roller control unit for a continuously-variable-ratio transmission **(CVT) of the toroidal-race rolling traction type**, said roller control unit comprising: a cylinder, having a cylinder wall and an end wall; a piston, within the cylinder and to which the roller is connected for movement therewith, characterised by **(+) an axially extending shroud of variable length extending between the piston and the end wall, thereby to define in combination with the piston and cylinder a chamber for receiving hydraulic fluid, and in which the shroud comprises a telescopic shroud which in a first position of the piston is extended and in a second position of the piston is retracted.**

Discussion of prior art and advantage(s):

page 1, line 11-33:
'Several patent publications of recent years, of which WO90/05860 is an example, describe toroidal-race transmissions in which direct connection of each roller to a piston subject to controlled hydraulic pressure suffices to maintain the angular orientation of each roller - and thus the ratio transmitted by it from an input disc - at the appropriate value at all times.

... One of the problems encountered in practice by CVT's in which rollers are so controlled is that the length of the stroke that the piston must execute in order fully to control the roller is relatively long. Consequently, the housing for the piston/cylinder is of such a length that it can be difficult to install within the tight confines of, for example, an engine compartment. It is an object of the present invention to provide a roller control unit for a continuously-variable-transmission of the toroidal-race rolling-traction type which at least reduces the above-mentioned problem.' **(= reduced size)**

page 5, line 20ff.:
'It may therefore be seen a significant saving is achieved in the length of the housing for the piston/cylinder unit, it being reduced by approximately the length of travel of the piston head.'

WO99/56036 (earliest filing date: 27.04.98)

Protected Solution(s):

sole independent claim:
A roller control unit for a continuously-variable-transmission **(= CVT of the toroidal-race rolling-traction type)** comprises:
a cylinder having a cylinder wall
a piston within the cylinder and being axially translatable therealong;
a chamber formed by said cylinder and piston for receiving hydraulic fluid which, in operation, causes said piston to move between first and second axially displaced positions; **(+ hydraulic cylinder having)** and
a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith;
characterised in that
+ said lubrication supply passage comprises a chamber formed between said piston and chamber wall and one or more radially extending passageways through said piston, each having a first end in fluid communication with said chamber and having a second end in communication with said roller.

Discussion of Prior Art and Advantage(s):

page 2, line 29ff.:
'Whilst the above-discussed arrangements provides a perfectly adequate roller control system, problems can arise in connection with the efficient supply of cooling fluid to the roller, particularly when its flow path is through the roller actuation piston. In such cases a small bore supply is often used and multiple bends are encountered before the fluid reaches the roller. The combination of these two features can cause undesirable pressure losses (= reduced efficiency) and reduce the effectiveness of the cooling system (= reduced lifetime). It is an object of the present invention to provide a roller control unit which reduces and possibly eliminates the problems associated with the above-mentioned control unit **(= improved efficiency, improved lifetime)**

WO99/58883 (earliest filing date: 08.05.98)

Protected Solution(s):

independent claim 1:
An hydraulic control circuit for a CVT transmission having a variator and a plurality of regime change clutches **(=multi-regime gearbox)** comprising: first and second hydraulic supply pipes; first and second hydraulic pumps associated with said first and second supply pipes respectively for pumping hydraulic fluid therethrough and for raising its pressure; a first hydraulic pressure control valve V1 for controlling the pressure of hydraulic fluid to be supplied to the roller control pistons of the variator **(i.e. CVT of the toroidal-race rolling traction type)**; a second hydraulic pressure control valve V2 for controlling the pressure of hydraulic fluid to be supplied to a clutching arrangement of the transmission **(=control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change)** ; characterised in that **(+) said valves are connected in flow series and by a first fluid directing valve means for directing flow from each pump to a first point upstream of valve V1 or to a second point downstream of valve V1 but upstream of valve V2.**

independent claim 26:
A continuously-variable-transmission having an hydraulic control circuit as claimed in any one of claims 1 to 25.

Discussion of prior art and advantage(s):

page 1, line 35 – page 2, line 10:
'An hydraulic control ... is described in our own PCT application number PCT/GB97/00956 **(=WO97/40296)** ... It is an object of the present invention to provide an hydraulic control circuit for a continually variable transmission which improves on the above design by providing a control circuit capable of more rapid response to adverse operating conditions (*1,*2)'

(*1 – page 13, line 14 suggests adverse operating conditions means 'emergency stop condititons' = **improved response**)
(*2 – confirms that WO'883 nests within WO'296. Claim language from WO'296 is accordingly included as underlined above)

ANNEX 8:
Scope and Advantage Diagram for the Torotrak Patent Portfolio

Figure A.1

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92011475, 21.12.90)

Figure A.2

improved smoothness of operation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre WO capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92011475, 21.12.90)

reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92011475, 21.12.90)

Figure A.3

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism
(WO90/05860, 21.11.88) 1

[]1 / improved smoothness of operation:
• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

[]1 / reduced cost:
• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

Figure A.4

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism (WO90/05860, 21.11.88) 1

[]1 / improved smoothness of operation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

[]1 / reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the piston and the roller carriage are connected by a pivotal joint located within the body of the piston
(WO94/01697, 03.07.92)

Figure A.5

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type
(GB1395319, pa in WO90/05860) 1

[]1 / reduced cost

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + roller assembly located by only 3 contacts - 2 with discs, 1 with operating mechanism
(WO90/05860, 21.11.88) 2

[] 2 / improved smoothness of operation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92011475, 21.12.90)

[] 2 / reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92011475, 21.12.90)

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the piston and the roller carriage are connected by a pivotal joint located within the body of the piston

(WO94/01697, 03.07.92)

[] 2 / reduced size:

- **Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + an operating mechanism having a first part operable to control the position of the roller centre along the torus centre circle but incapable of defining the tilt angle adopted by the roller, and a second part comprising a mechanical link connected to the roller bearings and operable to control the tilt angle, in which the link lies substantially parallel to the plane of the roller and is constrained to pass through a predetermined single point**
(WO97/01718, 28.06.95)

Figure A.6

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type
(GB1395319, pa in WO90/05860) 1

[] 1 / basic implementation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism
(WO90/05860, 21.11.88) 2

• CVT of the toroidal-race rolling-traction type + of the force balance type + both the tangential shift and the resulting pivotal movement are facilitated by mounting ball ends at opposite extremities of the carriage.
(GB1395319, pa in WO90/05860)

[] 2 / improved smoothness of operation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

[] 2 / basic implementation:

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the piston and the roller carriage are connected by a pivotal joint located within the body of the piston
(WO94/01697, 03.07.92)

• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type, + in which the roller assembly is located by only three

contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)
• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + sealing ring of the piston has a part-spherical outer face, allowing the piston to tilt slightly within the cylinder without losing sealing contact with it.
(WO90/05860, pa in WO94/01697)

[] 2 / reduced size:
• **Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + an operating mechanism having a first part operable to control the position of the roller centre along the torus centre circle but incapable of defining the tilt angle adopted by the roller, and a second part comprising a mechanical link connected to the roller bearings and operable to control the tilt angle, in which the link lies substantially parallel to the plane of the roller and is constrained to pass through a predetermined single point**
(WO97/01718, 28.06.95)

Figure A.7

• CVT of the toroidal-race rolling-traction type + of the force balance type (GB1395319, pa in WO90/05860) 1

[] 1 / basic implementation:

• CVT of the toroidal-race rolling-traction type + of the force balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism
(WO90/05860, 21.11.88) 2

• CVT of the toroidal-race rolling-traction type + of the force balance type + both the tangential shift and the resulting pivotal movement are facilitated by mounting ball ends at opposite extremities of the carriage.
(GB1395319, pa in WO90/05860)

[] 2 / improved smoothness of operation:

• CVT of the toroidal-race rolling-traction type + of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the piston and the roller carriage are connected by a pivotal joint located within the body of the piston
(WO94/01697, 03.07.92)

• CVT of the toroidal-race rolling-traction type + of the force-balance type, + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + the roller

centre is capable of movement, along the roller axis, relative to the rigid structure of the carriage, and the rigid structure of the carriage and the operating mechanism are connected by way of a hinged joint with a single degree of freedom.
(WO92/11475, 21.12.90)
• CVT of the toroidal-race rolling-traction type + of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + sealing ring of the piston has a part-spherical outer face, allowing the piston to tilt slightly within the cylinder without losing sealing contact with it.
(WO90/05860, pa in WO94/01697)

<u>[] 2 / reduced size:</u>
• Roller control system for a CVT of the toroidal-race rolling-traction type, of the force-balance type + in which the roller assembly is located by only three contacts with adjacent components, namely the two disc/roller contacts and the contact with the operating mechanism + an operating mechanism having a first part operable to control the position of the roller centre along the torus centre circle but incapable of defining the tilt angle adopted by the roller, and a second part comprising a mechanical link connected to the roller bearings and operable to control the tilt angle, in which the link lies substantially parallel to the plane of the roller and is constrained to pass through a predetermined single point
(WO97/01718, 28.06.95)

Figure B.1

• CVT of the toroidal-race rolling-traction type, end loading means for biasing the discs into engagement with each other
(GB1078791, pa in WO97/40292) 1

[] 1 / improved efficiency:

• CVT of the toroidal-race rolling-traction type, end loading means for biasing the discs into engagement with each other + hydraulic control means operative to vary the end load in sympathy with changes in the force exerted by the roller-control piston so as to maintain the traction coefficient at the roller-disc interface consistently below the limit at which traction would be lost
(WO97/40292, 19.04.96)

[] 1 / improved lifetime:

• CVT of the toroidal-race rolling-traction type, end loading means for biasing the discs into engagement with each other + hydraulic control means operative to vary the end load in sympathy with changes in the force exerted by the roller-control piston so as to maintain the traction coefficient at the roller-disc interface consistently below the limit at which traction would be lost
(WO97/40292, 19.04.96)

Figure B.2

• CVT of the toroidal-race rolling-traction type
(well known) 1

∏1 / improved efficiency:

• CVT of the toroidal-race rolling-traction type + end loading means for biasing the discs into engagement with each other
(GB1078791, pa in WO97/40292) 2

∏2 / improved efficiency:

• CVT of the toroidal-race rolling-traction type + end loading means for biasing the discs into engagement with each other + one of the discs is mounted on the shaft by means of an intermediate relatively flexible member.
(WO99/34133, 24.12.97)

• CVT of the toroidal-race rolling-traction type + end loading means for biasing the discs into engagement with each other + hydraulic control means operative to vary the end load in sympathy with changes in the force exerted by the roller-control piston so as to maintain the traction coefficient at the roller-disc interface consistently below the limit at which traction would be lost
(WO97/40292, 19.04.96)

∏2 / improved lifetime:

• CVT of the toroidal-race rolling-traction type + end loading means for biasing the discs into engagement with each other + one of the discs is mounted on the shaft by means of an intermediate relatively flexible member.
(WO99/34133, 24.12.97)

• CVT of the toroidal-race rolling-traction type + end loading means for biasing the discs into engagement with each other + hydraulic control means operative to vary the end load in sympathy with changes in the force exerted by the roller-control piston so as to maintain the traction coefficient at the roller-disc interface consistently below the limit at which traction would be lost
(WO97/40292, 19.04.96)

∏2 / unidentified advantage:

CVT of the toroidal-race rolling-traction type +end loading means for biasing the discs into engagement with each other +

comprising a housing, an input shaft, two input discs mounted on an auxiliary shaft for rotation therewith, an output disc assembly, the input discs and the output disc assembly defining between them two toroidal cavities
(unspecified document, pa in WO99/34134) 3

[] 3 / improved efficiency:
CVT of the toroidal-race rolling-traction type +end loading means for biasing the discs into engagement with each other + comprising a housing, an input shaft, two input discs mounted on an auxiliary shaft for rotation therewith, an output disc assembly, the input discs and the output disc assembly defining between them two toroidal cavities + the input shaft is arranged to drive the auxiliary shaft and the output disc assembly is supported from the housing
(WO99/34134, 24.12.97)

[] 3 / improved lifetime:
CVT of the toroidal-race rolling-traction type +end loading means for biasing the discs into engagement with each other + comprising a housing, an input shaft, two input discs mounted on an auxiliary shaft for rotation therewith, an output disc assembly, the input discs and the output disc assembly defining between them two toroidal cavities + the input shaft is arranged to drive the auxiliary shaft and the output disc assembly is supported from the housing.
(WO99/34134, 24.12.97)

Figure C.1

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect (GB2023753, pa in EP0354013) 1

[] 1 / reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + inlet & outlet ports formed in axial end wall of cylinder, outlet port lies axially proud of inlet port
(EP0354013, 04.08.88)

Figure C.2

• Roller control system for a CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / improved reliability:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect (GB2023753, pa in EP0354013) 2

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs
(WO92/01175, 13.07.90)

[] 2 / reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + inlet & outlet ports formed in axial end wall of cylinder, outlet port lies axially proud of inlet port
(EP0354013, 04.08.88)

Figure C.3

• Roller control system for a CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / improved reliability:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect (GB2023753, pa in EP0354013) 2

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs
(WO92/01175, 13.07.90)

• CVT of the toroidal-race rolling-traction type + stop means are mounted adjacent both the outer and inner edges of the part-toroidal races on the discs, to prevent the roller from running off those edges
(WO92/08912, 16.11.90)

[] 2 / reduced cost:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + inlet & outlet ports formed in axial end wall of cylinder, outlet port lies axially proud of inlet port
(EP0354013, 04.08.88)

Figure C.4

• Roller control system for a CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / improved reliability:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect
(GB2023753, pa in EP0354013) 2

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs
(WO92/01175, 13.07.90)

• CVT of the toroidal-race rolling-traction type + stop means are mounted adjacent both the outer and inner edges of the part-toroidal races on the discs, to prevent the roller from running off those edges
(WO92/08912, 16.11.90)

[] 2 / basic implementation:

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + inlet & outlet ports formed in axial end wall of cylinder, outlet port lies axially proud of inlet port
(EP0354013, 04.08.88)

• Roller control system for a CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + sleeve which fits over the shaft of the ram piston
(GB2023753, pa in EP0354013)

[] 2 / improved lifetime:

• CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + engageable component having variable capacity to transmit torque when engaged + control means responsive to raised upstream circuit pressure and operable, in use of the CVT, to reduce the torque-transmitting capacity of said engageable component.
(WO90/02277, 16.08.88)

Figure C.5

• CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / improved reliability:

• CVT of the toroidal-race rolling-traction type + hydraulic end stop effect (GB2023753, pa in EP0354013) 2

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs
(WO92/01175, 13.07.90)

• CVT of the toroidal-race rolling-traction type + stop means are mounted adjacent both the outer and inner edges of the part-toroidal races on the discs, to prevent the roller from running off those edges
(WO92/08912, 16.11.90)

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + inlet & outlet ports formed in axial end wall of cylinder, outlet port lies axially proud of inlet port
(EP0354013, 04.08.88)

• CVT of the toroidal-race rolling-traction type + hydraulic end stop effect + sleeve which fits over the shaft of the ram piston
(GB2023753, pa in EP0354013)

Figure D.1

• CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / reduced cost:

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs (WO92/01175, 13.07.90)

• CVT of the toroidal-race rolling-traction type + in which the two opposed faces of the ram are exposed in normal use to the pressures of two separate lines of fluid, each such line being pressure-controlled by separate means located downstream of the respective ram face, in which the outputs of the pressure control means combine in a common region connectable by valve means with each line, and in which a preset difference in fluid pressure between a line and the common region causes the valve means to open to allow fluid to pass from the common region to that line (WO91/14116, 16.03.90)

• CVT of the toroidal-race rolling-traction type+ physical displacement means comprise separate physical displacement members connected hydraulically and respectively to the opposed hydraulic cylinders of the ram whereby by simultaneously depressing one member and releasing the other, the operator changes the transmitted ratio by displacing the ram piston by which that ratio is determined.
(WO91/06791, 03.11.89)

Figure D.2

• CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / basic implementation:

• CVT of the toroidal-race rolling-traction type + all the cylinders lie to the same side of a common plane including the axis of the discs (WO92/01175, 13.07.90)

• CVT of the toroidal-race rolling-traction type + cylinders spaced around discs
(EP-B-0078125, pa in WO92/01175)

• CVT of the toroidal-race rolling-traction type + in which the two opposed faces of the ram are exposed in normal use to the pressures of two separate lines of fluid, each such line being pressure-controlled by separate means located downstream of the respective ram face, in which the outputs of the pressure control means combine in a common region connectable by valve means with each line, and in which a preset difference in fluid pressure between a line and the common region causes the valve means to open to allow fluid to pass from the common region to that line (WO91/14116, 16.03.90)

• CVT of the toroidal-race rolling-traction type + where the outlets of the respective control valves lead only to tank or exhaust
(EP-B-0078125, pa in WO91/14116)

• CVT of the toroidal-race rolling-traction type+ physical displacement means comprise separate physical displacement members connected hydraulically and respectively to the opposed hydraulic cylinders of the ram whereby by simultaneously depressing one member and releasing the other, the operator changes the transmitted ratio by displacing the ram piston by which that ratio is determined.
(WO91/06791, 03.11.89)

• CVT of the toroidal-race rolling-traction type + high powered pump
(GB 2023753, pa in WO91/06791)

Figure E.1

• CVT of the toroidal-race rolling-traction type
(well known) 1

[] 1 / improved lifetime:

• CVT of the toroidal-race rolling-traction type + ducting for introducing flows of cooling liquid to the roller thereby to remove heat from the roller during operation of the device, in which the ducting includes at least two mutually opposed outlets positioned for directing cooling liquid onto opposing portions of the roller. (claim 1 of WO97/37156, 01.04.96)

• CVT of the toroidal-race rolling-traction type + the torus radius of the race decreases as the distance of that point from the disc axis diminishes.
(WO 91/11637, 30.01.90)

• CVT of the toroidal-race rolling-traction type + hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith
(GB2282196, pa in WO99/56036) 2

[] 2 / improved efficiency:

• CVT of the toroidal-race rolling-traction type + hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith + said lubrication supply passage comprises a chamber formed between said piston and chamber wall and one or more radially extending passageways through said piston, each having a first end in fluid communication with said chamber and having a second end in communication with said roller.
(WO99/56036, 27.04.98)

[] 2 / improved lifetime:

• CVT of the toroidal-race rolling-traction type + hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith + said lubrication supply passage comprises a chamber formed between said piston and chamber wall and one or more radially extending passageways through said piston, each having a first end in fluid communication with said chamber and having a second end in communication with said roller.

(WO99/56036, 27.04.98)

• CVT of the toroidal-race rolling-traction type+ hydraulic cylinder having a lubrication supply passage for supplying lubrication to a roller connected to said piston for movement therewith + the [cylinder] stem having an end face exposed to a pressurising effect of the cooling fluid and the double acting piston having a confronting surface also exposed to the pressurising effect of the cooling fluid, such that any axial load on the stem is at least partially counteracted by an opposite effect on the confronting surface of the double acting piston.
(claim 13 of WO97/37156, 01.04.96)

Figure F.1

• CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / reduced size:

**• CVT of the toroidal-race rolling-traction type + at least two input discs and at least two output discs arranged alternately in coaxial sequence, all discs except the first and last in the sequence are formed with part-toroidal races on both faces of the disc, thereby defining a sequence of at least four clearances where an input and output race confront each other across an imaginary torus, and including: a separate set of rollers of adjustable orientation arranged to transmit traction across each successive clearance between the respective input and output races; means to coordinate all the rollers of each separate set so that they adopt the same orientation; and means to transmit drive from the output discs to at least one rotatable output member
(WO91/08405, 01.12.89)**

**• CVT of the toroidal-race rolling-traction type + in which the two opposed faces of the ram are exposed in normal use to the pressures of two separate lines of fluid, each such line being pressure-controlled by separate means located downstream of the respective ram face, in which the outputs of the pressure control means combine in a common region connectable by valve means with each line, and in which a preset difference in fluid pressure between a line and the common region causes the valve means to open to allow fluid to pass from the common region to that line
(WO91/14116, 16.03.90)**

**• CVT of the toroidal-race rolling traction type + an axially extending shroud of variable length extending between the piston and the end wall, thereby to define in combination with the piston and cylinder a chamber for receiving hydraulic fluid, and in which the shroud comprises a telescopic shroud which in a first position of the piston is extended and in a second position of the piston is retracted
(WO99/54646, 22.04.98)**

Figure G.1

• CVT of the toroidal-race rolling-traction type
(well known) 1

[] 1 / extended ratio range:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox
(GB1078791, pa in WO92/10697) 2

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + direct drive in high regime
(GB1078791, pa in WO92/10697)

[] 2 / reduced size:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

Figure G.2

• CVT of the toroidal-race rolling-traction type
(well known) 1

[] 1 / extended ratio range:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox
(GB1078791, pa in wo92/10697) 2

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + direct drive in high regime
(GB1078791, pa in WO92/10697)

[] 2 / reduced size:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

[] 2 / all major components coaxial with the operating axis of the variator:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit
(EP0149892, pa in WO91/08406) 3

[] 3 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + the driving connection includes a rotary member displaced from but parallel to the operating axis and lying radially outboard of the speed reducing gear unit relative to that axis
(WO91/08406, 01.12.89)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + different gearing combinations for the two gear units
(EP0149892, pa in WO91/08406)

Figure G.3

• CVT of the toroidal-race rolling-traction type
(well known) 1

[] 1 / extended ratio range:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox
(GB1078791, pa in WO92/10697) 2

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + direct drive in high regime
(GB1078791, pa in WO92/10697)

[] 2 / reduced size:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

[] 2 / improved smoothness of operation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system whereby firstly, during regime change, initiating engagement of the otherwise unengaged clutch before the variator reaches synchronous ratio such that the engine load created by the transmission varies and thereby induces a change of regime; and secondly, completing regime change by disengaging the clutch associated with the regime from which the transmission has been changed and completing engagement of the clutch under engagement.
(WO97/40296, 19.04.96)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change (WO97/40296, 19.04.96) 3

[] 2 / all major components coaxial with the operating axis of the variator:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit (EP0149892, pa in WO91/08406) 4

[] 4 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + the driving connection includes a rotary member displaced from but parallel to the operating axis and lying radially outboard of the speed reducing gear unit relative to that axis (WO91/08406, 01.12.89)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + different gearing combinations for the two gear units (EP0149892, pa in WO91/08406)

[] 2 / improved efficiency:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + mixing epicyclic gear unit is so arranged that its components are locked-up in at least one of the regimes and in which the speed-reducing gear unit effects a reduction in speed but no reversal of direction between its input and its output.
(WO92/03671, 17.08.90)

Figure G.4

• CVT of the toroidal-race rolling-traction type
(well known) 1

[] 1 / extended ratio range:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox
(GB1078791, pa in WO92/10697) 2

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + direct drive in high regime
(GB1078791, pa in WO92/10697)

[] 2 / reduced size:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

[] 2 / improved smoothness of operation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system whereby firstly, during regime change, initiating engagement of the otherwise unengaged clutch before the variator reaches synchronous ratio such that the engine load created by the transmission varies and thereby induces a change of regime; and secondly, completing regime change by disengaging the clutch associated with the regime from which the transmission has been changed and completing engagement of the clutch under engagement.
(WO97/40296, 19.04.96)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change (WO97/40296, 19.04.96) 3

[] 3 / improved response:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change + valves are connected in flow series and by a first fluid directing valve means for directing flow from each pump to a first point upstream of valve V1 or to a second point downstream of valve V1 but upstream of valve V2 (WO99/58883, 08.05.98)

[] 2 / all major components coaxial with the operating axis of the variator:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit (EP0149892, pa in WO91/08406) 4

[] 4 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + the

driving connection includes a rotary member displaced from but parallel to the operating axis and lying radially outboard of the speed reducing gear unit relative to that axis
(WO91/08406, 01.12.89)

- CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + different gearing combinations for the two gear units
(EP0149892, pa in WO91/08406)

Figure G.5

• CVT of the toroidal-race rolling-traction type (well known) 1

[] 1 / extended ratio range:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox (GB1078791, pa in WO92/10697) 2

[] 2 / basic implementation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + direct drive in high regime
(GB1078791, pa in WO92/10697)

[] 2 / reduced size:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + in low regime the gearing is set to recirculate power and so deliver to its output a power equal to the difference between its two input powers, whereas in high regime it is set so as to split the power flow and to deliver to its output a power representing the sum of the powers at its two inputs.
(WO92/10697, 11.12.90)

[] 2 / improved smoothness of operation:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system whereby firstly, during regime change, initiating engagement of the otherwise unengaged clutch before the variator reaches synchronous ratio such that the engine load created by the transmission varies and thereby induces a change of regime; and secondly, completing regime change by disengaging the clutch associated with the regime from which the transmission has been changed and completing engagement of the clutch under engagement.
(claim 12 of WO97/40296, 19.04.96)

• **CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change (claim 1 of WO97/40296, 19.04.96) 3**

[] 3 / improved response:

• **CVT of the toroidal-race rolling-traction type + multi-regime gearbox + control system comprising first control means for controlling the clutch apply pressure of one or other of the clutches and second control means for controlling the variator rollers, first and second control means being operable independently of each other thereby to achieve active control of the regime change + valves are connected in flow series and by a first fluid directing valve means for directing flow from each pump to a first point upstream of valve V1 or to a second point downstream of valve V1 but upstream of valve V2 (WO99/58883, 08.05.98)**

[] 2 / all major components coaxial with the operating axis of the variator:

• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit (EP0149892, pa in WO91/08406) 4

[] 4 / basic implementation:

• **CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + the**

driving connection includes a rotary member displaced from but parallel to the operating axis and lying radially outboard of the speed reducing gear unit relative to that axis
(WO91/08406, 01.12.89)
• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + a speed reducing gear unit and a mixing epicyclic gear unit in which the output of the mixing epicyclic gear unit and the input and output of the reduction gear unit are all coaxial with the variator operating axis, and in which there is a driving connection between the variator output and a component of the mixing epicyclic gear unit + different gearing combinations for the two gear units
(EP0149892, pa in WO91/08406)

[] 2 / improved efficiency:
• CVT of the toroidal-race rolling-traction type + multi-regime gearbox + mixing epicyclic gear unit is so arranged that its components are locked-up in at least one of the regimes and in which the speed-reducing gear unit effects a reduction in speed but no reversal of direction between its input and its output.
(WO92/03671, 17.08.90)

Figure H.1

• Position servo system comprising a driven mechanism, a first rotary actuating member by which operative control is normally applied to that mechanism, and a continuously-variable-transmission ("CVT") of the variable-ratio-epicyclic type, and in which there is a first connection between a component of the CVT and the first actuating member, and a second connection between a component of the CVT and the driven mechanism (JP63291770 - pa in WO97/18982) 0

[] 0 / unspecified advantage:

• Position servo system comprising a driven mechanism, a first rotary actuating member by which operative control is normally applied to that mechanism, and a continuously-variable-transmission ("CVT") of the variable-ratio-epicyclic type, and in which there is a first connection between a component of the CVT and the first actuating member, and a second connection between a component of the CVT and the driven mechanism, + the CVT has a rotary input from a prime mover separate from the actuating member, in that the CVT is disposed coaxially with the first actuating member, and in that an error between the positions of the driven mechanism and the first actuating member - indicative of the application of a substantial driving effort - results in a power output from the CVT, tending to apply torque to the driven mechanism so as to diminish the error.
(WO97/18982, 20.11.95)

Figure I.1

• CVT of the band-and-sheave type (general pa in WO95/17621) 1

[] 1 / advantage not investigated:

• CVT of the band-and-sheave type + in which there is a torque-sensitive connection between at least one of the pulley units and its shaft means capable of generating an axial unit/shaft means force that is a function of the magnitude and direction of the torque the pulley unit is transmitting and in which loading means operate on the pulley units to urge their sheaves together with a loading force (Paper 730003 ... presented at the International Automotive Engineering Congress ... in January 1973, pa in WO95/17621) 2

[] 2 / improved response

• CVT of the band-and-sheave type + in which there is a torque-sensitive connection between at least one of the pulley units and its shaft means capable of generating an axial unit/shaft means force that is a function of the magnitude and direction of the torque the pulley unit is transmitting and in which loading means operate on the pulley units to urge their sheaves together with a loading force + the input of power to the variator by way of a shaft means on either of the two axes has the effect, by way of the torque-sensitive connection, of tending to cause the axial separation of the sheaves of a unit on that shaft means to increase relative to that of the sheaves of the corresponding unit on the other shaft means.
(WO95/17621, 20.12.93)

[] 2 / improved stability

• CVT of the band-and-sheave type + in which there is a torque-sensitive connection between at least one of the pulley units and its shaft means capable of generating an axial unit/shaft means force that is a function of the magnitude and direction of the torque the pulley unit is transmitting and in which loading means operate on the pulley units to urge their sheaves together with a loading force + the input of power to the variator by way of a shaft means on either of the two axes has the effect, by way of the torque-sensitive connection, of tending to cause the axial separation of the sheaves of a unit on that shaft means to increase relative to that of the sheaves of the corresponding unit on the other shaft means.
(WO95/17621, 20.12.93)

Figure J.1

• CVT of the half-toroidal traction roller type, in which ratio change results when a roller exercises first freedom of movement by rotating about a first or precession axis and in which the roller mounting has a further freedom of movement about a second or tilt axis (US3008337, pa in WO96/28668) 1

[] 1 / improved response:
CVT of the half-toroidal traction roller type, in which ratio change results when a roller exercises first freedom of movement by rotating about a first or precession axis and in which the roller mounting has a further freedom of movement about a second or tilt axis + the precession axis is inclined at an angle to a plane lying normal to the axis of the races, and in which each equilibrium value of the ratio angle correlates with a unique angular orientation of the roller about the tilt axis
(WO96/28668, 16.03.95)

[] 1 / improved stability
CVT of the half-toroidal traction roller type, in which ratio change results when a roller exercises first freedom of movement by rotating about a first or precession axis and in which the roller mounting has a further freedom of movement about a second or tilt axis + the precession axis is inclined at an angle to a plane lying normal to the axis of the races, and in which each equilibrium value of the ratio angle correlates with a unique angular orientation of the roller about the tilt axis
(WO96/28668, 16.03.95)

Figure K.1

• CVT
(well known) 1

[] 1 / extended ratio range:

• CVT + multi-regime gearbox
(unspecified, pa in WO94/16244) 2

[] 2 / unspecified advantage:

• CVT + multi-regime gearbox + geared neutral arrangement
(unspecified pa in WO94/16244) 3

[] 3 / reduced cost:

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / reduced size:

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / specially convenient facility for incorporating extra regimes in both forward and reverse:

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.

(WO94/16244, 18.01.93)

Figure K.2

• CVT (well known) 1

[] 1 / extended ratio range:

• CVT + multi-regime gearbox (unspecified, pa in WO94/16244) 2

[] 2 / unspecified advantage:

• CVT + multi-regime gearbox + geared neutral arrangement (unspecified pa in WO94/16244) 3

[] 3 / reduced cost:

• CVT + multi-regime gearbox + geared neutral arrangement + epicyclic and variator ratios are chosen so that the changes between those regimes are all synchronous and that at a first given variator ratio all epicyclic components rotate at the same speed , whereby alternate regime changes occur at that first given variator ratio.
(WO94/24462, 15.04.93)

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / reduced size:

• CVT + multi-regime gearbox + geared neutral arrangement + epicyclic and variator ratios are chosen so that the changes between those regimes are all synchronous and that at a first given variator ratio all epicyclic components rotate at the same speed ,

whereby alternate regime changes occur at that first given variator ratio.
(WO94/24462, 15.04.93)

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / specially convenient facility for incorporating extra regimes in both forward and reverse:

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

Figure K.3

• CVT
(well known) 1

[] 1 / extended ratio range:

• CVT + multi-regime gearbox
(unspecified, pa in WO94/16244) 2

[] 2 / unspecified advantage:

• CVT + multi-regime gearbox + geared neutral arrangement
(unspecified pa in WO94/16244) 3

[] 3 / reduced cost:

• CVT + multi-regime gearbox + geared neutral arrangement + epicyclic and variator ratios are chosen so that the changes between those regimes are all synchronous and that at a first given variator ratio all epicyclic components rotate at the same speed , whereby alternate regime changes occur at that first given variator ratio.
(WO94/24462, 15.04.93)

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / reduced size:

• CVT + multi-regime gearbox + geared neutral arrangement + epicyclic and variator ratios are chosen so that the changes between those regimes are all synchronous and that at a first given variator ratio all epicyclic components rotate at the same speed ,

whereby alternate regime changes occur at that first given variator ratio.
(WO94/24462, 15.04.93)

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 3 / specially convenient facility for incorporating extra regimes in both forward and reverse:

• CVT + multi-regime gearbox + geared neutral arrangement + the power-recirculating epicyclic is associated with appropriate clutches whereby power is recirculated through that epicyclic in one of the regimes which includes geared neutral, but whereby in the remaining one or more regimes no power is recirculated within it and the drive reaches the CVT output by way of appropriate clutches and of whichever of the two driven shafts will rise in speed as that regime proceeds, and in that the two shafts are respectively connected both to opposite sides of the variator and to different output members of the input epicyclic.
(WO94/16244, 18.01.93)

[] 2 / improved smoothness of operation:

• CVT + multi-regime gearbox + control system for, firstly, during regime change, initiating engagement of the otherwise unengaged clutch before the variator reaches synchronous ratio such that the engine load created by the transmission varies and thereby induces a change of regime; and secondly, completing regime change by disengaging the clutch associated with the regime from which the transmission has been changed and completing engagement of the clutch under engagement.
(WO97/40296, 19.04.96)

Figure L.1

• CVT
(well known) 1

[] 1 / improved starting characteristics:

• CVT + starting device capable of slip, a fixed ratio component and a first one way clutch
(GB2025545, pa in WO94/04849) 2

[] 2 / improved flexibility of installation:

• CVT + starting device capable of slip, a fixed ratio component and a first one way clutch + an output from the starting device is connectable both to the CVT and to the fixed ratio component
(WO94/04849, 13.08.92)

Figure M.1

driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts (unspecified, pa in WO90/07660) 1

[] 1 / reduced size (of engine and transmission):
driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation. (WO90/07660, 06.01.89)

[] 1 / half shafts of equal and efficient length:
driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation. (WO90/07660, 06.01.89)

Figure M.2

driveline with CVT
(well known) 1

[] 1 / unspecified advantage:

driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts
(unspecified, pa in WO90/07660) 2

[] 2 / reduced size (of engine and transmission):

driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation.
(WO90/07660, 06.01.89)

[] 2 / half shafts of equal and efficient length:

driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation.
(WO90/07660, 06.01.89)

[] 1 / unspecified advantage:

- driveline with CVT + CVT of the toroidal-race rolling-traction type + of

the force balance type + control system subject to operator demand, energy input to the engine being subject to variable regulation by control system, control system is operable to regulate the reaction torque experienced within the CVT (unspecified, pa in WO93/21031) 3

[]3 / improved smoothness of operation:

• driveline with CVT + control system subject to operator demand, energy input to the engine being subject to variable regulation by the control system, control system is operable to regulate the reaction torque experienced within the CVT + control system is adapted continually to compute the variator reaction torque with relation to alternative calculations based on the transmission input and output torques respectively, and in that the system chooses for operation the calculation yielding the lesser value of variator reaction torque and applies a related hydraulic control pressure
(WO93/21031, 16.04.92)

Figure M.3

• driveline with CVT
(well known) 1

[] 1 / unspecified advantage:

• driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts
(unspecified pa in WO90/07660) 2

[] 2 / reduced size (of engine and transmission):

• driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation.
(WO90/07660, 06.01.89)

[] 2 / half shafts of equal and efficient length:

• driveline with CVT + CVT having the capability of a "geared neutral" state, a slipless driving connection between the output member of the engine and at least such one input of the CVT; two substantially coaxial driving shafts rotatable about substantially fixed axes, connected to and driven by the CVT output member, and adapted respectively to drive two laterally-displaced driven wheels by way of universal joints and half-shafts + in which the combination of the output axis of the engine, the driving connection and the output axis of the variator are arranged in a "U"-shaped formation.
(WO90/07660, 06.01.89)

[] 1 / unspecified advantage:

• driveline with CVT + CVT of the toroidal-race rolling-traction type + of the force balance type + control system subject to operator demand, energy input to the engine being subject to variable regulation by control system, control system is operable to regulate the reaction torque experienced within the CVT
(unspecified, pa in WO93/21031) 1

[]1 / improved smoothness of operation:

• driveline with CVT + CVT of the toroidal-race rolling-traction type + of the force balance type + control system subject to operator demand, energy input to the engine being subject to variable regulation by the control system, control system is operable to regulate the reaction torque experienced within the CVT + control system is adapted continually to compute the variator reaction torque with relation to alternative calculations based on the transmission input and output torques respectively, and in that the system chooses for operation the calculation yielding the lesser value of variator reaction torque and applies a related hydraulic control pressure
(WO93/21031, 16.04.92)

[] 1 / unspecified advantage:

• driveline with CVT + over a working range of engine speed the engine is constrained to work to a performance "map" correlating each value of that speed with a particular value of engine torque
(unspecified pa in WO95/09996) 3

[] 3 / conventional variation of acceleration with engine note

• driveline with CVT + over a working range of engine speed the engine is constrained to work to a performance "map" correlating each value of that speed with a particular value of engine torque + driver demand for a rise in engine speed is programmed to initiate a response in three successive stages: 1: initial engine speed rises quickly to a predetermined value ("engage speed") without any substantial rise in final drive speed; 2: both speeds then continue to rise and to be related by a predetermined function until engine speed reaches a value ("limit speed") commensurate with the driver's demand, and 3: limit speed is then maintained during any further change in final drive speed
(WO95/09996, 01.10.93)

Figure N.1

• first and second CVTs, first and second epicyclic gear sets (US4718299, pa in EP0306272) 1

[] 1 / reduced cost:

• first and second CVTs, first and second epicyclic gear sets + the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.
(claim 1 of EP0306272, 02.09.87)

• first and second CVTs, first and second epicyclic gear sets + in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.
(claim 8 of EP0306272, 02.09.87)

[] 1 / reduced size:

• first and second CVTs, first and second epicyclic gear sets + the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.
(claim 1 of EP0306272, 02.09.87)

• first and second CVTs, first and second epicyclic gear sets + in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the

second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.
(claim 8 of EP0306272, 02.09.87)

[] 1 / improved efficiency:
- **first and second CVTs, first and second epicyclic gear sets + the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.**
(claim 1 of EP0306272, 02.09.87)

- **first and second CVTs, first and second epicyclic gear sets + in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.**
(claim 8 of EP0306272, 02.09.87)

[] 1 / identical steer performance in high and low regimes:
- **first and second CVTs, first and second epicyclic gear sets + the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.**
(claim 1 of EP0306272, 02.09.87)

- **first and second CVTs, first and second epicyclic gear sets + in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second**

inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.
(claim 8 of EP0306272, 02.09.87)

[] 1 / permit synchronous change between high and low regimes:
• first and second CVTs, first and second epicyclic gear sets + the first and second input axes of the epicyclic gear sets and the first and second output axes of the first and second variators all coincide.
(claim 1 of EP0306272, 02.09.87)

• first and second CVTs, first and second epicyclic gear sets + in the first regime the first and second inputs/outputs of the first epicyclic are driven by way of the transmission input and by the output of the first variator respectively to provide drive for the first driven member from the third input/output, and the first and second inputs/outputs of the second epicyclic are driven by way of the transmission input and by the output of the second variator respectively to provide drive for the second driven member from the third input/output, and in second regime the output of the second variator drives the third input/output of the first epicyclic directly and so drives the second driven member, the output of the first variator drives the second input/output of the first epicyclic and the first input/output of the first epicyclic and the output of the second variator respectively drive the first and second inputs/outputs of the second epicyclic and so provide drive to the second driven member by way of the third input/output of the second epicyclic.
(claim 8 of EP0306272, 02.09.87)

Note: given that there is only one filing in this section, effort has not been expended in confirming that both solutions provide all advantages.

Figure O.1

Valve characterised by 1. and 2. chambers and a double-headed piston having a 1. head within the 1. chamber and a 2. head in the 2. chamber, said 1. head acting to divide the 1. chamber into two portions, the first of which has an inlet for receiving hydraulic fluid from a 1. source and the 2. chamber having a 2. inlet for receiving hydraulic fluid from a 2. source, said 2. head being operably connected to the 1. head by a joining member and being moveable therewith, said 2. chamber having a 1. inlet for receiving hydraulic fluid from a source, an outlet for supplying hydraulic fluid at pressure to another apparatus , and a 3. obturable outlet, the arrangement being such that the pressure of the hydraulic fluid in the 2. chamber varies in sympathy with the net pressure in the 1. chamber. (wo97/40292, 19.04.96)

Note - no prior art mentioned in wo97/40292

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