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STATISTICAL STUDIES OF

PATENTS LITERATURE

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Thesis submitted for the
degree of Doctor of Philosophy

Centre for Information Science
The City University
London

October 1982

FOR CAROLYN,

MARTIN AND ALEXANDER

AND OUR FUTURE LIVES

IN THE NEW WORLD

Culture is concerned with establishing ideas. Education is concerned with communicating those established ideas. Both are concerned with improving ideas by bringing them up to date. The only available method for changing ideas is conflict which works in two ways. In the first way there is a head on confrontation between opposing ideas. One or other of the ideas achieves a practical dominance over the other idea which is suppressed but not changed. In the second way there is a conflict between new information and the old idea. As a result of this conflict the old idea is supposed to be changed. This is the method of science which is always seeking to generate new information to upset the old ideas and bring about new ones. It is more than the method of science - it is the method of human knowledge.

Edward de Bono
"Lateral Thinking"

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DECLARATION

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ABSTRACT

This study has been undertaken to determine what pseudo-proprietary information and patenting activity statistics could be derived from an online patents database.

To achieve this, a thorough investigation was made of patenting in the field of an important group of beta-lactam antibiotics, the Cephalosporins. Patents data was retrieved from the World Patents Index online files of Derwent Publications Limited, and the bibliographic details of each patent application retrieved analysed according to numbers of patents per patentee, priority and publication dates, types of patents, etc.

A review of technological advances in this subject was conducted, demonstrating the value of patents literature for such purposes.

The relationship between sales volumes and patenting activity for Cephalosporins patentees has been investigated and found to show a significant correlation between these parameters. As an extension, the USA patenting and sales activity for the leading USA Industrial Corporations (the 1981 Fortune 500) was studied; overall a high correlation was exhibited, but there were notable differences between different industries.

A number of bibliometric studies have been undertaken with a variety of patents data for a number of technologies. These studies include the application of Bradford-Zipf plots, other productivity studies and Vector Analysis to patents.

Whilst previous studies on journal literature have investigated the applicability of frequency distributions as measures of author productivity, this study has for the first time applied Lotka's Law, Price's Pareto-type Distribution, Simon-Yule Distribution, Shockley's Lognormal Distribution, Borel-Tanner Distribution, Williams Geometric Series, Fisher's Logarithmic Series and the Negative Binomial Distribution to patents data. Theoretical distributions were ascertained using a series of microcomputer programs written in BASIC programming language. The results indicate that of the distributions investigated, the Negative Binomial most closely fits the observed data when goodness-of-fit is measured by the Kolmogorov-Smirnov Test.

1:INDUSTRIAL INNOVATION AND INFORMATION FLOW

According to Usher[1], there are three general theories of invention: the transcendentalist, the mechanistic and the cumulative synthesis. The transcendentalist approach attributes invention to the inspiration of genius. Rare and infrequent flashes of insight yield brilliant ideas which become path-making inventions. This is the traditional picture, where the individual plays a crucial role. The lone inventor makes a great impact on technology by a single creative thought. His flash of genius is largely independent of economic forces. Curiosity and fortuitous events are major elements.

The mechanistic approach adopts the view that invention proceeds under the stress of necessity. Needs dictate the direction of change and inventions emerge. In this approach economic forces predominate. Invention is not visualised as an autonomous process yielding to unpredictable events. Costs and revenue considerations become crucial. The individual and lone genius revolutionising technology are rejected as the typical source of invention.

The last approach sees major invention emerging from the cumulative synthesis of what has preceded. These inventions require an act of insight to overcome resistance or discontinuity. They are likely to occur to individuals who are directly concerned with the problem and its solution. The requirement of the act of insight reduces the predictability of the event. It is not certain that it will occur. Unlike the mechanistic approach, the individual is not merely an instrument of an inevitable historical process. He has an important role to play. His role is not that of the transcendentalist's genius who is struck by a brilliant idea, but rather of the mind engaged in the solution of technical problems. An act of insight will be conditioned by the specific problems encountered; if and when it occurs it will be through a synthesis of previous knowledge. This approach is probably the most realistic. Invention is not dependent on the emergence of genius. There are too many examples of multiple invention for this to be a realistic view of the process. Furthermore "it is clear from the analysis of patent statistics.....that invention in general and significant technical advances in particular, are not random occurences"[2].

Nor is it an inevitable process dictated by the passage of time and economic pressures. Certainly, necessity will promote invention; wartime experience confirms this. Similarly great men emerge to make great inventions, but these occurences are not typical. Theories of invention must describe the usual, not the rare. In these terms, the cumulative synthesis approach is probably the most plausible.

In 1968 the SAPPHO project (Scientific Activity Predictor from Patterns with Heuristic Origins) was launched to study the success and failure of industrial innovation[3]. Two important factors emerged from this study. The first is that it was noted that in introducing new products and processes to the market there is a high failure rate. It varies from 60 to 90%, depending on the sector of industry and the nature of the market. The second fact is allied to this. Innovations appear to happen in clusters, very seldom in isolation. Thus, when the world market for a particular chemical expands and forces up its price, several firms in the industry will encourage research into cost reducing or quantity increasing processes. Of this group of innovating firms, one or two will succeed commercially with a process, others will succeed technologically but not commercially, and some will fail on both counts.

The SAPPHO team investigated why some companies succeeded outstandingly where others failed. By conducting a series of interviews with key personnel in the chemical and scientific instruments industries the investigators hoped to find a group of characteristics that would effectively discriminate between a successful and a less successful or failed innovation, thus throwing light upon the necessary and sufficient conditions for commercial success, given technical success.

The variables which were found to show the greatest differences between successful and less successful innovations (in both industries) were as follows. Successful innovators showed the following characteristics:-

- they have better understanding of user needs, sometimes by collaborating closely with potential customers;
- they do thorough market research or possess the necessary experience of user requirements;
- they pay more attention to marketing;
- their development work is more efficient, but not necessarily quicker than that of the failure cases;

- they remove technical snags from the product or process before they launch it, not after customer complaints;
- they usually have a larger development team on the project and therefore spend more money on it, even when the successful firm is smaller than the failure;
- they make more effective use of outside technological and scientific advice and information sources, even though they carry out most of the work in-house; and
- they have better contacts with the outside scientific community in the specific area concerned and not merely in a general way.

The responsible individuals in the successful attempt are usually more senior and have greater authority than their counterparts who fail. In the instrument industry they have more diverse experience including experience abroad. The greater authority of the key individuals in the successful attempts is a factor in providing the scale of effort which is needed as well as the cooperation of R&D and marketing.

In the SAPPHO results it emerged that although most firms involved with innovations tend to have good contacts with the scientific and technological community, the discriminating factor, a subdivision of this one, is that the successful innovators make use of this connection with specific reference to the innovation project itself. Not only do they have constant and high quality information flows, they pay special attention to those relevant to the project.

Hill[4], in discussing the place of patents in the field of scientific and technical literature, has drawn attention to the SAPPHO report conclusions and has commented upon the difficulties in the use of patents as an information source for technological developments.

T. J. Allen[5] has shown a correlation betwen successful innovative effort and systematic literature searches and staff consultations. Allen and Cohen[6] found that R&D teams with a poor innovative record spent more time than successful teams on initial data gathering but neglected information seeking at later stages of a project, or at best fluctuated in their attention to information gathering during the life of the project. Teams with better results tended to be more consistent in the proportion of effort they put into data collection.

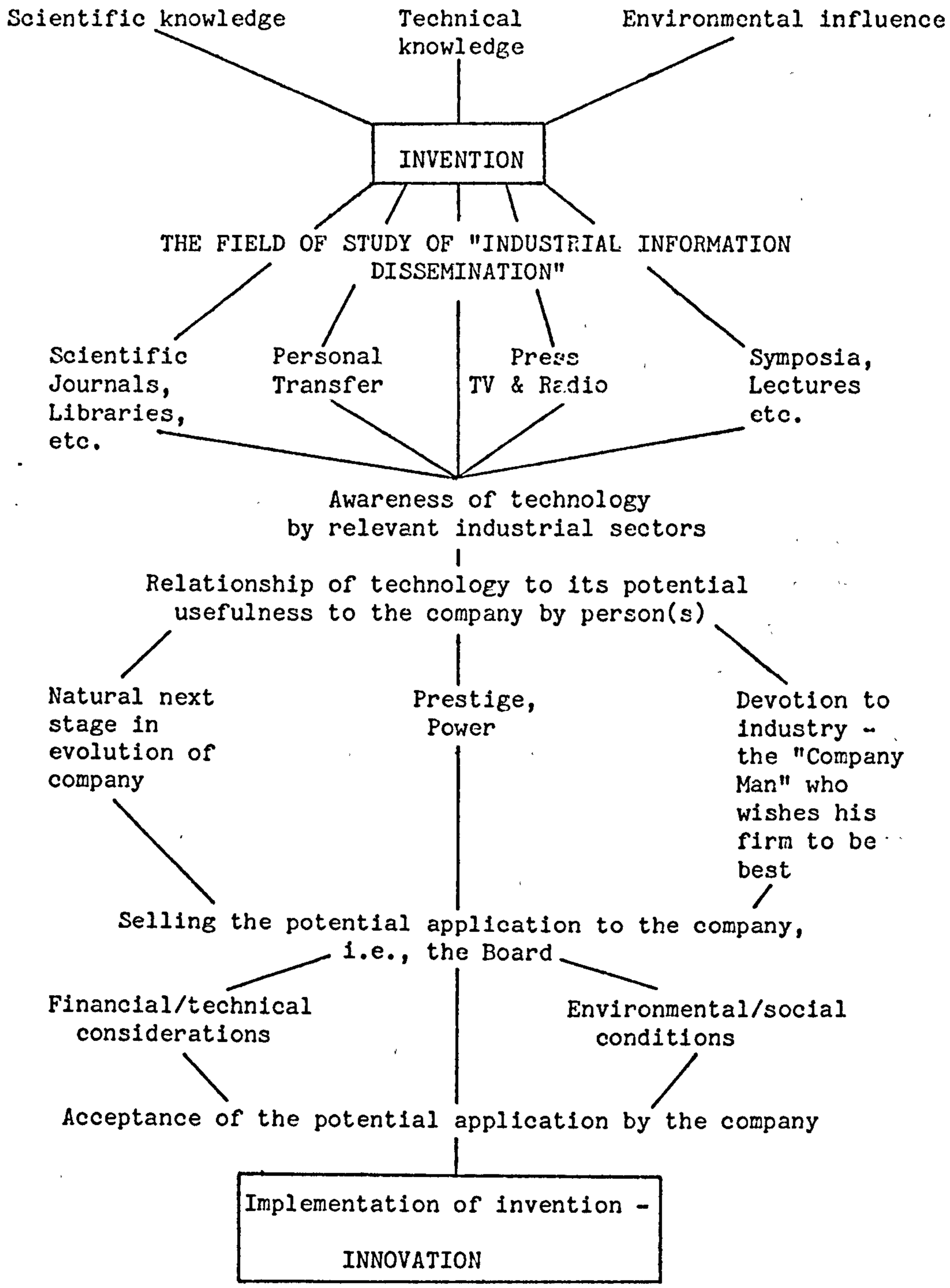


Figure 1: A hypothetical model of Innovation from (Grace[8])

Allen also found that high performance by teams tended to correlate with the use of internal sources of information. Comparatively poor performers not only tended to rely on outside sources but also to overrate the quality of those sources. Relevant literature was under-used by the poorer performers, and where they did use the printed word it was frequently "low grade", meaning that it was not academic nor professional but commercial, therefore outside the control of the professional institutes and "open to the temptation of distortion towards the products of the heavy advertisers".

Carter and Williams[7], who investigated about two hundred firms in a wide range of industries, defined twenty-four characteristics of the "technically progressive" firm (these may also be regarded as conditions for successful industrial innovation as it is a reasonable assumption that progressive firms will also be innovative). Six of these characteristics dealt with information flow:-

- high quality incoming information
- regular surveying of ideas
- willingness to buy "know-how" and enter into joint ventures
- knowledge sharing with other firms
- an outward looking tendency
- effective internal communication and coordination.

Grace[8] has presented a hypothetical model of innovation as in Figure 1.

From the foregoing, there is a clear indication that the innovative process, to result in commercially viable and successful products and processes, relies to a very large extent on the careful gathering and dissemination of pertinent information.

It is in this scenario that patents information plays a vital role. To satisfy questions such as: should a research project be carried out, or should the necessary know-how be acquired in another way, or should the project be abandoned, requires an efficient and continuing survey of patents information.

2: INVENTIONS AND PATENTS

An invention is a novel idea resulting from inventive activity and is capable of industrial application. Under most legislations, therefore, an idea, to be protected by law (i.e., "patentable"), must be new in the sense that there is no evidence that the idea has already been published or publicly used before; it must be non-obvious in the sense that it would not have occurred to any specialist in the particular industrial field, had such a specialist been asked to find a solution to the particular problem; and it must be applicable in industry in the sense that it can be industrially manufactured or used.

A patent is a document, issued by a government office, which describes the invention and creates a legal situation in which the patented invention can normally only be exploited (made, imported, sold, used) with the authorisation of the patentee. This protection of the invention is limited in time - generally for 15 to 20 years. The term "patents" is derived from "literae patentes", open letters, used by the Crown to confer rights or status. A patent for an invention is a form of industrial property, and is similar in many ways to private property. Thus, the owner can sell all or part of his private property, and equally the owner of industrial property can sell all or a part of it. Similarly, just as an owner can rent or lease private property for a period, so the owner of industrial property can grant licenses to others to use it. Normally the consideration for such a licence is a royalty.

A further point of resemblance is that the owner of private property can sue deliberate trespassers, while with industrial property the owner can sue for infringement of his rights. Both forms of property are part of the owner's estate and would on his death pass to the person specified in his will; in the case of industrial property owned by a company this means little as usually the company outlives most people.

In the case of private property the document which specifies the ownership (title deed) defines the boundaries of the property. Similarly, in the case of a patent specification for an invention there are the "claims". These are brief statements which define the

boundaries of the monopoly of the patent. In both cases the documents are subject to the laws of interpretation of documents. Thus it can be seen that a patent specification is both a technical document and a legal document.

PATENTS - A DEFINITION OF THEIR PURPOSE

The primary intention of the patent system is the encouragement of new industries. The theory of the system has been succinctly described by Blanco White[9] in his discussion of the British system:

> The basic theory of the patent system is simple and reasonable. It is desirable in the public interest that industrial techniques should be improved. In order to encourage improvement, and to encourage also the disclosure of improvements in preference to their use in secret, any person devising an improvement in a manufactured article, or in machinery or methods of making it, may upon disclosure of his improvement at the Patent Office demand to be given monopoly in the use of it for a period of sixteen years. [Blanco White was referring to the former UK regulations; under the terms of the Patents Act (1977) a maximum of 20 years is permitted.] After that period it passes into the public domain; and the temporary monopoly is not objectionable, for if it had not been for the inventor who devised and disclosed the improvement nobody would have been able to use it at that or any other time, since nobody would have known about it. Furthermore, the giving of the monopoly encourages the putting into practice of the invention, for the only way the inventor can make a profit from it (or even recover the fees for his patent) is by putting it into practice: either by using it himself, and deriving an advantage over his competitors by its use, or by allowing others to use it in return for royalties.

Parker[10] has stated that patents are intended to raise the incentive to devote resources to technological change and that they are designed to combat the awkward properties of knowledge and speed the rate of its dissemination.

HISTORICAL ASPECTS OF PATENTS

Many authors have written on the history of patent systems, tracing their development from antiquity through to present day legislation. Two of these accounts have been given by Skolnik[11] and Capsey[12]; their works are quoted extensively in the following paragraphs, as the clarity and conciseness of their accounts would be difficult to improve upon.

Records of early civilisations disclose a series of discoveries and inventions. Thousands of years before the development of writing, which occured about 2500 BCE, fire and its many applications had been discovered, the wheel had been conceived, animals had been domesticated, tools had been introduced, and humans had engaged in activities such as agriculture, mining, metallurgy, construction and boat building. From the dawn of history until humans learned to write, broad-based civilisations were dependent on the discovery of nature's secrets and on technological inventions and improvements.

The pace of discovery and invention, extremely slow throughout most of antiquity, accelerated appreciably with the emergence and development of the Greek civilisation. Some of the many inventions which came forth during the height of the Greek civilisation were the water clock (Ktesibios); balance, lever, endless screw (Archimedes); surveyor's instruments, water level, screw press (Hero of Alexandria); and others such as the water wheel for pumping water and grinding grain, and the catapult as a military weapon. History tells us that the governing body in Athens granted franchises to those who invented or introduced new products, such as a new dish based on a special recipe for which the chef was given a six months monopoly - the so-called "food patents" of Sybaris.

From the Roman empire came the introduction of road construction, public hygiene with the construction of aqueducts and sewers, a completely new concept of architecture, and hydraulic cement for constructing buildings. The hydraulic cement was made possible by the presence of pozzalana sand near Rome; with the downfall of Rome the quality of this cement could not be matched until the introduction of Portland cement in the 19th. century.

Over the thirteen centuries of the Greek and Roman cultures, from about 900 BCE to 400+ CE, Western society was transformed from small agricultural communities to states with large cities. This new social structure was based on extensive trade between cities and states and required services such as fresh water and sewers, transportation facilities and industries. Thus arose a class of artisans with technical skills and technological knowledge. Even during the Middle Ages, from about the 5th. to the 14th. century, which we think of as the Dark Ages (especially from the 5th. to the 9th. century), inventions continued to come forth, such as fireplaces with chimneys, hot air stoves, the horse stirrup, wheeled plow, horse harness (which led to oxen being replaced by horses for agricultural tasks), carriages with springs for transporting people, canal-lock chambers, windmills, ship rudders,the compass and weight driven clocks.

Monopolies as such existed as long ago as the Byzantine Empire - but they were not for inventions. One example of the early use of privileges for technology occured in 1331 when Edward III wished to attract Flemish weavers to England. He issued letters of protection, analogous to a passport, but not giving exclusive rights.

The bait offered to the Flemish weavers was a promise of "good beer, good beds and still better company, English girls being renowned for their beauty". This worked so well that the Flemish authorities had to make arrangements to prevent the excessive "export" of weavers.

By the end of the 13th. century, the beginning of the Renaissance, the concept of patents for inventions had emerged. The Mediterranean area, and especially Italy, was dominant during the early part of the Renaissance. Outstanding metal, glass and textile artisans and gunsmiths were centered in various cities such as Florence and Venice. The first record of a granted patent for invention was that by the Republic of Florence in 1421 for a barge fitted with hoisting gear to load and unload marble. This first granted patent rewarded the inventor, Filippo Brunelleschi, with an exclusive three-year monopoly. The grant included the following wording:-

Because Brunelleschi did not want to give the invention to public use for fear of being robbed of the reward of his labours, the privilege is granted with the express intention not only that the invention may be made useful as well as for himself as for the generality but particularly also that he himself may be urged to further exertion, and stimulated to achieve greater inventions; the Government agrees to protect the inventor against unauthorised working and to grant the author an immediate monopoly for the period stated by prohibiting the use of every form of transport ship not in use at the date of the privilege unless it be built by Brunelleschi himself or with his consent.

The Republic of Venice, one of the most industrially and commercially active sites in Europe during the 15th. century, granted similar monopolies to foster new enterprises.. These monopolies were called "privileges" and the first was granted by the State of Venice to John Speyer in 1469 for a printing process.

However, in spite of such grants of privilege, no formal patents system was set up. Venice also granted what we would now call patents, and in 1474 this led to the Venetian senate voting the first patent legislation by a considerable majority. The main portion of the law reads as follows:-

> It is enacted by the authority of the present Council that whoever will make in the City any new and ingenious artifice, not previously made in our State, will be obliged to register it at the office of our provediters of the Commune, as soon as it will be reduced to perfection so that it will be possible to use and apply it. It shall be forbidden to anyone else in our land and place to make any other artifice to the image and similarity of that one without consent and licence of the author during the term of ten years. And if nevertheless someone did it, the aforesaid author and inventor would be free to cite before any office of this City, and the said who would have imitated would be compelled to pay one hundred ducats, while the artifice would be immediately destroyed. But our Government will be free, at its complete discretion, to take over and use for its needs any of the said artifices and instruments, under the condition, however, that others than the authors may not employ them.

This was not strictly applied, and some of the patents lasted more than ten years - usually in multiples of five years. Note in this Venetian law the preservation of the State's rights to use the invention.

By 1550 over one hundred patents had been granted in Venice under its patent law of 1474, which, as Capsey[12] observed, was more like our concept of copyrights than patents.

The industrial and commercial dominance of the Mediterranean area did not last long. Two factors contributed to the diffusion of Italian technology. Italian craftsmen were persuaded or induced by lucrative offers of privileges of monopoly to bring their skills and knowledge to other European states. Religious persecution and warfare in Italy further stimulated the migration of Italian craftsmen. During most of the period from the 15th. century through to the 17th. century, craftsmen and technologists were a highly mobile group throughout Europe and many settled in the newly established American colonies, going where the rewards were greatest.

The granting of monopolies was the primary reward, but the reward was highly localised and no invention of merit remained confined to one locality for long. Johann Gutenberg's invention of movable type in the 1450s, for example, spread from Mainz where Gutenberg had his printing plant, throughout Europe within 30 years - all without gain to Gutenberg.

Other countries also developed patent systems. In Antwerp there was a well established patent system in the 16th. century and as early as 1551 we find a patentee criticised for not working his patent. This is one historical precedent for the inclusion in the patent laws of many countries provisions making it obligatory for a patentee to work his invention or be willing to grant licences to others to work it. There were also patents valid in Brabant and Liege, and a flourishing Dutch patent system before 1550.

France also had an early patent system, and here it was usual practice to examine the inventions for which a monopoly was sought and also to perform experiments. Thus, in 1609, Le Coure and Thouyn petitioned for patents for furnaces which they claimed they had invented. A practical examination before the minister Sully was imposed to decide the issue. In spite of all these rather advanced ideas, the French system was apparently without any formal legal basis.

Many other countries entered the field of patents for inventions at an early time; these included the German States. In 1535 the Margrave of Brandenburg-Onalzbach, who owned Tarnowice in Silesia, granted an eight-year monopoly for a pump to be used in mines. Austria, Poland, Berne, Zurich and Russia also granted patents in the 16th. and 17th. centuries. One interesting point about the early Dutch system was that in the 16th. and early 17th. centuries written descriptions of the inventions were consistently required; this was not always so in other countries.

Colonial America was predominantly agricultural. Less than 10% of the population was employed in manufacturing processes. Because there was a need for new industries, colonial legislatures invoked the exercise of monopoly, but generally without the abuses of the European practices, to encourage manufacturing and to induce European artisans to settle in the colonies. The first patent in colonial America was granted in 1641 by the Massachusetts General Court to Samuel Winslow for making salt "after a method invented by himself" for a period of ten years provided the process was operable within one year. Salt, being a necessity, was the subject of other granted patents in Plymouth (1641), Massachusetts (1652), Virginia (1660), New York (1661), Connecticut (1691) and South Carolina (1725), each presumably by a new process, but without the need to prove it. Pennsylvania, which had more industries than the other colonies, surprisingly granted no patents until after the Revolution.

The Continental Congress adopted a resolution in 1783 recommending the enactment by each state of Copyright Acts. All but one state did so by 1787. These acts were superseded by the United States Constitution of 1789 which empowered the Federal government "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries".

Congress passed the first US Patent Act on 10 April, 1790, which granted patents for up to 14 years and placed administrative responsibility for the granting of patents on the State Department. The first board of examiners consisted of Thomas Jefferson (Secretary of State), Henry Knox (Secretary of War) and Edmund Randolf (Attorney General). The Act required inventors to file a specification in writing, a

drawing, and - if feasible - a model. The first patent granted under the Act was to Samuel Hopkins on 31 July, 1790, for "Making Pot and Pearl Ashes".

THE BRITISH SYSTEM

Monopoly, not invention, was the underlying principle of the patent concept, and originally the word patent referred to the grant of a special license or privilege issued under the Great Seal by the Monarch to one of his subjects, usually one of the nobility. English rulers, over a period of about two centuries, exercised the monopoly principle as a right of the crown to grant charters, commissions, offices titles, favours, sanctions and the exclusive right to practice an art or trade, to the making using or selling of a product and to the regulation of trade. For example, in 1449, Henry II granted to John Utyman, who came to England to make stained glass windows for Eton College chapel, a monopoly for stained glass manufacture. This art had long been practised in Europe, but not in England, thus a monopoly was granted for introducing a new technology into the country.

The practise of granting monopolies led to many abuses and hampered or prevented the introduction of new industries by anyone not of the favoured class. This had led to complaints in Parliament as long ago as 1347, when a foreigner named Tidman had been given an exclusive right to export Cornish tin without paying tax. This abuse apparently got worse, so that in her last Parliament, Elizabeth I was forced to revoke a number of her letters patent which related to such offensive monopolies. This event, in 1601, was also significant in English constitutional history; it was the first time that a Parliament made an unwilling sovereign do something that he or she did not wish to do - well before the Civil War. Such patents, however, continued to be granted in the early years of the reign of James I, including one giving the sole right to make cigars. In view of the King's views on smoking this monopoly is rather surprising.

The agitation caused by such abuse of monopolies led Parliament in 1623 to pass the Statute of Monopolies (although it was not, in fact, signed by James I until the following year), which made all monopolies illegal except for those relating to "Manners of New Manufacture". The word "new" in this exception is significant, and this part of the Statute of Monopolies became the foundation of the British patent system. In fact

the words of Section 6 of this statute continued to appear in the definition of invention in legislation even up to the Patents Act (1949); this definition read as follows:-

> "invention means any manner of new manufacture the subject of letters patent and grant of privilege within section six of the Statute of Monopolies and any new method or process of testing applicable to the improvement or control of manufacture, and includes an alleged invention."

In the above quotation from Section 101(1) of the Patents Act (1949), the reference to methods of testing was newly inserted to previous definitions in earlier legislation.

One of the main features of the Statute, the protection of inventions, was the major exception to the prohibition against the crown's granting of special privileges. Until recently, English law considered the granting of a patent to be the prerogative of the crown, i.e., a privilege not a right of the inventor; however, the Patents Act (1977) in contrast implies a right for the inventor.

In the 1640s, after the crown's monopoly power was eliminated, English patents were granted for a period of 14 years (two generations of apprentices) with the requirement that they be directed to the creation of new industry. Written descriptions or drawings were not required. Specifications, written under the inventor's initiative, gradually became a relatively common practice. Specifications became a consistent practice, indeed, a requirement, as a result of a patent suit in 1770, and not by statute.

During the years which followed the enactment of the Statute of Monopolies, patents were granted fairly frequently and there were actions for infingement of these patents. These included a famous one in which James Watt successfully sued Cornish mine owners for infringing his patent on a condensing steam engine. However, it was very expensive to get patents, and separate patents were needed for England (including Wales), Scotland and Ireland. With the approach of the Great Exhibition in 1851, acts were passed to produce a unified United Kingdom patent system, and also to reduce the costs to applicants.

The patent specification reached something like its present form with the provision in the 1883 Act that the specification which described the invention must end with claims defining that invention. In 1905, after an investigation which showed that a large proportion of the granted patents were invalid in view of what was known before they were applied for, the Patent Office was instructed to carry out searches in the prior art to see if anything which was the same as that claimed as the invention could be found. This put the patent system on the basis on which it stands today. It is of interest to note that such "novelty" searches were introduced in the USA in 1790, but were abandoned in 1836 following a fire on 15 December of that year which destroyed the Patent Office and its search file of about 1,000 patents; novelty searching was reintroduced in the USA in 1872 following the introduction of a new classification system.

Under the present UK system [Patents Act (1977)] a patent may only be granted for an invention provided that (a) the invention is new, (b) it involves an inventive step, and (c) it is capable of industrial application. An invention is taken to involve an "inventive step" if it is not obvious to a person skilled in the art. Excluded from patentable inventions are such things as mathematical models, computer programs and literary, musical or artistic works. In deciding whether an application for a patent meets the regulatory criteria, a novelty search is carried out. Such a search involves an examination of all matter - whether a product, a process, information about either, or anything else - which has been made available to the public by written or oral description, by use or in any other way. This, naturally, includes matter contained in patent applications published on or after the priority date, i.e., the date upon which the details of the invention were first filed as a patent application, as well as all previously published patent applications.

In many countries the patent applications are published, or "laid open to public inspection" (OPI), before examination, usually eighteen months from the priority date [see below]. If the applications are proceeded with, then - following examination - they are republished, usually about twelve months after the unexamined document. This is now the case in the United Kingdom, the unexamined published applications being designated the "A" documents, the examined ones are designated the "B" documents. Because of the examination process, the examined documents often differ from the unexamined - for example, the claims may be narrower in scope.

In 1967 the Banks Committee was appointed to investigate changes needed to the patent system, especially as a result of Britain's entry into the Common Market and various international arrangements for patent cooperation. The Banks Committee presented their report in July 1970[13]. Following this, report the Government issued a White Paper on Patent Law Reform in April 1975; this was the precursor to the revised Patent Act (1977), the details of which were published in December 1976 and which became effective from 1978.

INTERNATIONAL ARRANGEMENTS

The laws of a country relating to industrial property are generally concerned only with acts accomplished or commited in the country itself. Consequently, a patent, an inventor's certificate, a trademark registration, or the registration of an industrial design, is effective only in the country where the government agency effected the grant or registration; it is not effective in other countries. Therefore, if the owner of a patent, an inventor's certificate, etc., desires protection in several countries, such protection must be obtained in each of them separately.

It was mainly to facilitate the obtaining of this protection abroad for their own citizens that, in 1883, eleven countries established the International Union for the Protection of Industrial Property by signing the Paris Convehtion for the Protection of Industrial Property.

Since that time the number of contracting States has been constantly growing, and now stands at ninety. The Convention has been revised several times, and additional agreements have been concluded among some of the member States on special problems. Gradually, provisions have been written into the Convention to ensure better protection.

Consultations amongst member States on all kinds of practical problems have become more and more frequent, and the international Secretariat of the Union (WIPO - World Intellectual Property Organisation; one of the fourteen specialised agencies of the United Nations Organisation) has been given new tasks, particularly in the field of assistance to developing countries, finding solutions for some of the complex problems of technical cooperation among the patent offices of the various countries, in matters of standardisation of document format, and search and patent documentation matters.

The Paris Convention, concluded on 20 March, 1883, was revised at Brussels in 1900, at Washington in 1911, at The Hague in 1925, at London in 1934, at Lisbon in 1958 and in Stockholm in 1967.

The Convention is open to all States. Instruments of ratification or accession are deposited with the Director General of WIPO.

The Convention applies to industrial property in the widest sense, including not only inventions, trademarks, service marks and industrial designs, but also trade names (designations under which an industrial or commercial activity is carried on), indications of source, apellations of origin and the repression of unfair competition.

The substantive provisions of the Convention fall into three main categories: national treatment, right of priority and common rules. Under the provisions on national treatment, or assimilation, the Convention provides that, as regards the protection of industrial property, each contracting State must grant the same protection to nationals of the other contracting States as it grants to its own nationals. Nationals of non-contracting States are also protected by the Convention if they are domiciled or have a real and effective industrial or commercial establishment in the contracting State. These provisions guarantee not only that foreigners will be protected but also that they will not be discrimated against in any way.

The Convention provides for the right of priority in the case of patents and inventor's certificates, trademarks and industrial designs. This right means that, on the basis of a regular first application in one of the contracting States, the applicant may, within a certain period of time (twelve months in the case of patents), apply for protection in all the other contracting States; these later applications will then be regarded as if they had been filed on the same day as the first application, termed the "priority date". In other words, these later applications will have priority (hence the expression "right of priority") over applications which may have been filed during the said period of time by other persons for the same invention. Moreover, later applications, which are based on the first application, will not be invalidated by any acts accomplished in the interval, such as, for example, publication or exploitation of the invention, the sale of copies of the design, or use of the trademark, and these acts cannot give rise to any rights for the benefit of third parties.

One of the great practical advantages of this provision is that when an applicant desires patent protection in several countries he is not required to present all his applications at the same time but has twelve months at his disposal to decide in which further countries he wishes protection and to organise with due care the steps he must take to secure protection.

These later applications are known as "priority" applications, because they quote the date of the first one as "priority". They are also known as "convention" applications because of the International Convention. The resulting set of equivalent applications or granted patents, one from each country, is known as a "patent family"; indexes of such families are usually known as concordances. It should be remembered, however, that national law requirements may make minor variants necessary or desirable and that the descriptions of the invention in each family member document may not be identical; for example, it may be possible to make a more extensive claim in one country than another. Furthermore, because of the twelve month period during which convention applications can be made, a later application may describe a more advanced stage than, or improvement of, the original, or priority, invention.

The Convention, in relation to patents, lays down a few <u>common rules</u> which all the contracting States must follow. Some of the more important of these rules are as follows:-

(a) Patents granted in different countries of the Union for the same invention are independent of each other: the granting of a patent in one country does not oblige the other countries to grant a patent; a patent cannot be refused, annulled or terminated in any country on the grounds that it had been so dealt with in any other country.

(b) The grant of a patent in one country of the Union may not be refused and a patent may not be invalidated on the grounds that the sale of the patented product, or of a product obtained by means of the patented process, is subject to restrictions or limitations resulting from domestic laws in another contracting State.

(c) Each country of the Union must maintain a special industrial property service and a central office for the communication to the public of patents, trademarks and industrial designs. An official periodical journal must be published by this office; the journal must contain the names of the owners of the patents granted, with a brief description of the patented inventions.

It is to be noted that, except for the provisions with which each contracting State must comply, the most important of which are given above, the Convention leaves every contracting State free to legislate as it wishes in industrial property matters. In particular, each State is free: to exclude certain kinds of products or processes from patentability; to decide whether patents should be granted with or without an examination as to their novelty and patentability; to fix the duration of patents; to fix all the details of procedure and administration.

The flexibility of the international protection of industrial property has allowed the member States of the Union to maintain or establish their legislations in conformity with local conditions and concepts.

The Convention further expressly provides that all or any of the member States may conclude separate, special agreements on particular aspects of industrial property. Such special agreements may not, of course, be in conflict with any of the provisions of the "general", i.e., Paris, Convention.

PCT AND EUROPEAN PATENTS

One of the special agreements entered into by members of the Paris Union, or Convention, is the Patent Cooperation Treaty, commonly referred to as its acronym "PCT", which was signed at Washington on 19 June, 1970, by 35 States.

The treaty provides for the filing of an "international application" where protection is sought for an invention in several countries. The formalities of the international application are regulated in detail. Filing of such applications has the same effect as if applications had been filed separately in each of the countries in which protection is desired. On filing an application the applicant designates the countries in which protection is sought.

The international application is then subjected to a search to discover "prior art" and also, if specially requested by the applicant, to a preliminary examination to establish whether the invention seems to be new, non-obvious and industrially applicable.

Once the relevant reports are established, and not before, the application is processed separately in the various countries, each of which will then grant or refuse protection.

The international application, together with the international search report, is published generally upon the expiration of 18 months from the date of filing of the first application.

This procedure has great advantages over other (national) procedures, not only for the applicant and the national patent offices, but also for the general public.

It offers advantages to the applicant because it allows him to decide whether he wishes to pursue his application in several countries at a time when, thanks to the international search report, he is in a better position to judge whether the expense of proceeding in those countries is justified. The procedure under PCT, which is administered by WIPO in Geneva, is also to the advantage of the national patent offices because receiving an international search rport, or even an international preliminary search report, together with the application greatly reduces, if it does not entirely eliminate, their tasks of searching or examining. For the general public the advantage lies in being able to see the application published together with the international search report and thus be in a position to understand the invention and evaluate the chances it has of protection. The first PCT applications were published in October, 1978; during 1980 about 3,500 PCT applications were filed.

A further special agreement is the European Patent Convention (EPC) which was signed in Munich in 1973. This Convention involves only European countries and provides for early publication, as with PCT, but goes beyond the PCT in providing for central examination, grant and opposition proceedings.

It too provides for designation of States in which protection is sought. The grant of a European Patent in effect represents a bundle of national patents; and revocation and post-grant procedures, other than opposition, take place before national offices. All EEC countries, plus Monaco, Norway Switzerland, Liechtenstein and Sweden are likely to be involved eventually. The EPC is administered by the European Patent Office (EPO) in Munich (with branch offices in Berlin and at Riswijk in the Netherlands); the first filings under EPC were in June, 1978; the first applications were published in December, 1978, within the time scale of this study; a few such documents were thus included in the retrievals of patents data sets described later in this work.

During 1980 a total of 17,505 European Patent Applications were received by the EPO; 47.9% were in English, 36.8% were in German, 13.8% were in French and 1.5% were in other languages. Some 94.1% were based on an earlier priority document. The average number of states designated was 6.67 per application - the UK being the most frequently designated with 943 designations per 1,000 applications.

The majority of these applications (54.4%) were filed at the EPO, mainly at the Munich branch, the remainder being filed at the national offices of the member states (27.3% in the UK, 12.0% in France). 64.8% of these applications originated from EPC member states (29.1% from Germany, 8.5% from UK, 11.6% from France, 5.8% from Switzerland, 3.1% from The Netherlands and the remaining 6.6% from Austria, Belgium, Luxembourg, Sweden and Italy). Of the 35.2% originating outside EPC member states 23.9% originated in the USA, 8.3% from Japan with the residual 3% being derived from 40 states.

In addition, 1980 saw some 2,435 international applications filed under PCT which designated EPO (approximately 69% of all PCT applications filed in that year). Of these 49.4% were filed in the USA, 8.6% in Japan, 10% in Sweden, 6.5% in UK and 3.4% in France.

Thus 1980 saw a total of about 19,940 European Patent Applications filed, which at 6.67 designations each represents the equivalent of 133,000 national patent applications. It is expected that when operating fully some 26,000 applications per year will be processed.

Reviews of recent changes in patent law in the UK and on an international basis have been given by Murphy[14] and Oppenheim[15], the latter concentrates on the likely effect of these changes on information scientists and commercial information services.

COSTS AND BENEFITS OF THE PATENT SYSTEM

Without doubt the most important benefit expected of the patent system is the stimulation of invention and development of new products and processes. The monopoly power conferred by patent grants is the price which society pays for this. In simplest terms, the most important issue of patent policy is whether the costs of the system outweigh the benefits. On a more sophisticated plane the problem is to design a system, e.g., by adjusting the length or strength of patent grants, that will yield the maximum surplus of benefits over costs.

Inventions and innovations bestow benefits on society. How beneficial they are depends on how fully they are utilised: this is one of the paradoxes of the patent system. Under the system inventors are given the right to control and restrict the use of their inventions, so outputs may be lower and prices may be higher than they would have been if the inventions were utilised under fully competitive conditions. Normally patentees can choose between alternative methods of controlling utilisation. They can reserve exploitation of the invention exclusively to themselves, calling upon the courts to censure anyone who attempts to infringe upon that right. In this way, the profit maximising price can be set directly. Alternatively, they can license as many or as few companies as they please to exploit the invention, charging royalties for the privilege. In fixing the royalty rate the patentees can in theory achieve the same price-quantity outcome and profits as they could by retaining exclusive exploitation, other things being equal[16]. In many countries patentees can also strengthen their control over licensees by prescribing prices at which the product can be controlled, imposing production quotas and limiting licensees to particular markets or fields of use.

That patent owners exercise their power to set prices exploiting what ever monopoly power their patents confer does not mean that society is denied the advantages arising from invention and innovation. On the

contrary, society gains at least from the resources that cost-saving innovations release for alternative uses, less the research and development cost of achieving that saving.

Additionally, consumers other than the patentee benefit directly in two ways: firstly, after the patent has expired the patent holder should in principle have no further power to restrict production; thus, competitive pricing will prevail and consumers will reap the full benefits of the invention. Ideally, the life of a patent should be no longer than it needs to be to encourage the optimal amount of invention, so that monopolistic restrictions are terminated as soon as possible[17]. Secondly, consumers may also realise immediate gains even when innovations are exploited monopolistically; according to Scherer[18] several theoretical cases must be distinguished:-

Case 1: A new and superior consumer product is introduced. It can be shown that the innovation necessarily increases consumers' surplus unless the innovator is able to practice perfect first-degree price discrimination. Consumers therefore benefit directly even when the product is priced monopolistically. Whether overall social welfare is enhanced depends upon the costs of the innovation, the impact of the innovation on substitute products and other considerations.

Case 2: A new and more efficient production process is introduced by a firm already exercising monopoly power. Here the effect is to shift the monopolist's marginal cost curve downwards, inducing a decrease in price if the marginal revenue curve is continuous. Consumers enjoy lower prices and higher consumers' surplus.

Case 3: A substantially more efficient production process is introduced under patent protection into a previously competitive industry. The company controlling the new process will find it worthwhile to monopolise the industry, computing its marginal revenue and setting a price that drives existing producers out of business. Alternatively, it will license the invention at a per-unit royalty equal to the difference between cost of production and price. In either case consumers benefit from the lower price. This result is more likely the greater the reduction in costs are and the more elastic demand is at outputs exceeding the pre-innovation levels other factors being equal.

Case 4: A slightly more efficient production process is introduced under patent protection into a competitive industry. If the patentee could monopolise the industry without restraint by virtue of his patent, he would like to set the price, but he cannot do this because of competition from the pre-innovation process. He must therefore either set a slightly lower price and drive others out, or license others at a per-unit royalty slightly less than he desires. Here the reduction in price will be insignificantly small and consumers generally will not benefit from the innovation until its patent protection has expired and competitive pricing commences. Then the innovator's profits are redistributed to consumers and, in addition, the welfare loss is transformed into consumers' surplus.

In three cases out of the four, consumers gain immediately to some extent from the introduction of a patented invention, though they enjoy the full price reduction benefits only after its patent protection has expired. Except when innovator's profits come largely from cannibalisation of the profits that would otherwise have been enjoyed by the producers of substitute products, it is likely that society as a whole, i.e., including both consumers and producers, gains from inventions and innovations induced or hastened by the grant of patent rights.

3: THE NEED FOR PRODUCT DEVELOPMENT AND INNOVATION

Product development refers not only to the creation of new products, but also to the alteration or improvement of existing products.

Unquestionably the need for continual product development is great, for society's needs are always changing, and different products must be forthcoming to fulfil those needs. All products have certain deficiencies, for they are the result of a great many compromises: the perfect product is yet to be made. Research makes possible the reduction of these deficiencies resulting in improved products. However, there are other reasons underlying the temendous impetus behind product development efforts in modern industry.

Figure 2 is a visualisation of the concept of the product life cycle, which holds that every product has a natural lifespan, varying from a very short time for certain "fads" to a relatively long time for certain stable products, and that it moves through its lifetime by stages.

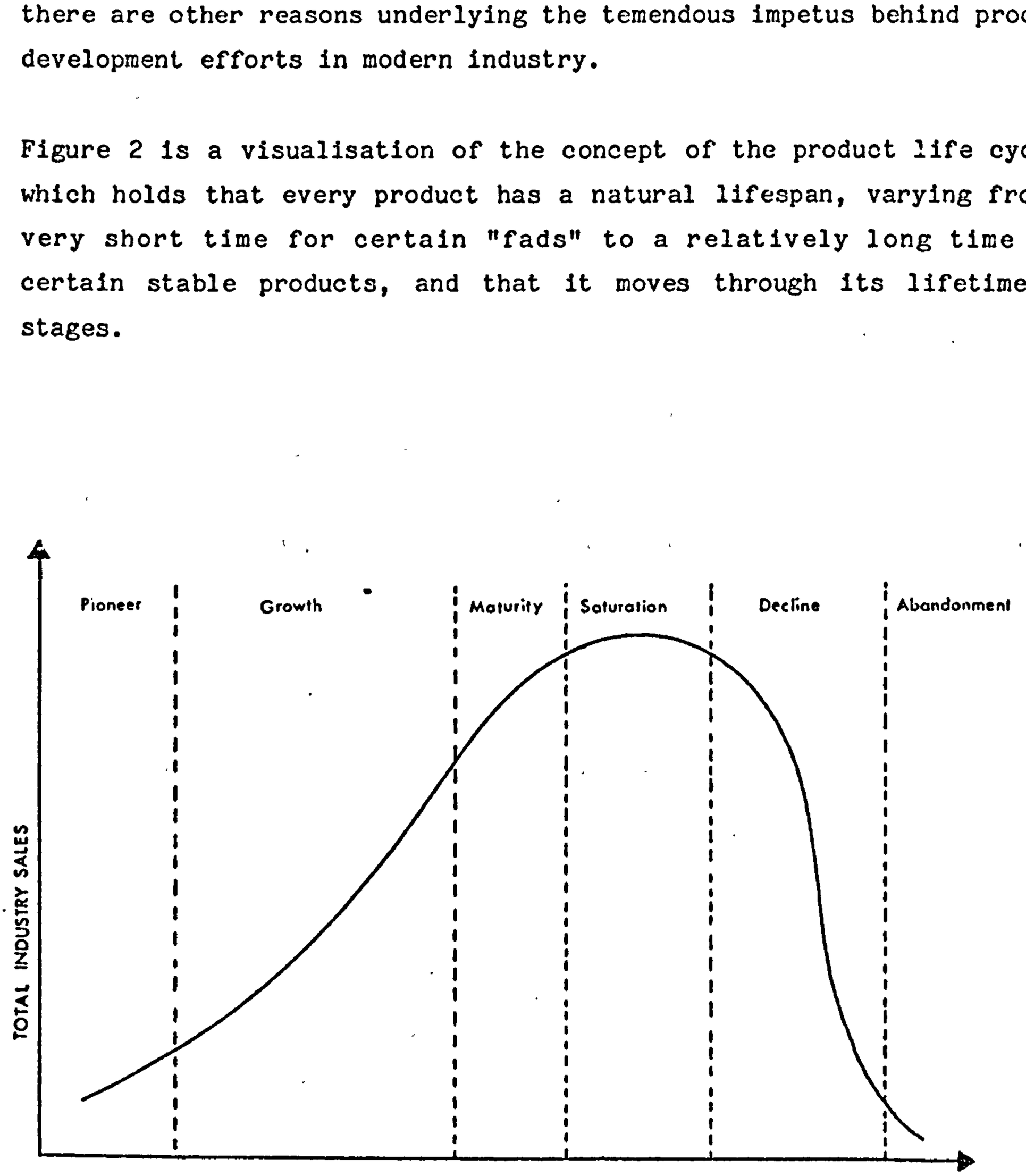


Figure 2: Illustration of Product Life Cycle

The first portion of a product's life cycle is the pioneering stage in which competition is slight or non-existant, prices are relatively high, distribution and market are limited, and rapid improvements are being made in its technology. As the product grows in popularity it moves into the second phase of its life cycle: the growth stage, in which demand rapidly expands, prices fall, more companies enter the market, thereby making competition more intense, distribution is greatly broadened and good profits are being made. As competition intensifies and the market becomes saturated, the product moves into its maturity and saturation stages at the top of its cycle, where prices have bottomed out because of competition and technology. The product is well recognised in the market and has maximum distribution. Saturation may last for a long period, as in the case of many products with long-run demand characteristics. But sooner or later demand for the product begins to decline as new products replace it. With sales declining, competition becomes more ferocious. Marginal competitors fall by the wayside. Profits become almost non-existant. And so the life of the product comes to its end, prolonged perhaps for a while by a few hard-core users.

The concept of the product life cycle is extremely important, for it indicates that sooner or later all products die and that if management wishes to sustain its revenues it must replace the declining products with new ones. The product life cycle concept also indicates what can be expected in the marketplace for a new product at various stages of its development.

Continual innovation of new products renders existing ones obsolete. For that reason management has become accustomed to the fact that no matter how good its product is today, someone will bring out a better one tomorrow. IBM's bringing out of a copier to match that of Xerox is a case in point. Xerox management realised that sooner or later some large company was bound to come after their lucrative copier market. But Xerox's management was not sitting idly by, for no sooner did IBM management announce its new copier than Xerox announced the introduction of a superior product; one could surmise that Xerox was undoubtedly aware of IBM's intentions and had been withholding the announcement of its new development in order to top IBM's new product introduction.

Continual research on new product innovation is now regarded as a constant function of business. It is a mistake to wait until one has been defeated in the marketplace before tooling up to meet the competitive challenge. Market position is such an important asset that few intelligent managements wish to risk losing it by resting on the laurels with the same old products.

Modern management operates on the theory that sooner or later - and it will probably be sooner - someone is going to make its products obsolete, so let it be us; we will be our own toughest competitor.

Many organisations have growth as one of their objectives. While some growth can be realised as a result of normal expansion in the market, and additional growth may be realised if one's products are in a segment of the market that is growing rapidly, still many concerns are not satisfied to grow only at the rate of their markets; they want faster growth. To obtain it they see the introduction of new products to be a good strategy. So new product development has become one of the cornerstones underlying the strategy of growth.

Companies are therefore motivated to conduct research and development (R&D) activities and to devote sufficient resources, both money and manpower, in the quest for innovation leading to new products which leads in turn to larger market share and increased products.

FIRM SIZE, INVENTION AND INNOVATION

Several authors (see for example Scherer[18]) have addressed the question: are large firms in general more effective than small firms in making technological inventions and introducing them into commercial practice?

A number of *a priori* hypotheses favourable to big business exist. One of the best known is that by Galbraith[19] who asserts that the costs of technological innovation in modern times are so great that they can be borne only by large corporations:

> There is no more pleasant fiction than that technical change is the product of the matchless ingenuity of the small man forced by competition to employ his wits to better his neighbour.. Unhappily it is fiction. Technical development has long since become the

> preserve of the scientist and engineer. Most of the cheap and simple inventions, have, to put it bluntly and unpersuasively, been made....Because development is costly, it follows that it can be carried on only by a firm that has the resources which are associated with considerable size.

Furthermore, it is argued, R&D projects are risky as well as expensive. Small companies place themselves in a dangerous position when they invest all their resources in a single innovative project whose prospects for technical and commercial success are far from guaranteed. This, combined with the risk aversion to which business managers and investors are supposedly prone, is said to discourage technical pioneering by small companies. On the other hand, the large corporation can afford to maintain a balanced portfolio of R&D projects, letting the profits from successes more than counterbalance the losses from those that fail. The ability to average out losses and gains may lead large firms to consider innovative opportunities on their "best guess" merits, without being constrained unduly by risk aversion[18].

There may also be economies of scale in the conduct of R&D. A big laboratory can justify purchasing all sorts of specialised equipment, making experimentation easier. It can employ specialists in many disciplines to cross-fertilise one another and to lend temporary assistance when a team working on some development project encounters a technical problem outside its normal sphere of expertise. This latter advantage might be minimised if small firms called upon the services of outside consultants, but it is not clear whether such outside assistance is sought as willingly and speedily as internal expertise[18].

R&D projects may benefit from economies of scale realised in other parts of the large firm's operations. Large corporations can attract additional capital at lower cost and in greater quantity than their smaller cousins[18], and may thus be better able to finance ambitious R&D projects. They have well established marketing channels and may enjoy certain economies of scale in promotion and distribution. Their promotional advantages often permit them to penetrate markets more rapidly with new products, thus affecting the profitability of developing a new product.

Large producers have an advantage in making process innovations. A new process that reduces costs by a given percentage margin yields total larger savings to the company producing on a large scale that to the company producing smaller quantities. As a result the large firm presumably has stronger incentives to develop such improvements.

The disadvantages of size must, however, be contrasted with the above real and/or apparent advantages[20]. Decisions to bear the risks of R&D projects are made by individual managers, not by impersonal organisations and so the argument on risk spreading may not hold water. In a small company, the decision to go ahead with an ambitious project typically involves a small number of people who know one another well. In a large corporation, the decision must filter through a whole chain of command. Each member of the chain is risking his or her reputation, if not money, in backing the project. Under these circumstances there is a distressingly high probability that some member of the chain - from the person who had the idea to the corporate vice-president for research - will block the idea[18].

A direct consequence of this problem is a bias away from really imaginative innovations in the laboratories of large corporations. But more important, inability to get ideas approved by higher management drives many of the most creative individuals out of large company laboratories to go it alone in their own ventures. Thousands of researched based new enterprises have been founded by frustrated technicians from leading corporations such as IBM, Sperry-Rand, Hughes Aircraft, Western Electric and Texas Instruments[21].

A related malady is the propensity for research in large laboratories to become over organised. If too many people are involved in a project they spend a disproportionate amount of their time writing memoranda and reports to each other at the expense of more creative endeavour. Also, the quickest and surest path to higher status and pay in a large company's R&D establishment often lies in giving up work "at the bench" and becoming a member of the management team. Although some companies have tried to combat this tendency by creating well paid positions for senior research workers, it is still commonplace to find the most able workers in a laboratory devoting nearly all their time to supervising a swarm of drones. This is not the way truly creative work gets done[16].

4: ECONOMIC ASPECTS OF R&D

Schumpeter[22] first gave prominence to innovation in theories of economic progress. Schumpeter identified innovation as one of the principal internal promotors of economic growth. His definition of innovation included not only the introduction of new products and new techniques of production, but also the opening up of new markets and supply sources, the improvement of management techniques and the introduction of new distributive methods. The person responsible for doing these and other "different things" was the entrepreneur. Schumpeter emphasised that the inventor and innovator need not be the same person, and in his view it was even highly improbable that the two functions would be combined.

In describing the actual process of innovating, Schumpeter was rather more interested in important, large step innovations. He assumed, firstly, that the innovation would require "new plant"; secondly, that the innovation will be carried out in a "new firm" established for the purpose. He extended this second assumption to argue that the firm, after achieving its purpose, will, like a human being, have completed its alloted span and decay and die. A third, related assumption was that the innovation, embodied in the "new plant" of the "new firm", will be accompanied by the coming to the forefront of "new men", the entrepreneurs. These are assumptions, Schumpeter says, about which "there is no lack of realism".

Schumpeter admitted an exception to his second assumption in the case of the large corporation through which a continuous stream of "new men" pass with their respective innovations. He named this phenomenon "Trustified Capitalism" in comparison with the "Competitive Capitalism" of his model. The increasing predominance of Trustified Capitalism in the economy, together with the establishment of permanent R&D teams within companies forced Schumpeter to reconsider his third assumption also: "This social function [entrepreneurship] is already losing its importance....innovation itself is being reduced to routine. Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways"[23].

Solo[24] criticises Schumpeter's theory of innovation. She rebuts his assumption about "new firms" on the grounds that R&D is a normal

business activity. Other things being equal, the more the efficient innovating firm competes, the less efficient innovator is forced out of existence, not just the non-innovating firm as Schumpeter suggests. The assumption of "new men" is also question by Solo; the R&D team of the modern company builds up its stock of knowledge and ability over time. As this ability grows so does the confidence of management in the work of R&D teams and in the Research Manager concerned. Rising confidence will lead to an increasing propensity to innovate by general management. Solo postulates, therefore, that innovation is possibly more likely to be connected with a previously successful R&D department than with "new men".

Such criticism of Schumpeter's model, however, is possibly unnecessary in view of his own later admission of the obsolescence of entrepreneurship itself. However, Schumpeter's earlier model of the process of innovation has proved, and may continue to prove, its worth in the case of really major innovations in a few selected fields.

Schumpeter's entrepreneur, having acted with enterprise and carried out innovation, must like other factor inputs, be rewarded. It is this payment for entrepreneurial services that forms Schumpeter's well known concept of profit as a reward for innovation: "It is the premium put upon a successful innovation in a capitalist society and is temporary by nature; it will vanish in the subsequent process of competition and adaptation"[22].

Entrepreneurial profit is assumed to be one of the main motivating factors in bringing about innovation. The innovating firm in the era of trustified capitalism will also be, by definition, a monopolist, or at least an imperfect competitor, of the product or technique it has introduced. Consequently the reward which the innovating firm of trustified capitalism can be presumed to seek will be a composite of entrepreneurial profits and monopoly earnings. This introduced the classic policy maker's dilemma of weighing the social benefits of perfect competition against the cost of losing economies of scale. To this problem is now added the social cost of losing innovatory effort if one of the possible rewards of innovation, namely monopoly earnings, is removed or lessened.

Schumpeter defends these monopoly earnings. The balance of advantages is poised in favour of the consumer; he postulates that big business

and imperfect competition have done more to advance than to retard the consumer's standard of living. Monopoly earnings, accumulated in the past, act as a lubricant to innovation and in practice may well be the most convenient way of financing further innovatory steps. No one is more cautious than a lender and nothing appears riskier than novel, untried ideas.

Monopoly earnings as well as financing innovation can induce innovations. In the dynamic capitalist society as pictured by Schumpeter there exists a "perennial gale of creative destruction". This is the appearance of competitors with improvements to, or imitations of, the original innovation. Should the perennial gale appear too quickly or blow too strongly profits might be "washed away" discouraging innovation. A monopoly or imperfect competitive position can give the innovator's profits some protection, and so in the long run will encourage more general economic expansion than it discourages. As Schumpeter tritely remarks: "cars are travelling faster...because they are provided with brakes"[23].

Many economists have argued and developed the merits and demerits of Schumpeter's theories. Some have misinterpreted Schumpeter and, as Markham indicates[25], it is important that we do not confuse the theses of the "neo-Schumpeterians" with Schumpeter's. Schumpeter merely implies a "threshold" theory. That there is a minimum firm size with a minimum amount of market power which is necessary to facilitate and induce innovation in a market economy. The neo-Schumpeterians state that the innovatory effort, as measured by the R&D input of a firm, will be a continuously increasing function of market power, size of firm and/or of retained monopoly earnings.

The dichotomy perceived by Schumpeter between the innovator and the entrepreneur has often ceased to exist (because of large and formalised in-house R&D efforts). According to Reekie[26] R&D can be either offensive, defensive, a business status symbol or a department set up for trouble shooting.

The status symbol R&D department has never been so prominent in the UK as in the USA. The annual announcement in the corporation's report that the firm spent $X million on R&D in the preceding year is used to enhance the firm's standing with the investment analyst and with existing and potential customers[27].

Application of results, if any, would be the exception and not the rule.

The trouble shooting R&D department has a rather more positive role to play in the company but its activities tend not to be R&D in the sense used here. The function of such a department is to primarily investigate technical faults or complaints brought to the attention of management by production or sales departments.

Offensive R&D is directed at discovering entirely new products or processes, either as additions to or replacements for an existing range. This is often begun because of an entrepreneurial hope of expansion.

Defensive R&D is R&D conducted to improve the quality or cheapen the procedures of existing products or processes, often this is initiated for fear of being supplanted.

Where R&D is conducted of course, all four motives for performing it will be operating to a greater or lesser degree. Rarely will R&D be conducted for any one of these motives alone.

Arguments that represent applied research as routine, while conceding that there are many technical difficulties, maintain that industrial laboratories pursue projects the outcome of which is less uncertain than that of basic research. This description is especially true of some types of industrial research concerned with problems of design and engineering development. Thus, Mansfield[28] found that in more than three quarters of the projects undertaken by the laboratories of an electrical equipment manufacturing company, the probability of technical success was estimated at about 0.8. Only 44% of the projects actually resulted in technical success, but even this percentage suggests that the degree of uncertainty is not very high compared with that in basic research. In short, industrial laboratories limit their research to the application of known principles discovered elsewhere to practical problems, the solution of which is relatively routine after the basic research is completed.

The argument goes on to say that because profit-maximising companies are reluctant to undertake risky, innovative R&D projects, individual inventors, as pointed out by Jewkes et al[20], are prominent in lists of important inventions.

Most of the discussion of applied versus basic research in economic literature refers to research other than pharmaceutical research. Pharmaceutical research, which is highly dependent on exploration, does not fit into the standard model well; the line between basic and applied research is especially indistinct in this field. While the very definition of basic research would exclude any deliberate search for specific drugs, pharmaceutical discoveries take the form of new drugs.

Economists have suggested that increased expenditures on research other than basic research would not increase the number of inventions. The inventor draws on his knowledge of previous basic research, but his own efforts do not closely correspond to the amount of funds he has at his disposal. The efforts depend more on the prospect of economic reward resulting from the patent on a product and on the natural curiosity of the inventor. Examples given suggest that the inventor does not require the resources of the large firm and that economies of scale are unimportant in the research preceding the invention[1,18].

The large firm's advantages, it is suggested, are more likely to be present in the development stage following the invention, including the development of the design of the product and of production processes. The advantages of scale in this stage come from the need for the skills of many specialists in different aspects of the problems of manufacturing a new product. Since small firms have difficulty in raising large amounts of capital, particularly when the investments do not produce any collateral, they may be unable to develop a product because of the large expense of making many designs, the practicality of which must be tested through numerous trials. If the project fails, as many do, the inventor may not be able to recover his funds. In addition the small firm cannot support the large number of different specialists necessary for the development of a product. [See also the section on Firm Size, Invention and Innovation in Chapter 3].

Schmookler[29] extended the model to analyse the forces influencing the rate of innovation. This extension employed the traditional tools of demand and supply. Schmookler conceived of a supply curve of innovations which shifts to the right with reductions in the cost of innovation. Nevertheless, Schmookler's own emphasis is on the importance of the demand for innovation rather than on the supply. In his view, innovations respond to increases in demand which are the result in the rise

in the level of income, the growth of population, changes in prices of competing products and changes in factor costs.

Schmookler maintained that accumulated knowledge only influences the rate of innovation by limiting the scope of inventions. He did not accept the idea that scientific discoveries alone stimulated inventions. In other words, a shift in the supply curve of innovations to the right would not result in an increase in the number of innovations. There had to be an increase in demand for this to happen; apparently Schmookler believed that the demand for innovations was inelastic with respect to their price. His evidence consisted of the record of inventions in four industries: petroleum refining, paper making, railroading and farming. In these industries the demand for innovation determined the number of innovations. According to Schmookler hundreds of inventions could be traced to the recognition of a problem and the use of available knowledge to solve it. In addition, he showed that in railroading the number of inventions increased historically with the amount of investment.

Schmookler argued that even in the more science-based fields, R&D expenditures are not greatly influenced by individual scientific discoveries. He recognised that discoveries in pure science sometimes provide the stimulus for invention, but most of the inventions, even in science-based industries, derive from the same stimuli as in the industries which he examined in detail. He therefore concluded that the number of inventions depends more on the expected sales of products embodying the invention.

Salter[30] has given greater credit to the growth of knowledge. Salter suggested that when a new Technology arises, it will bring forth a flow of significant improvements and modifications. Salter also suggested that as a technology matures, significant advances become less frequent.

Schwartzman[31] points out that both Schmookler and Salter ignore certain other conditions influencing the quantity of resources employed in applied industrial research. Other factors include those affecting the cost of research, such as the prices of resources used in industrial research; the degree of protection provided by patents; and regulatory requirements, which in the case of the pharmaceutical industry are most

important. Thus, restrictions by the FDA in the USA on clinical testing and regulatory requirements governing proof of the efficacy and safety of drugs raise the costs of research, delay marketing of drugs, and thus reduce the expected rate of return from investment in R&D. Another important factor affecting the amount of resources devoted to applied research is the amount of protection patents give to manufacturers of new products.

Schwartzman[31] states that hitherto analysis of the sources of innovation has been far too general. In some fields, for example, physics, where practical applications may follow fairly quickly on the growth of basic scientific knowledge, the underlying theory may be sufficiently complete for additions to knowledge to be readily translatable into practical devices. Industrial research, which utilises the results of such fields, in that case, may not diminish significantly with reductions in the protection provided by patents. In addition, secrecy of production processes may adequately protect innovators against rapid imitation and loss of sales. In fact, one study suggests that in many industries firms would not reduce the extent of their research if patents were not available[18]. The much more important consideration may be the availability of a sufficiently large market at prices which provide some profit. Drugs, like all chemical inventions, however, are too easily imitated by too many firms for patent protection to be ignored. The pharmaceutical industry differs from others in that patents almost invariably refer to products rather than to processes, and it is relatively easy to imitate the product once it is available on the market and chemists can analyse its composition.

RELATIONSHIPS BETWEEN GNP, R&D AND PATENTS

The Gross National Product (GNP) is the total money value of all goods and services produced in a nation in some specified period of time, usually one year. It is widely used as an indicator of the well-being of that society and is largely used for measuring prosperity and diagnosing economic ills.

In 1969, Price[32] investigated the relationship between the size of the national scientific effort and a number of national socio-economic variables such as GNP and GNP per capita. Price's measure of "scientific size" was the number of authors producing scientific papers in a given time period. He concluded that national scientific effort was closely associated with GNP levels, and produced a graph showing a clear log-linear relationship between the two.

Davidson-Frame[33] investigated whether there was a relationship between the size of a country's scientific effort and the size of its resource base. He used counts of scientific papers, the data being drawn from Science Citation Index (SCI, published by the Institute for Scientific Information Inc., Philadelphia). Of the 271,435 papers covered, 95.4% could be attributed to 33 developed countries and only 4.6% to 74 underdeveloped countries. SCI does not cover all underdeveloped country publications, but probably includes most significant work from such sources. Davidson-Frame produced a log-log plot of GNP against number of scientific papers and found a relation between 1973 SCI data and 1972 GNP data, thus confirming the relationship described by Price. The regression equation for Davidson-Frame's graph had the form:-

$$\ln y = -26.34 + 1.383 \ln x$$

where y is the number of scientific papers and x is the GNP. The correlation coefficient, r, was found to be 0.91. Davidson-Frame then separated the developed from the underdeveloped countries; he then found the following results:-

Developed countries : $\ln y = -18.063 + 1.066 \ln x$ ($r^2 = 0.799$)
Underdeveloped countries : $\ln y = -20.849 + 1.115 \ln x$ ($r^2 = 0.655$)

Davidson-Frame concluded from this that quite a high percentage of the variation in the dependent variable could be explained by the GNP levels.

Blute[34] has carried out a similar study. She used a count of scientific and technical journals currently being published in 1961 in 40 countries, adjusted by United Nations mid-year population estimates for that year, to give an index of the number of publications per million of population. She correlated this against an index of economic development: this was per capita GDP (Gross Domestic Product) at factor cost in 1963 in hundreds of US dollars. Blute found that production of scientific and technical periodicals was a positive function of the economic index. Using the least squares method she found that the best mathematical expression for her results was the power formula:-

$$y = ax^b$$

The studies of Price, Davidson-Frame and Blute did not consider patents, only journal literature.

The patent system, as it operates in both developed and underdeveloped countries, has not been without its critics; this is especially true of the underdeveloped nations. Many of these countries are considering changes, or have made changes, to their national patent laws which weaken the strength of their national patents, for example, by shortening the maximum lifetime of a patent. Furthermore, there has been considerable pressure from the underdeveloped countries for changes to the Paris Convention; these countries believe that the Convention was written by developed countries for developed countries and has an implicit bias against the underdeveloped nations.

R&D-based companies and other corporations which undertake significant patenting activities are concerned with the anti-patent policies adopted by a number of underdeveloped countries. Such companies will obviously be reluctant to apply for patents in countries which are likely to adopt anti-patent legislation in the near future. One of the principle arguments used to justify the attitude by the underdeveloped countries is that patents do not help their economic development - indeed, quite the reverse. They claim that patents hinder their development since multi-national corporations gain monopoly rights on key inventions in their country, but satisfy demand by importation from elsewhere. As a result, no local employment is created and no local factories are built. Instead, valuable foreign currency is lost. Duffy and Oppenheim[35] have carried out research to assess the relationship between patenting activity and national prosperity in the hope

that such research would shed light on the arguments as to whether patents help or hinder economic development.

In their studies, for the years 1961 to 1977, GNP and GNP per capita data were correlated in turn with patents indexes for the year in question. The patent indexes used were the total number of patent applications to a country, the number of applications by nationals of the country and the number by non-nationals. The data was divided into two sets: one each for the developed and the underdeveloped nations. The 33 developed countries were the western nations, Eastern European nations, South Africa, Israel, Rhodesia, Japan, Australia and New Zealand. The underdeveloped countries were 66 non-western nations. Correlations were carrid out using both linear and double log plots. GNP or GDP was the independent variable, patenting activity the dependent variable.

In addition to this, the same manipulations were carried out with the GNP or GDP data lagged two years behind the patent data; two years was chosen as being the average time between a patent application and the time that the work leading to the patent was carried out. The authors felt that economic conditions two years before a patent application more closely represented the prevailing economic conditions when the inventive activity was carried out than at any other time. In each case, r, the correlation coefficient was calculated, as was also the coefficient of determination, r^2. On the basis of the least squares method, the values of the parameters a and b were calculated for the following equations:

$$y = a + bx \qquad \text{(for the linear plot)}$$

$$\ln y = \ln a + b \ln x \qquad \text{(for the log plot)}$$

These expressions represent the equation of the regression line which best fits the given data.

For the developed countries, Duffy and Oppenheim found that the coefficient of determination, r^2, for a plot of log-GNP againt log-patenting was high; the r^2 values were all greater than 0.75, thus implying a significant relationship between a developed nation's GNP and its inventive activity. As GNP can be interpreted as a nation's gross economic demand for technological change, it appears that the level of inventive activity is related to this demand. However, there is still

a certain inventive activity that is not linked to the level of GNP. This could be due to scientific activity which is not affected by economic conditions, in other words scientific developments which progress independently[36].

The values of r^2 for log plots of GNP against domestic patenting were significntly higher than the corresponding values for foreign patenting. This result was interpreted to mean that once countries have achieved a certain wealth they seek to maintain it by using a large amount of resources to perform research, thus leading to a significant amount of inventive activity.

The values for r^2 were lower for linear plots of GNP against patenting than were the r^2 values for the log plots. For GNP against total patenting, r^2 varied from 0.49 to 0.64, indicating a signifcant relationship between GNP and inventive activity. The r^2 values were higher for GNP against domestic patenting than for GNP against foreign patenting, even with linear plots.

The r^2 values for log and linear plots of GNP per capita against patenting were much lower, varying from 0.15 to 0.46 (log plot) or from 0.03 to 0.20 (linear plot). If GNP per capita is interpreted as the level of national affluance, then the authors conclude that the individual personal economic status has less effect on a nation's inventive activity than that nation's total wealth.

These authors also investigated whether the level of GNP in a given year influenced patenting activity in that year, or two years later by comparing the log-log plots for GNP against patenting and GNP two years earlier against patenting. They found that the r^2 values were slightly higher for the lagged plot of GNP against foreign and total patenting, but not for the domestic patenting plot and conclude that there is little evidence for patenting lagging behind the economic variable.

As with the developed countries the r^2 values for a double log plot of GNP against patenting were high for the underdeveloped countries. For plots of GNP against total patenting, the r^2 value varied from 0.70 to 0.80, most being >0.75. The r^2 values for linear plots of GNP against patenting were lower, but still indicted a relationship, varying from 0.44 to 0.81; however most of the values were <0.70.

In contrast to the developed countries, the values of r^2 for both the linear and log plots of GNP against patenting for the underdeveloped countries were higher for the foreign patenting than for the domestic patenting. This implies that GNP has a greater effect on foreign inventive activity than it does on domestic inventive activity. It appeared that the higher the level of GNP, or wealth, of an underdeveloped country, the greater the number of investors who are patenting in that country, wealth being used as an indicator of the potential size of the market.

The r^2 values of double log plots of GNP per capita against patenting activity were very low. The same applied to the linear plots of GNP per capita against patenting. It appeared that in the underdeveloped countries, affluance had no influence on inventive activity.

In looking at differences between the developed and the lesser developed countries double log plots of GNP against domestic patenting for both groups of countries were compared. The plots showed that for a given level of GNP underdeveloped countries produce less inventive activity. This may be because underdeveloped countries devote less of the GNP to inventive activities; they also lack the infrastructure of research.

The authors observed that the graphs were essentially parallel. For a double log plot, this was taken to indicate that underdeveloped countries are proportionately as far behind the developed countries at one level as they are at another. This means that for increases in economic size, there is little progress in narrowing the gap. Moreover, over the fifteen years analysed, there seemed to be no indication of a trend toward the closing of this gap.

The double log plots of GNP per capita against domestic patenting were also compared. Both sets of results were low; but the r^2 values of the developed countries were much higher than those of the underdeveloped countries. Duffy and Oppenheim state the results imply that the level of inventive activity in underdeveloped countries is not responsive to changes in the level of national affluance. National affluance appeared to have more effect on inventive activity in the developed countries. Inventive activity flourishes where there is an economic surplus. In the underdeveloped countries, quite major shifts of affluance still leave the majority of the population very poor.

Duffy and Oppenheim conclude that increases in GNP in underdeveloped countries leads to increasing use of the patent system by foreigners rather than by nationals. In contrast, for developed countries, the greater the GNP, the greater the domestic patenting. For neither set of countries was GNP per capita found to be significantly linked with any patenting variable. Overall, these authors could find little evidence to support the view that patenting helps underdeveloped countries' economies to prosper; even if the economies do prosper it is foreign patentees who benefit.

Jonason[37] has used patent statistics of the number of patent applications as a basis for discussing and explaining the industrial development trend in Sweden during the period 1925 to 1936.

She comments that the interest that has grown up recently in using statistics on filed patent applications as an aid to technological forecasting could be extended and diversified if other aspects that these figures help to explain are taken into consideration. The pattern of patent applications can be studied, such as by different categories of applicant or different forms of influence between groups and countries. She states, for example, that the distribution of families of patents technically and geographically, can serve to demonstrate the varying spread of different economic interests. Statistics of this kind for recent years can easily be compiled since today most patent applications, Jonason observes, are published within a fixed period from the date of filing or priority.

Knowledge of this kind about the pattern of patent applications could be of some help in considerations of what measures can be taken in order to stimulate or improve the climate of innovation, and how and towards what such measures should be directed. She concludes that insofar as the patents system is regarded as an integral part of the industrial development trend, it should be possible to study various aspects of this trend through the patents system.

Kleinknecht[38] has used patent application statistics in similar ways to study the industrial economics of The Netherlands. It is envisaged that as economists become more aware of patents statistics, and as such statistics are made more readily available to them further studies, especially in macroeconomics, will be undertaken.

5: MEASUREMENT OF R & D EFFORT

Three of the most frequently used measures of R&D effectiveness are numerical counts of (i) publications produced, (ii) of patents issued, and (iii) of new products introduced. Each of these measures has advantages and disadvantages and each has its own sphere of maximum applicability in the R&D spectrum. Each measure has the advantage that the individual components which go to make up the counts are readily identifiable, easily obtainable and obviously verifiable. Each measure has the disadvantage that there will almost certainly be an inevitable lack of uniformity and value between any two individual components going to help make up a count.

(i) Publications Produced

Some research workers may publish a flood of papers, each having but a minimum effort behind it, while others for the same aggregate effort will publish only a few really important papers. Also in some industries much R&D effort will never be indicated by publications (or patenting) but only the ultimate new product. If an interindustry study is to be undertaken, account must be taken, therefore, of the varying propensities to publish and to patent if either of these measures are being used. Similarly, an R&D effort may be successful but because of commercial developments elsewhere, the results of the effort may be obsolete and so possibly no new product will be introduced.

Lipetz[39] deemed it most probable that publications are produced by research workers working towards the basic research end of the R&D spectrum rather than those at the development end. If this is the case, then to the qualifications already mentioned must be added a restriction in applicability to research efforts predominantly concerned with the earlier stages of the R & D spectrum.

In dealing with the matter of publications specifically by the pharmaceutical industry, Schwartzman[31] has commented that scientists in pharmaceutical laboratories want to publish their work, and their employers, who share some of the benefits, encourage publication.

Acceptance by a journal signifies that the work meets the usual scientific standards, so it provides an outside check on the quality of the

work in the laboratory. Research-orientated firms willingly risk revelations that may aid competitors, since their success depends more on a well-developed programme of research, an accumulation of knowledge and a highly motivated team of scientists than on secret bits of information. Rarely is a single publication of crucial importance, and encouraging publication stimulates greater effort.

The number of publications is an index of output, and therefore of input. Scientists themselves regard articles as the end-product of research whether or not they report drug discoveries, and reports of findings related to physiological processes may be more valuable ultimately to those directly concerned with individual drugs. The research-orientated firm, in fact, may turn out many valuable scientific reports and few drugs; other firms may profit from drugs which eventually result from the reports. To the extent that scientists seeking advancement publish articles reporting trivial experiments, the measure is, as Reekie says, deficient - but the error need not bias the estimate of the effect of firm size on research effort.

Using Derwent's Ringdoc service, Schwartzman examined the numbers of publications produced by forty USA pharmaceutical companies between 1965 and 1970; these numbers he compared with the size of the firms as measured by sales of ethical drugs (and thus as a measure of R&D success). The results showed that the number of publications increases more than proportionately with sales size. An increase of 1% in sales size he estimated to yield an increase in research effort of 1.62%.

(ii) Patents Issued

The patent count as a measure of R&D effort effectiveness has received the stamp of respectability by its fairly prevalent use by some prominent economists such as Schmookler[29], Freeman[40], Scherer[41] and Reekie[26].

However, it should be noted that the propensity to patent varies from industry to industry and from firm to firm. Certain industries and firms may, therefore, be either inadequately represented or over-represented by patent statistics.

Kuznets[42] points out advantages in the use of patent count methods. Firstly, patent law ensures in theory that any invention which is granted a patent is original, non-obvious and is a technical possibility. Secondly, since the obtaining of patents requires both time and money it can safely be surmised that the invention which is patented is expected, at least, to be commercially worthwhile. Unfortunately "commercially worthwhile" inventions include those which may be patented solely for the purpose of restricting entry into a given market and blocking the innovation of the invention or similar imitation by others rather than for protecting the innovation of the patenting inventor, i.e., patents solely for the purpose of "disclosure". As Kuznets says, however, unless the numbers of patents issued for the purpose of such unfair marketing strategies is both large and variable, then this qualification is of minor importance.

Patent statistics are also defective as an index of the inventive output of an R&D effort in that they include patents taken out by the organisation concerned but which need not relate to inventions emanating from the official R&D department. Schmookler[29] indicates that an organisation's patents will reflect inventive activity on the part of the scientist, engineers and administrators in other departments of the organisation as well as inventive activity in the R&D department. Similarly many individual inventors, working alone or in academic institutions may well assign their commercial rights in an invention to an organisation which in turn will apply for a patent in its own right.

Furthermore, there is no certainty that the patents taken out by firms in period "t" can be definately ascribed to some specific R&D effort conducted in time "t-k" where "k" is a constant period. For example, administrative delays at the Patent Office may vary. Conversely it could be suggested that similar delays prior to acceptance will confront each patentee, and while this will alter over time the changes will be gradual and probably not erratic and irregular from month to month.

In opposition to this rationalising, however, intra-firm delays to provide a complete specification will vary from firm to firm, and invention to invention, depending on the inventive step itself and on the resources of the firm to perform the necessary R&D in the "race to patent". However, since the gap between the filing of an application

and the provision of the complete specification is fixed by law this latter factor may not be of great importance.

A further difficulty in using patent counts as a measure of R&D appears to be that not all inventions are patented. A declining percentage of inventions are being patented[29] and there appear to be fewer inventions to patent. Many reasons for this have been put forward. Schmookler noted that corporate patenting was not increasing at anything like the rate expected from the increased funding of corporate R&D. He suggested that this was due to a shift of attention away from empirical and towards more scientific research. It seems that firms are finding increasingly that being without a patent is not so dangerous as they had feared. They are still able to reap most of the benefits from an invention. The firm may well rely on secrecy to protect the invention rather than risk exposing it to competitive imitation.

Like journal publications, patent statistics are also limited in their applicability to one part only of the R&D spectrum. Edwards[43] indicates that patent grants give no protection or property rights to the information provided by a basic research effort. Scientific knowledge is not patentable, and hence patents give no index of the success of basic research effort, despite the fact that it is at this stage that the bulk of R&D effort is expended, and it is here that the production and marketing constraints essential for success of the R&D project as a whole are applied with greatest stringency.

Angilley[44] has argued that patent counts are of little value in examining research performance at either international levels or at individual company levels. His arguments to support these claims are, firstly, that different sized companies display different propensities to patent, managerial attitudes often affect the decision on whether to patent a potentially useful compound. Secondly, the types of invention which are patentable vary from country to country, for example between UK and USA, and, since USA industrial counterparts are typically larger that UK companies, any resultant bias would be of importance.

In commenting on patent statistics and corporate policy on whether or not to patent, Christian[45] points out that the utility of a scheme for classifying and aggregating patents depends on more than its consistency with certain theoretical propositions. A scheme is ultimately

judged by its ability to meet the needs of different users at a reasonable cost. Users of classified and aggregated patent data include, among others, those who analyse and predict the rate and direction of technological change, prospective or actual patent applicants who wish to identify competing patents and analysts of the relationship between patented inventions and other economic variables.

These latter users wish to analyse the role of invention in the systems of scientific advance, technological change and economic performance. Inventions cannot be measured directly: therefore, analysis focuses on patent activity, particularly by the private profit-seeking firms who dominate industrial consumer-oriented innovation. Much of the knowledge that these firms develop in their research and development efforts to develop new goods can be described as a "free good": it may be appropriated without payment by other agents who have not performed costly R&D projects. Immediate imitation of innovations would prevent the inventing firm from reaping profits and earning a return to its R&D investment; it designs an innovation strategy around the development and at least partial maintenance of a monopoly over the new product. Patent systems permit one such strategy: a government grants rights over the use of an invention for a certain period of time in exchange for disclosure of the invention's crucial knowledge, a registration fee, and sometimes maintenance fees. The firm, which has already made an invention and has evaluated its market potential, will weigh the costs and benefits of patent protection against the costs and benefits of other available strategies.

Christian observes that the analyst of the economics of science, technology and innovation seeks an indicator that directly reflects calculable inventive output, which is jointly determined by the technical per-unit reduction in service costs and demand conditions in the markets where invention is applied. These factors enter the firms decision to patent: other things being equal, an invention that is worth more to society will be worth more to the inventing firm, provided it can maintain a monopoly over the relevant innovations. But other facts intrude as well: the decision to patent implies costs, including the cost of strategies foregone. If the value of alternative strategies varies systematically, then the relationship between the number of patents taken out and actual inventive output will also vary. There are good reasons to believe that the attractiveness of patent protection does vary systematically, as a function of the effectiveness of

other strategies, including secrecy, the maintenance of a technological lead, and shelter behind other non-technological barriers to enter. Use of patent statistics as indicators of inventive activity therefore requires that account be taken of these systematic influences which are separate from the value of inventive output. Two aspects of market structure seem likely to influence the decision to patent. Concentration in an industry suggests the existence of other advantages to existing firms which deter entry by new firms; these barriers may adequately protect the exploitation of new knowledge so that patent protection becomes redundant. Vertical integration, particularly between the equipment supply stage and the production stage, may permit a strategy of secrecy, offering the innovator the monopolist's differential cost-price structure without the costs and risks of patenting.

These non-technical factors and others flavour the economic analysts's choice of patent statistic methodology. To account for the variability in the firm's decision to patent and analyse the effect of changing technology independantly of market structure and other influences requires that patents be divided into groups where the non-technological factors vary little. The prominence of market structure variables in the analysis of patent decision suggests that patents be broken down by industry. Such a breakdown has been attempted for the resources devoted to private sector research and development, according to the principal economic ectivity of the performing firm. This scheme is conservative, and it assumes that firms will only innovate in their current activity, and not enter new fields. An alternative approach, currently practiced by OTAF, divides patents according to their likely use; this is the product field approach. From the perspective of the ecomomic analyst, such a system should classify a patent in only one group, that containing the component furthest upstream that the patented invention changes. In principle, the analyst would then compare this data with R&D data broken down by the product group of the goal of R&D; whether such data can ever be available is a separate question. Another question is whether the (ideal) product group classification scheme for patents discussed here can be compared with the currently available industrial breakdown of the resources devoted to R&D.

Reekie[46], whilst defending patent counting as a valid technique, admits it has three major disadvantages: patents do not differentiate between inventive steps of differing economic and/or technical magnitude; Angilley's second argument concerning differences in patentable inven-

tions in differing countries applies; and, patents only refer to the creation of new technology, yet they are often used to assist in the understanding of the total morphology of an industry.

The effect on patent counting techniques of variations in the quality of patents has been commented upon. Some patents may contain structural inventions whilst others contain highly significant inventions, yet they are equal in numerical terms. Federico[47] claims that the patent laws of some countries encourage the filing of hasty and premature applications. This can be done to establish the applicant as the first applicant, for example. Applications may thus be filed for inventions which are subsequently found to be worthless. Bosworth[48] claims that patents have increased in quality in the last few years. He agrees with Lutz[49] that the courts in the US have raised the standard of invention. In addition, a higher proportion of patented items seem to be exported. This could be interpreted as implying an increase in the quality of the inventions. Scherer[41] believes it may be possible to correct for the variation in quality and suggests a method of this. This is an important deficiency of patent-based indices, for if the quality variations become great, central trends may be obscured.

Another factor which may affect patent-count indices is that of novelty. The same invention should only receive one patent in a particular country. This means that, if two groups of workers invest in research which leads to the same invention, their effort would only be recorded once. R&D input measures would show up both efforts. However, this is not felt to be a serious defect on the part of patent-based indices. Overall the number of multiple inventions is not great.

Some workers feel that patent-based indices should not contain patents that are unworked. They think that only patents worked for at least part of their lifetime should be included. As Encel and Inglis[50] point out, patents may not be used for a variety of reasons. The inventions may be useless, too novel, not in demand and the inventors may have no cash backing. However, all patents represent inventive activity of a kind and are, therefore, part of the output of the system. In addition, obtaining information on working would very much complicate the collection of patent data. Bosworth[48] has suggested a possible solution to this problem. Bosworth felt that a simple index of patent sealings was an inadequate proxy for changes in technology. He thought that the renewal of a patent indicated that it was of some

commercial use. He therefore developed a new index of patent sealings weighted by the number of renewals. He claimed that the new index was more realistic.

Sanders[51] believes that, for patents to serve as a useful index of inventive activity, the following conditions must be observed:

i) The proportion of inventive activity resulting in patented inventions must have remained essentially invariate over the span of time during which patents are deemed to serve as a useful index.

ii) The input of effort per average patent must have remained invariant.

Sanders thinks that neither of these conditions holds. He thinks that, since the inclination to patent varies widely from one industry to another, and since ascendancy of different industries has varied widely over the decades, it is reasonable to assume that the proportion of inventive activity to patenting has not been constant. Sanders also thinks that the average input per patent is different for assigned and unassigned patents. As the proportion of individual to corporate patenting has changed, he believes input per average patent has changed. Despite this, Sanders believes that patents provide a valuable resource for the study of the innovative process.

Schmookler[52] believes that the forces which cause variation in the input per average patent are long term in nature. He, therefore, recommends that in an analysis using patent statistics, periods which are not too far apart should be compared. This should reduce the effects of these long term trends. He agrees that there is no guarantee that the proportion of inventive activity devoted to producing patented inventions has remained constant. He claims, however, that the use of patents as an index of inventive activity can be justified by the assumption that the average application in one period represents "a quantum of activity of all kinds which is equal to the amount of inventive activity of all kinds represented by the average application in any other period". Gifillan[53] does not agree with this.

Schiffel and Kitti[54] also considered the two points put forward by Sanders. They think that his second point is less important when comparing countries through time, since one would expect input per patent to change in a somewhat similar manner across countries because

of the international character of science. They also believe that, if the effect of patent law revisions could be controlled, that the first point would be of reduced importance.

Comanor and Scherer[55], using data concerning USA companies, have illustrated that the numbers of patents filed correlate more closely with R&D manpower than with new product sales. They suggested that patents may be a better index of innovative input rather than output, and, if they are correct, this adds weight to the weakness of patent counting as a measure of innovative output.

In their investigation, Comanor and Scherer used several indices:

a) Sales during the first two years following the introduction of new chemical entities (NCEs) 1955-1960.
b) Sales during the first two years following the introduction of all new products 1955-1960.
c) Number of patent applications 1952-1957.
d) Number of patent grants 1955-1960.
e) Average number of professional people employed 1955-1960.
f) Average number of total research employees 1955-1960.

They found high correlations between the two measures of new product introduction and the two patent variables. However, firm size was found to correlate highly with both the new product introduction measure and patent variables. Therefore, they calculated partial correlations with the firm size constant. Patenting and firm size were found to account for 67 to 83 per cent of the total variation in the indexes of new product introduction.

They next tried correlating the new product indices against the number of R&D personnel. As indicated above, they found higher correlations than before. If, however, the effects of firm size where removed, the patent-based indices were found to be as good at predicting new product introduction as were the indices of R&D personnel.

They found a higher correlation between the total number of research employees and the patent indices than between the number of professional people employed and the patent indices. They interpreted that as meaning that patents are more likely to indicate the total size of a research effort than to indicate the rate of significant innovation.

Schmookler[52] tested the relationship between the number of technological workers in the US and patent applications for the period 1870-1940. He used Census data to obtain the number of technological workers. He found that the increases in the number of technological workers was matched by an increase in the numbers of patent applications. He took this as evidence that patent statistics could be used as measures in inventive activity.

Schiffel and Kitti[54] report that various studies have demonstrated that the number of patents granted to a firm is correlated, after a time-lag, with the firm's inputs in terms of R&D expenditure, the number of R&D employees and the industry in which a firm operates.

Freeman[56] also reports that several studies in the US and Europe have shown fairly strong correlation between R&D expenditures and patenting behaviour.

Machlup[57] has expressed the opinion that patent statistics are a useful index of investment innovation. He believes that they are best used in conjunction with other indices, when they provide valuable evidence about the relation between invention and economic progress.

These imprecisions can, however, be modified in certain circumstances. For example, if the patents of the companies examined refer only to one industry, or to closely allied technologies, the inter-industry differences in the propensity to patent will be minimal. This is probably true especially of the pharmaceutical industry which regards patents as being of prime importance, thus making inter-company differences in patenting attitudes insignificant. Reekie[46] thus argues that patent activity is a valid guide to industrial morphology and, whilst it cannot replace measures such as employee counts, sales records, market share and profit figures, the technique serves as a useful complimentary measure - especially as patents are an easily available and underutilised source of information.

Schumpeter[23] has asserted that, since modern industrial research requires large resources, large firms would do proportionately more research than small ones and so produce proportionately more innovations. Scherer[18] has suggested three additional reasons for expecting large firms to be more innovative relative to their size: (1) by undertaking several reserch projects simultaneously they can reduce

their risks; (2) their diversification permits them to exploit the unexpected benefits of research; and (3) they can achieve economies of scale in research.

Some studies of pharmaceutical research have disagreed with Schumpeter. According to Mansfield[28] and Grabowski[58], large drug companies do not spend proportionately more money on research than smaller ones. Comanor[59] has observed diseconomies of scale in research. Schnee[60] has concluded that leading companies do not produce proportionately more innovations than other firms.

Confirmation of Schumpeter's thesis, however, has been provided in studies by Schwartzman[31]. This worker studied, for forty US pharmaceutical companies, the relationship between the numbers of laboratory workers (exclusive of auxilliaries) and numbers of US patents issued between 1968 and 1970. His results showed large, and increasing, economies of scale with increase in company size. He also showed that sales-size is less closely correlated to the number of patents than with other measures of research output. He concludes that large firm size encourages innovation in the pharmaceutical industry.

It is of interest to note that, in considering the possible implications of a merger between the UK pharmaceutical companies Beecham Group Limited and Glaxo Holdings Limited the Monopolics Commission[61] reported in 1972 that: " But, while we accept that 'large' research organisations may have some advantage because of the resources at their disposal we think it necessary to distinguish between size achieved by growth within a company and size achieved by joining together two prcviously independent and, in some fields, competitive organisations, marked by some differences in approach. Success in pharmaceutical research depends primarily on the ability to generate promising novel ideas and on the possession of the scienfitifc resources to develop from these ideas valuable products. There are no grounds for believing that the merging of Beecham and Glaxo would result in more promising ideas than if the two continued to work independently. Indeed, the elimination of competition seems more likely to lead to fewer ideas in their large field of common interest, the anti-bacterials. Nor do we believe that the merger would facilitate the processes of developing valuable commercial property from novel ideas. Each company has adequate resources to do this without the aid of the other and should be able to

generate or obtain such funds as it may need to increase its resources. Neither company needs to acquire another research organisation for this purpose".

Scherer[41] examined 448 of the largest corporations in the USA using a patent count for R&D output and sales as an index of size. He showed that whilst patents were an increasing function of company size, the relationship did not rise more than proportionally; in other words the larger company was not relatively more productive in R&D than the smaller. Mansfield[62] in a similar, but by industrial classification more restricted, study came to more specific but similar conclusions to Scherer. Mansfield examined companies in the chemical, petroleum and iron and steel industries. He "tentatively" concluded that, holding R&D expenditure constant, the effects of firm size on the average productivity of such expenditure was negative in each industry. In other words R&D productivity was lower in the largest firms than in the large and medium sized ones. In all three industries R&D expenditure ceased to be an increasing function of firm size after a certain point. However, holding firm size constant, Mansfield discovered that in the petroleum and iron and steel industries, R&D productivity fell after a point as R&D expenditure was raised. No such falling off in productivity was observed in the chemical industry. In certain industries, therefore, the largest R&D effort size may not have such a negative effect on R&D productivity as does the largest firm size.

In his studies Reekie[26] concluded that patents obtained in R&D are a function of the level of R&D effort. He also found economies of scale in the companies investigated, i.e., the larger is the R&D effort, the more efficient it is. He also observed that despite the presence of continuing scale economies in R&D effort, that the most productive size of firm (as opposed to the size of R&D effort) were the "very smallest" and "medium to large" companies. There the combination of R&D intensity and efficiency was such as to maximise patent output per unit of pharmaceutical output.

Steward, Peters and Wibberley[63] have pointed out that Reekie's proposition that "patenting activity is a useful indicator of an industry's technological progress" is not based on a demonstrated relationship with the rate of new product introduction. Instead it relies on a convergence between certain features of patent data and <u>a priori</u> reasoning based on more qualitative knowledge of pharmaceutical innova-

tion. Reekie's recognition of the 'major disadvantage' that patents "do not differentiate between inventive steps of differing economic and/or technical magnitude" does not lead to an attempt to empirically investigate the significance of this. Inter-industry and inter-firm variations in propensity are considered to be minimal due to the selection of one industry and the 'prime importance' of patenting within the industry.

The data on patenting activity used by Reekie are the total numbers of patents within certain categories accepted at the UK Patent Office between 1900 and 1966 which he presents in time-series form. He concludes that patenting activity as a reflection of "technological advance ... is displaying classic exponential growth and in 1966 was still showing no sign of having reached a ceiling or reverting to the more familiar S-shaped ogive or logistic curve". The question as to how precise or distorted a reflection is being shown by these data is not pursued and instead the post-1935 growth is simply correlated with the onset of the "therapeutic revolution" following Domagk's discovery of Prontosil.

Steward et al. doubt the validity of the methodology pursued by Reekie, especially as regards the value of his data as a measure of 'technical advance'. These doubts concern the following points:

(1) The universe of technical activity covered by British patents

The sample of firms covered are by definition operating in the U.K. market and include many foreign firms. It is considered that"there are good reasons to believe that any patenting activity which such firms will have indulged in in their home countries will be repeated in England" due to their presence in the U.K. market and the status of Britain as "one of the world's principal patenting countries". While this may be true it is by no means certain that the actual extent of international pharmaceutical research activity underlying patent activity remains unclear. There will also be imprecision concerning the U.K. patent data and their relation to the research preceding them.

(2) Awkwardness of U.K. data for time-series analysis

The arbitrary and variable time-periods in which patent data at the UK Patent Office are available for convenient counting places constraints on the precision with which fluctuation over time can be assessed. This problem is compounded by the dates identified being for acceptances rather than applications.

(3) Arbitrary selection of relevant patents

The classifications selected: A5B (pharmaceutical compositions), C2A (antibiotics), C2U (steroids) and C2V (vitamins) are very broad and do not refer with precision to pharmaceutical patenting alone. Although attempts to "minimise these imperfections were made by disregarding in certain instances companies with little or no pharmaceutical R&D" Reekie himself is led to conclude that "the findings in the study must consequently be viewed with not a little scepticism in view of the inevitable inclusion of non-pharmaceutical patents".

A further criticism of this work is that patents assigned to class C2C (Organic Chemistry) were included; although selecting those in this class which relate to pharmaceuticals would be a formidable task.

Walsh et al[64] adopted an approach to the measurement of pharmaceutical patent activity which overcame some of the defects of Reekie's study. They achieved a more comprehensive coverage of international activity and a more useful and precise measure of patent dates (though still acceptance rather than application dates) by counting the total patents included under the category of 'Pharmaceuticals' in Chemical Abstracts. They went on to examine the relationship between this data series and the numbers of annual introductions of NCEs into the U.S. market. The results pose an interesting problem. These authors point out:

"The trends of patenting activity appear to follow very roughly the trends of NCE introduction with a time lag of the order of 5 years for the period following the war until about 1960, although a 'bump' in the overall increase in patents immediately after the war is not mirrored in the trend in NCE output. This is to be expected as many patents not published during the war appeared when it was over. The 5 year time lag would correspond approximately to the sequence patent application, patent publication and drug introduc-

tion. After 1960 however, the trends change. The number of patents continues a general upward trend. Although a short drop occurs after 1960, the general upward trend is resumed after a few years. The number of NCEs introduced, on the other hand, declines to about war-time level and (with fluctuations) remains low for the rest of the period".

Three reasons are suggested for the possible explanation that patent applications are being made for an increasing number of compounds which have not yet been introduced as drugs in the U.S. market:

(a) there is now a greater delay between discovering a new drug and FDA approval,
(b) more compounds are now being produced which are not found to be commercially worth marketing, and
(c) a higher proportion of compounds being produced are performing unsatisfactorily in the required biological, clinical and toxicity tests.

Steward and Wibberley[65] have provided evidence to support each of these propositions. To reduce the impact of the peculiarities of the U.S. market a better comparison for the later period is with Reis-Arndt's[66] measure of world introductions of NCEs. Although reducing the divergence, it still remains apparent. The conclusion drawn concerning the value of patent data as an indicator is that "If it is correct that an increasing number of compounds continue to be discovered and patented in the course of drug R&D, but that fewer of them are reaching the market as drugs, the implication is that trends in patenting (for pharmaeuticals) provide an indicator of inventive activity rather than innovative activity".

There remains the possibility, however, that the technical characteristics of what is being measured by the patent statistics is changing, reflecting a change either in R&D activity or in propensity to patent. Reekie's data on product and process patents indicated such a change, although if the trend he demonstrated is applicable worldwide and has continued after 1966, it would leave the above questions unresolved. The difficulty of tackling the problem is that the Chemical Abstracts database encompasses an enormous technical variety of patents of which those referring to NCEs are only a proportion. It cannot be assumed that trends in this patent activity are neceassarily being accurately reflected in the gross patent figures.

Steward et al[63] have also reported on an extension to their studies, in which patenting activity was measured by two methods:

(i) U.K. Patents granted to a named company were identified using the Patent Office "Name Index to Complete Specifications" searching primarily classifications A5B and C2C. Scrutiny of the specification was undertaken to select patents which are linked to research activity oriented toward novel chemicals.

(ii) Priority applications for patents were identified using the Derwent WPI/WPIL online database. Patents were selected from Derwent classes B1 - B6 (Pharmaceuticals). Again these were scrutinised to select the technically relevant patents.

Preliminary results of the work indicate that, although these data require further detailed analysis, they do illustrate interesting fluctuations in patenting activity. Correlation with NCE introductions must bear in mind the increasing lag between patenting and marketing. There does seem to be some relationship between patenting activity and NCE introduction.

Aggregation of the data indicates that there appears to be a relationship between the rate of product introduction in the 1970's and a rise in patenting activity between 1966 and 1969. A comparison of patenting activity in the U.K. owned research intensive section of the pharmaceutical industry with R&D expenditure of the U.K. owned pharmaceutical industry indicates a high correlation.

These early results suggest that the more precise methods adopted may be of value, not only for casting light on the validity of patent data as an indicator, but also for the analysis of changes in technical activity in the industry in a changing regulatory and scientific environment.

Aries[67] has used data concerning patents obtained internationally (i.e., patents obtained by companies in their country of domesticity together with their non-domestic counterpart parents) as a measure of R&D activity. He does point out that patents alone cannot be used as an index of successful R&D. He suggests that the "patent balance" - a measure of the success of one country's inventors in obtaining non-domestic patents as compared to the success of foreigners in

obtaining patents in his own country - is a better measure. He reports on a study that showed that some countries, such as France, have a very low patent balance, and some researchers do not even bother filing applications overseas. As an example he quotes a key cephalosporin patent of Smith, Kline and French Laboratories Inc. which was filed in only two European countries, thus permitting highly ethical companies like Ciba-Geigy to enter the market without an NRDC license and with the aid of Montedison and its affiliate Lark SpA.

Aries also draws attention to a particular problem which is applicable to all parameters used as indices of R&D effort; this is the fact that companies frequently employ subsidiaries to publish, file patent applications and market new products overseas, and thus it is difficult to attribute figures from "counts" to a parent company in a reliable manner. Furthermore, the complexity of licensing arrangements also makes collection of some of these figures unreliable.

Whilst acknowledging that time series of patent data give a very useful indication of the strength and direction of secondary and induced innovative activity associated with the take-off of a new industry, sector or product group, and they therefore provide an important analytical tool for a study of the economics of industrial sectors, Walsh[68] has cautioned that in studying patenting activity it is necessary to contextualise the statistical data in terms of the evolution of industrial sectors and "new technology systems". Aggregate patent data do not reflect the appearance of major or radical inventions or innovations of the kind that may lead to new industries, beacause their numbers would be too small to show up in the aggregate trend. In practise, such innovations have appeared at the same time as the first indication of upsurge in patenting activity in each of the dye, plastics and pharmaceutical sectors; but in other sectors a major patent might appear several years earlier, and not be signalled by any perturbation in the aggregate trend.

From her investigation, Walsh concludes that it is essential to use qualitative material, and possibly other statistical indicators, in addition to patent statistics to study trends in invention and innovation over a whole industry life cycle, or in a comparison between a cross section of sectors (possibly each at an unknown stage in their life cycles). Thus, for example, a simple comparison between patent output in different sectors of the chemical industry during the 1930s

might suggest that the dyestuffs area was more inventive or innovative than the plastics sector. In terms of the absolute number of new chemical compounds that became commercially viable products, then it probably was; but in terms of signficance, plastics patents at that time represented more radical innovations and inventions, which later gave rise to a much greater upsurge of secondary product innovations and process, fabrication, end use and machinery innovations.

Simiarly a study of patent output in the pharmaceutical sector in the mid 1960s and 1970s might suggest a continuing rapid rate of innovation. In fact, the continued rapid state of invention was not reflected in an equivalent number of innovations. The industry was becoming subject to diminishing returns on R&D.

The use of patent and other data, conversely modifies case study or historical material and in particular "conventional wisdom" about innovation in general or the development of a particular innovation. Thus, the traditional view of the dye industry for example, has been strongly modified by the patent and demand statistics. The implication of this for policy makers is that "conventional wisdom" and case history material about a particular industrial sector may prove to be misleading or selective unless considered in the context of patent and other statistical material. Government policy is increasingly considered at the sector level (e.g., policies to promote biotechnology, the electronics industry) and relies on an examination and analysis of developments in that particular sector.

Soete and Wyatt[69] have compared foreign patents across a number of different major world "patent systems" at the global and industrial sectoral level. As well as data on US patents collected by OTAF, they have used patent data collected by WIPO and the EEC.

Using data for the late 1970s they have compared gross national R&D expenditure (a science and technology input proxy) with various patent measures across several OECD countries. The patent measures included the number of domestic patent applications and patents granted; and the number of foreign patents obtained in the USA, Japan, West Germany, France and UK. They have also compared, across industrial sectors, the domestic patenting activity of the USA, West Germany, France and UK with their patenting activity in each of the other three countries.

Using foreign patents as a science and technology output indicator, Soete and Wyatt have studied the evaluation of a number of countries' technological performances across a broad range of industrial sectors.

The analysis performed by these workers indicates that science and technology output indicators based on foreign patenting activity has considerable advantages over other indicators: it is easily available; it is collected in a reliable well publicised manner; and has been collected for many decades.

(iii) New Products

The third measure of the effectiveness of an R&D effort mentioned earlier was the new product count. Some of the disadvantages applicable to patent statistics and publications also apply in this case. Again there is a lack of uniformity from one new product to another. Again this parameter does not indicate how much part R&D effort on other products has been used in the product in question, nor how much of the R&D effort incurred on the new product will be utilised in the future on other projects. However, the general advantages of ease of obtainment and objectivity are both present. The commercial worth of the R&D effort as measured by new products is more certain than when measured by patents. Companies do not introduce new products without at least the hope that they will enhance or consolidate their market position.

The major disadvantages are the need to avoid including imitations, as opposed to innovations, in the count and the danger of including innovations which are a result of an R&D effort elsewhere, such as licensed products. A new product count is strictly merely an index of a company's innovatory effort not of its R&D effort. However, if the count can be restricted to those innovations proceeding from the company's own efforts it could prove to be most useful. If the new products count is so restricted then it will account for all new products emanating from the development end of the R&D spectrum within the firm and for the proportion, varying from firm to firm, of the new products emanating originally from the basic or applied research sectors of the R&D spectrum within the firm. Other sources of invention outside the company's official R&D unit have already been mentioned in the discussion on patents; basic research information leading ultimately to new products could come also from research associations, university contacts and others.

Thus while a new product is basically an innovative index, not an R&D output index, if it is restricted as suggested above, then, since by far the greatest part of R&D is expended at the development end of the R&D spectrum, then a known R&D effort can be asserted to be responsible for a very major part of the output gauged by this index.

A major prcblem associated with new product counts is the definition of what is a "new product". A new salt or ester of an existing drug may represent a useful therapeutic advance, most often through inmproved pharmacokinetics, which can permit greater convenience in dosage schedules and improvement in safety. However, the market launch of such derivatives may require much smaller research investment compared to basic new agents for the same or similar therapeutic indications. Similarly a new derivative which represents a new use of a drug which is already available may not necessarily be considered a significant innovation.

A National Economic Development Office Pharmaceutical Working Party concluded in its report published in 1972[70] that the numbers of new chemical entities, or NCEs (defined as those unique compounds which become ingredients in one or more products), marketed provide a more meaningful measure of innovative activity than a count of new products.

Schwartzman[31] has also examined the introduction of NCEs as a measure of R&D effort. His results demonstrate that the largest firms, with the greater R&D expenditure, discover relatively more new drugs than do smaller firms. He also provides evidence that smaller firms devote their R&D resources disproportionately to the design of new dosage forms and combination preparations than do the larger companies. He points out that the leading twenty USA pharmaceutical firms by sales in 1965 accounted for 82% of new single entities between 1966 and 1972, and for only 36% of the new combination preparations. In addition, these twenty firms produced only half of all new dosage forms. Most of the new dosage forms produced by large companies followed shortly after the introduction of an NCE. Small firms, on the other hand, produce new formulations of old drugs whose patents have expired. The R&D work performed by small companies is thus limited to developmental projects where the degree of uncertainty of technical failure is small. They choose old, standard drugs for new combination and new dosage forms, so the toxicology and clinical tests - which are extremely expensive to conduct - are either unnecessary or perfunctory.

Reekie[26] has stated that because of the lack of understanding of disease causes, most pharmaceutical research in R&D is of of a random, rather than rational, nature. This renders the R&D a relatively expensive "suck-it-and-see" process using a series of costly animal screens which in turn do not provide definite evidence of the reaction of man to the new drug.

This author goes on to say that while most new products are either re-presentations or combinations of existing drugs this does not reflect the distribution of the industry's R&D effort. Most R&D expenditure is directed at obtaining new preparations. Whether or not more resources are devoted to obtaining re-presentations or combinations than is required to obtain the advantages that such products possess is a question which can possibly only be answered by the medical profession. In any event, he concludes, the R&D effort involved is absolutely small.

Reekie goes onto suggest that approximately half of all new preparations may be "molecular manipulations". These will have been the subject of considerable R&D effort and are often condemned as being clinically equivalent to existing preparations. He indicates that each "manipulation" must be judged on its merits. On the one hand the tetracycline variants may have been the result of vast and needless R&D expenditure, whilst on the other hand there are the examples of cortisone and semi-synthetic penicillin derivatives.

In another publication Reekie[71] has elaborated on the subject of "molecular manipulation" (sometimes also known as "molecular roulette") and offers the process as a particular criticism of drug patents inasmuch as competitors are encouraged to search for "me-too" products which are similar chemically to a profitable but patented drug, and which have similar therapeutic properties.

Grabowski, Vernon and Thomas[72] have used the measurement of NCEs as an index of R&D effort in a study to estimate the effects of governmental regulations on innovation. These workers showed that innovation in the pharmaceutical industry has been subject to a number of adverse structural developments in recent years. They observed a sharp decline in the number of introductions of NCEs and rapid increases in costs and risks. They listed five hypotheses to explain their observations: (1) increased regulation of the industry, especially in the USA, associated

with the 1962 amendments to the Federal Food, Drug and Cosmetic Act is the cause; (2) the decline is illusory since only ineffective NCEs have declined; (3) a depletion of research opportunities has taken place: (4) the thalidomide incident has made firms and physicians more cautious; and (5) costs have risen as a result of advances in the technology of safety testing.

In order to separate the effects of regulations from other factors, these workers developed an international comparative analysis of R&D productivity changes in the USA and UK.

A principal finding that emerged from this analysis was that US "productivity" - defined as the number of NCEs discovered and introduced into the USA per dollar of R&D expenditure - declined about sixfold between 1960-1961 and 1966-70. The corresponding decrease in the UK was threefold. Clearly, they state, some worldwide phenomenon, which might be labelled a "depletion of research opportunities" - but which probably includes the effects of other factors such as the thalidomide incident and higher costs due to new developments in safety testing - seems to hold for pharmaceutical R&D. However, they found strong support for the hypothesis that an additional factor had been at work in the USA industry.

They conclude that this additional factor, which has lowered USA productivity at a significantly higher rate, is the increased regulations resulting from the 1962 amendments. On the basis of their analyses the authors estimate that the introduction of the 1962 amendments, at a minimum, double the cost of an NCE.

As far as could be ascertained, no studies have been conducted on the effect on the UK industry of the establishment of the Committee of Safety of Drugs set up under the Medicines Act, 1968.

A study in 1970 reported by Meinhardt[73] showed that the chemical and related industries (including as a major component the pharmaceutical industry) tended to patent more, and market products based on such patents more than for other industries. Unfortunately in this work the pharmaceutical industry was not separated out for special consideration.

In a two part study, Nolan, Oppenheim and Withers[74] initially studied how the proportion of patents in the UK relating to pharmaceuticals has

grown in the period 1941 to 1977. Over the period studied pharmaceutical patenting in the UK grew exponentially up to 1961 and, after a small drop in 1961-3, has grown arithmetically ever since. This is in contrast to total patenting in the UK where a decline has been observed since 1969. The authors also showed that 28% of a random sample of 500 UK drug patents published in 1951 and 1964 were kept in force for their full lifetime of sixteen years. This contrasts with the corresponding figure for patents in all subjects for which only 13 - 15% are kept in force for the full term.

Using a random sample of 21 pharmaceutical companies from a number of countries, and using the Derwent CPI service, the authors examined the correlation between patents, profits, turnover and sales. They found that overall, patenting is positively correlated with profits and with sales, but for certain companies, there was a significant negative correlation, whilst for others there was no significant positive or negative correlation. They also found that turnover was significantly correlated with both R&D and patenting activity. However, no conclusion could be drawn from this study about cause-effect relationships. It was not clear whether high patenting activity causes high sales, high sales cause high patenting, or whether, in fact, both are controlled by other variables.

In the second part of their study, Nolan et al found that the marketing activities of pharmaceutical companies had declined in the period from 1974 to 1975; although this trend was not confined to any particular area other than that of the CNS-active drug market. They state that this decrase may in part be due to increasing costs of developing new drugs and in part to increased legislation concerning safety, which factors they argue tend to lengthen the time interval between patenting and marketing of drugs.

The majority of drugs (73%) considered in their study were covered by patents. However, they were not able to ascertain an obvious reason as to why some drugs were successful in terms of sales volumes.

These authors found differences in corporate attitudes and approach towards patenting amongst the 21 companies selected for special study. The levels of patent applications and publications were sporadic, but on the whole they observed a decrease in patenting activity levels. This is in contrast to the overall patenting activity where a steady

increase in patenting levels may be observed. They also observed that some companies have a propensity to offer their patents to be endorsed licenses of right rather than exploit the patents themselves and that those companies active in patenting do not usually market a large number of products.

Nolan et al. pointed out that their investigation revealed that most companies did not utilise their own patents in developing products, but relied upon licensing arrangements , or to a greater extent, on manufacturing drugs or compositions now out of patent cover. They found that only up to 18% of patents (depending on the company) led to marketed products.

On looking into licensing arrangements, these authors found that, for the small sample studied, the majority of companies which were involved in such agreements with other companies did so without marketing a novel product based on the same patent themselves. A small number of companies did manufacture drugs in direct competition with the drugs based on the patents so licensed. They also found that over half of the products identified through the Monthly Index of Medical Specialities, published by Haymarket Publishing Limited, London, consisted of drugs no longer covered by patents, and that of the remainder over half consisted of products marketed subject to licensing arrangements; only the smallest group consisted of products which were protected by patents.

The authors were not able to find any general criteria for the relative success of the companies studied in this second part of their study, although the earlier part indicated a correlation between patenting and profits. Neither were they able to find correlations, significant or otherwise, when patent, marketing or profit data were tested. From this they conclude that their studies indicate that profitability lies in marketing products under license rather than carrying out large amounts of R&D and marketing the drugs resulting from that effort.

Oppenheim[75] has observed that the pharmaceutial industry is particularly active in protecting its patenting rights as indicated by the fact that during the period 1974 to 1977, out of a total of twenty seven patent infringement actions in the UK, ten related to pharmaceutical products; this is a very high figure when taken in the context that only 1 to 2% of all patents relate to pharmaceuticals. Further-

more, Oppenheim points out that a number of pharmaceutical companies have applied for an extension of term of their patents on some major drugs; indeed six out of fourteen extension cases in the same chronological period related to pharmaceutical patents.

6: THE IMPORTANCE OF PATENTS INFORMATION

As stated earlier, a patent is a document, issued by a patent office, which provides a description of an invention. Furthermore, the patent, if granted, creates a legal situation in which the invention disclosed can be exploited, for example by manufacture or use, only with the specific consent of the patentee. The patent is thus a legal exclusive right in the form of a contract between the State and the creator of some technology. The inventor has to provide detailed knowledge of his invention and, for making this knowledge public, the State grants to the inventor the sole rights to what he has invented for a limited period of time.

The patent is thus a publication which constitutes a source of information. Because of the incentive given by the exclusive rights granted by a patent, the inventor is encouraged to disclose his invention or, in other words, to disseminate information. Provided that the invention is clearly described in the patent, others can utilise the ideas to develop further improvements or to find better ways of accomplishing the same result. That is to say, technology may advance by building on technology. The disclosure of an invention in a patent may also prevent a duplication of research and the needless expenditure of efforts and funds.

Kronz and Grevink[76] have stated that, if it is accepted that the main purpose of patents is to promote technical and industrial innovation, and not only to create monopoly rights, a distinction should be made between three groups of innovation-related factors:-

A - factors reflecting the need to innovate,
B - factors reflecting the capacity to innovate, and
C - factors reflecting the incentive to innovate.

The principle components of type A factors appear to be:-

A1 - the number and characteristics of scientific and technical problems to be solved without having recourse to imitation, and
A2 - the degree and character of national and international competition imposed on or demanded by the economy.

In essence there is a need for social progress and thus a need for innovation.

The principal components of type B factors appear to be:-

B1 - the number of entrepreneurs (firms and skilled individuals) engaged in the production of technology (goods, devices, processes),

B2 - the capital and labour engaged in R&D, and

B3 - the extent and character of the economic and industrial structures of a given country.

In essence there is a capacity in existence able to bring about innovation.

The principal components of type C factors appear to be:-

C1 - the mental disposition and environmental constraints for improving the standards of life by technical innovation, and

C2 - the existence and the quality of an economic order and a body of law favouring innovation.

In essence there is an incentive for advancing the state of the art by innovation.

Parker[10] has emphasised that the information resource which patents represent provides a significant economic advantage to society. For an economy to grow, it is axiomatic that there must be innovative individuals in that society; but for these persons to innovate they must be well informed and the society of which they are part must be able to produce, disseminate, retrieve and use knowledge efficiently. Patents as a source of knowledge thus constitute one of the building blocks of economic progress.

It follows from this that in a highly competitive industry, or one subject to rapid growth, or to rapid technological advance, or, indeed to any combination of these, patents and the information they contain are of vital importance. If maximum use of this information is to be attained, then the patents and/or the information have to be organised.

Before considering how this organisation has been brought about and how various products have developed with which to manipulate patents data, some appreciation of file size is important. Marmor[77] has reported that the United States Patent and Trademark Office (USPTO) receives about 600,000 non-USA patents each year under the exchange provisions of the PCT. These, together with the 70,000 to 80,000 USA patents issued annually, indicate the rate at which the patent files are growing. Pilch and Wratschko[78] have indicated that, on average, every 8 seconds of a working day a patent is issued from one of the 45 major patent issuing authorities in one of fourteen different languages.

Returning to the USPTO files, Marmor states that after patent family duplication elimination and multiple filing because of classification cross-referencing, the USPTO search files contain more than 11.5 million US patent documents and 9.5 million non-USA patent documents, together with approximately 1 million items of non-patent literature - a staggering 22 million documents growing at a rate of 650,000 items per year. By comparison, Chemical Abstracts provided almost 500,000 abstracts in 1978[79].

At the time this study was initiated, Derwent services covered the documents of 26 patent issuing authorities providing a weekly input of 9,500 documents which, it was calculated, would have cost more than £5000 to purchase - and to this must be added the costs of screening their 150,000 multilingual pages for items of interest to any particular user wishing to consult patent literature.

From all this it follows that there are a number of reasons why one should consult patent specifications. These are summarised in the range of information which users of the patent system or patent literature usually call for as reported in a 1979 British Library Consultative Paper[80] and are as follows:-

(a) The latest patent on a topic or topics. In other words the user is concerned with current awareness searching and seeks information either on new developments or on research in progress, since patents often give an indication of this.

(b) State of the art searches; clearance searches. These are jargon terms for extensive retrospective searching which may be concerned with finding out whether a new idea is really novel or

whether a new line of production, research or development is worth starting.

(c) Retrospective searching is also undertaken when the requirement is simply to find one or more ways of solving a problem - in which case it may be sufficient to retrieve only one or two documents, adequate to generate ideas in the mind of the technologist or engineer.

(d) Patents are used as a source of information about the level of R&D activity in a company. Much can be deduced in cerain cases by a study of the level of patenting activity in a company, or the changes in activity with time. In this situation the user would study both applications and granted patents.

(e) The status of a patent. Has an application been granted and, if so, is the patent still in force or has it been allowed to lapse.

(f) Another area of information which is continually sought is the identification of the number of countries in which protection for a particular invention has been obtained. Family information, as it is called, may also be sought for other purposes such as obtaining a translation of a foreign patent written in a language unfamiliar to the user.

(g) Finally, in this list of types of information must come that of opportunities for licensing. This is related to the status of a patent but requires much more knowledge than that; in particular, whether the invention in which the licensee is interested has been carried through to full scale production or whether it is still in the development stage.

There are further interrelated and increasingly recognised uses to which patents information may be put. Firstly, there is the use of patent literature as a tool for industrial forecasting for marketing and research strategists[81]; secondly, the use of patents in bibliometric analyses to determine pseudoproprietary information[82,83], such as predicting the fate of products under development[84,85]. [These aspects of the use of patents information are dealt with more fully below.] It

may also be necessary to watch for patent applications which may infringe upon one's own proprietary rights.

Patent information may also provide ideas for new products or new applications for existing products; it may suggest companies for acquisition or collaboration and it will help identify personnel with specialist expertise.

PATENTS - AN UNDERUTILISED INFORMATION RESOURCE

Despite the important, if not vital, reasons given above for using patents as a source of information on both past and recent developments in technology, it is generally recognised that they remain an under-utilised medium of information apart from their legal use. Furthermore, many information workers consider patents to be an information source of last resort.

The field of information science abounds with user studies. The habits and preferences of users of all types of information products and services have been analysed and reported in countless studies. User studies on the use of patents literature are, however, very rare.

In a 1962 NAS-NRC symposium on the role of patents in research, C. G. Suits, Director for Research of the General Electric Company, presented the results of a study of technical papers submitted for publication by staff members of the General Electric Research Laboratory[86]. A sampling of papers submitted for publication approval yielded the following statistics:-

57% - involved no subject matter on which it was desired to file patent applications

35% - included important patentable subject matter, which, at the time of the request to publish had been adequately covered by patent applications already on file

7% - included patentable subject matter on which new patent applications had to be filed to permit publication approval; prompt filing and prompt approval usually followed

1% - included proprietary information on which no patent application was filed. Questions of patentability may have been involved. There might have been an extensive delay in publication, or there might have been no publication.

This information was presented by Suits to indicate the extent to which patent filing provides the freedom to publish. The statistics shed some light on the relationship between patents and technical literature.

The study findings indicated that of the papers submitted for formal publication by GE staff members, 42% included patentable subject matter on which a patent application had been, or would have been, filed. Presumably most of these applications ultimately matured into patents so that nearly 42% of the published literature written by the researchers covered material that will also be found in the patent literature. Since the published literature is generally available more than a year before the issuance of the US patents (note that the same does not apply to other countries, but it is assumed the GE patents would be the subject of US applications; see also comments below), and since it is usually written in a style far more palatable to the engineer and scientist than the patent document, the formal technical literature may take the place of the patent document as a means to disseminate technical information in nearly 42% of the published literature (assuming the GE laboratory output is typical of all journal literature).

It should be noted that the 42% found in the GE study is the percentage of literature for which patent applications had been filed not the percentage of patents with subject matter common to published literature.

A second study was performed in 1966 by J. S. Gilmore of the Denver Research Institute under contract to NASA[87]. This study sought to identify the channels through which commercial firms acquire new technology. Patents were one of a number of channels studied. In this study technology acquisition "channels" were investigated in commercial firms and organisations in five industries. The industries surveyed were: batteries, medical electronics, industrial controls, printing machinery and vocational technical education.

Through 217 interviews in 73 companies and 480 mail questionnaires, participants were asked to rank a number of alternative channels of information gathering for both "awareness" and "problem solving". Patents ranked very low behind such other channels as trade and professional journals, meetings, supplier personnel, vendor catalogues and textbooks.

On a scale of 100, patents ranked 5 for both "awareness" and "problem solving", while trade and professional journals, meetings, supplier personnel and vendor catalogues ranked above 30 in nearly every instance. Abstracting services ranked at about the same level as patents. The importance ranking was stratified by the orientation of the individual responding. Research-orientated personnel ranked patents at 9; product-orientated personnel ranked patents at 3; and respondents from the management category ranked patents at 5. In spite of this low ranking, Gilmore reported: "Patent literature, although not widely used, was highly valued, both for the specific and detailed technical information it contained and for that portion of a patent application which surveyed the state of the art".

A further study dealing with the use of patent information was conducted by a committee of the American Chemical Society in 1969[88]. The ACS surveyed 2,790 chemists with a mail questionnaire and received 1,394 responses. Respondents were asked to indicate whether certain categories of information services were available to them and whether they were using the services that were available. Patents services were available to 84% of the respondents and were used for current awareness by 63% and for searching by 45%. A total of 68% of the respondents used the patents services either for current awareness or for searching. The other services considered in this study were: abstracting services (92% use), title services (62% use), Science Citation Index (24% use) and computerised information services (60% use). This is clearly a different set of alternative sources of information to the set used in the NASA study. Furthermore, the NASA study sought to rank a broader range of services in terms of importance for "awareness" and "problem solving". The ACS study was limited to "availability" and "use". Nevertheless, the differences in the quantitative results of the two studies are striking.

An analysis of the characteristics of the respondents to the two studies clearly indicates the reasons for the different results. The respondents to the ACS study were predominantly PhDs heavily research-orientated, working for large organisations. The majority of respondents to the Denver Research Institute study did not have graduate degrees, were product or development orientated and worked for relatively small organisations. The comparison of the characteristics of the respondents to the two studies is summarised in Table 1. The results reported in the two studies on the relative use and importance of

patents information provide some insight into the characteristics of different types of users.

Study	PhDs	Research or research orientated	Development or product orientated	Size of Firm
DRI	19%	15%	52%	61% had less than 500 employees
ACS	55%	67%	23%	73% had sales >$100 million per year

Table 1: Comparison of DRI and ACS Study Respondents

Chasen[89] has commented that librarians, especially those in corporate libraries, who are seldom the direct users of patents, should become knowledgeable in the rich resources of patents data. Chasen points out that technology transfer can be accomplished by the engineer and scientist having the complete picture which the librarian offers in response to a search request.

Chasen surveyed (a) major library schools in the USA to ascertain whether courses on patents information were included in curricula for special librarians, and (b) a number of major industrial libraries in the USA on their patent handling and management. Chasen found that not one of the four Schools of Library Science he surveyed had a specific course in patent literature and that the professors responsible thought they had not made their students aware of the value of patents, although each thought that a specific course would be desirable.

Chasen's survey of industrial libraries (two public and eleven corporate) is equally revealing. The questions asked and responses received are as follows:-

(1) My library is the central point in my organisation to handle and order patents. Response: Yes - 2 public libraries; Yes - 4 special libraries; No - 7 special libraries.

(2) When performing a literature search, patent literature is included in the final results. Response: Yes - 1 public library and 9 special libraries; No - 1 public library and 2 special libraries.

(3) Are you, or is any member of your library staff, trained in patent searching? Response: Yes - 2 public libraries and 5 special libraries; No - 6 special libraries.

(4) Do you believe, as a professional librarian, we have overlooked patents as a valuable information resource? Response: Yes - 2 public libraries and 7 special libraries; No - 4 special libraries.

(5) Any comments of the value and pertinency of patent literature as an integral part of a literature search would be greatly appreciated. Responses:

From public libraries:

"A literature search would be of greater value if it included patent literature as well."

"The Brooklyn Public Library subscribes to The Official Gazette - for full patents we send patrons to the New York Public Library."

From special libraries:

"Look upon patents as just another piece of published technical information. Wasn't this settled years ago? Why another study? It seems we keep re-inventing the wheel."

"I am sure all major libraries in research orientated firms such as GE or Dupont [sic] include and pay close attention to patent literature, when performing technical literature searches. However, this is certainly not the case in many literature searches from other sources."

"One member of the library staff attended a half-day seminar on patent searching: thus, we have a cursory understanding of the process and its inherent problems."

"I think it is just now becoming important as a source of information since the advent of the online systems and the numerous databases. Our appreciation of this type of information will greatly increase in the next several years."

"My staff engages in a great deal of literature searching to provide evidence of patent infringement."

"We have a patent attorney at our company, and his office takes care of all patent matters. We do searches for our patent attorney."

Starkloff, Hesse and Paul[90] offer two possible explanations for the underutilisation of patents as an information source: (a) patent literature as an information source is considered not very useful (benefit/cost ratio too low), and (b) knowledge about patent literature and its benefits is not widely distributed (benefit/cost ratio is high, but unknown to potential users).

These workers carried out an investigation in Germany, France and Ireland through mail questionnaires, interviews and expert panel discussions. They concluded that the use of patents is limited because both knowledge of the patents literature and experience in its use are not very widespread. In other words, the potential users who theoretically could profit most from the application of information found in the patent literature: (a) are not aware of the possibilities of this source of information, (b) do not have enough specialised training and knowledge to work the patent literature, (c) find other ways of information gathering more efficient, or (d) live in a psychological environment that does not encourage the use of patent literature.

Bank[91] has stated that the most important reasons for the low degree of exploitation of the patent literature seem to be: (a) lack of knowledge of its contents, its qualities or even its existence, (b) it is considered too difficult to access, or potential users lack knowledge of access possibilities, and (c) the special language used in patent documents, derogatorily called "patentese".

In a follow up study to those of Starkloff et al. and Bank, Thomsen[92] concluded that the most important problem areas in the matter of access to patent information and documentation in public patent libraries are: (a) identification of user's needs, (b) the extent of the documentation needed, (c) publicity programmes, (d) location of the patent information centres, and (e) organisation and staffing of the centres.

Shuchman[93] has reported on a survey of the patenting activities of 1315 American "bench" engineers; in answer to a question which asked how useful they find a variety of sources of information this group replied that patents were among the least useful sources. Only 4.8% rated patents "very important"; another 15% rated them "moderately important".

Shuchman reports that the survey data also indicated that patents information use varied between industries, for example between the aerospace and metallurgical industries (although she gives no data on such differences), but that it is consistently low irrespective of differences based on educational degree or engineering discipline. The population of engineers surveyed communicates largely on an informal basis and mostly within the company.

Shuchman states that "there is no printed alternative to reading patents" and, because of their reluctance to read such documents, engineers are unlikely to pick up information about new inventions from journal sources as such a large proportion of inventions are never disclosed outside the patent literature[94,95].

Shuchman concludes that in all likelihood, informal communication and internal company reports provide engineers with their link to technological innovations, albeit that her survey results indicate that the link is weak.

A study on the uniqueness of patents as a technological resource given in the Eighth Report (1977) of the Office of Technology and Assessment Forecast (OTAF) of the US Patent and Trademark Office[94(8),95] adds further possible factors in the matter of use of patent literature: (a) the information in a patent may be outdated as a result of the delay between the development of the invention and its acceptance and publication as a patent, (b) the inefficiencies in such secondary patent literature as abridgments, and the structure of indices to patents, hinder certain types of searches, (c) the fact that non-domestic patents may be in an unknown language to the potential user, and (d) potential patent users have a belief that the information contained in patents will eventually come to their attention through other means such as scientific or technical journals.

In discussing the OTAF programme and functions, Marmor et al.[96] postulated that there are four "myths" associated with patents which lead to their under-utilisation; these are: (a) patented technology is reported and adequately covered by the non-patent literature, (b) patents to a large extent do not disclose significant new technology, (c) by the time a patent is obtained everyone knows about the technology since patents are untimely, and (d) the validity of the disclosure may be suspect.

For (a) and (c), Marmor presents counter arguments similar to those given by other workers, and which are discussed below. With regard to (b) Marmor points out that over 80% of granted US patents are owned by organisations, mostly large corporations. He states that the top 343 patenting organisations represent only 0.7% of the total number of patenting firms, but they receive 41% of the patents granted. Thus most patents are obtained by the serious inventor working for organisations which invest considerable sums of money in obtaining patents (attorney's charges, searching costs, filing fees, etc., easily adding up to many thousands of dollars). The costs are such that the corporations will be selective in their patenting activities and that what is patented or described in patents are technological developments that corporate developers consider promising and useful.

In considering the validity of disclosures, Marmor points out that although a commonly held misconception is that patented technology is passed on reluctantly and with some of the important features missing, just the opposite is likely. Patent laws require inventors to disclose the best mode of their inventions; to do otherwise constitutes fraud which makes the patent unenforceable. Furthermore, patent disclosures are virtually always far more detailed and complete than non-patent literature since they often contain many detailed drawings and examples which publishers of books and periodicals are reluctant to publish.

Oppenheim[97] has also referred to the reluctance of publishers to print dozens of drawings - often with only minor differences between them - or to print scores of examples, and quotes as possible cases where publishers would have been hard to find, the many voluminous specifications relating to computers, especially British Patent 749,836 which has 267 pages of specification with 780 drawings, and British Patent 1,108,800 which had to be bound in four volumes.

Marmor's "myths" type (a) and (c) are interrelated; indeed they can be considered as a single function since it is axiomatic that, if "everyone knows about the technology" prior to the issuance of a patent [myth (c)] then that knowledge could only be gleaned by disclosure elsewhere, almost invariably through the non-patent literature [myth (a)], although some information transfer will be by personal contact such as at conferences and symposia.

There have been several studies reported in the literature designed to quantify the extent to which technology described in patents has been published in the non-patent literature.

In an article published by UNESCO, Vcerasnij[98] states, without apparent detailed statistical analysis, that only 5 to 10% of new technological solutions offered by patents is published elsewhere.

In 1974 Liebesny, Hewitt, Hunter and Hannah[99] gave the following examples of important inventions which were first disclosed in the patent literature several years before their appearence in other forms of literature:-

Invention	Inventor	Date of published patent	Date of first disclosure in other form of literature
Punch card	Hollerith	1889	1914
Television	Baird	1923	1928
Jet engine	Whittle	1936	1946
Ductile cast iron	Morrough	1939	1947

Liebesny and his co-workers studied the overlap of a random sample of 1058 British patents with journal literature. The patent specifications were published in 1962, 1965 and 1968. Name (author) searches were carried out in the names of the inventors through Chemical Abstracts, Engineering Index and Electrical and Electronic Abstracts. The main results obtained are given in Table 2 and demonstrate an overlap rate of 3 to 9% depending on subject matter.

An analysis of time difference between date of publication in a journal article and date of publication of the patent or date of application for a patent showed a peak of journal publishing occured a year after application for the corresponding patent; this is illustrated in Figure 3.

Liebesny et al. also made an analysis of the number of multiple publications from their sample of patents. They found that in six cases two journal articles appeared, in three cases three journal articles appeared and in one case four journal articles appeared.

	1962	1965	1968	Total
Chemical Patents				
Investigated	91	95	127	313
Retrieved	9(10%)	10(11%)	8(6%)	27(8.6%)
Electrical Patents				
Investigated	49	89	74	212
Retrieved	5(10%)	4(4%)	7(9%)	16(7.5%)
Mechanical Patents				
Investigated	143	181	209	533
Retrieved	3(2%)	12(6%)	3(1.4%)	18(3.3%)
Totals	283	365	410	1,058
	17(6.0%)	26(7.1%)	18(4.4%)	61(5.8%)

Table 2: Numbers of specifications in respect of which subsequent references were found in other forms of literature, by subject.[99]

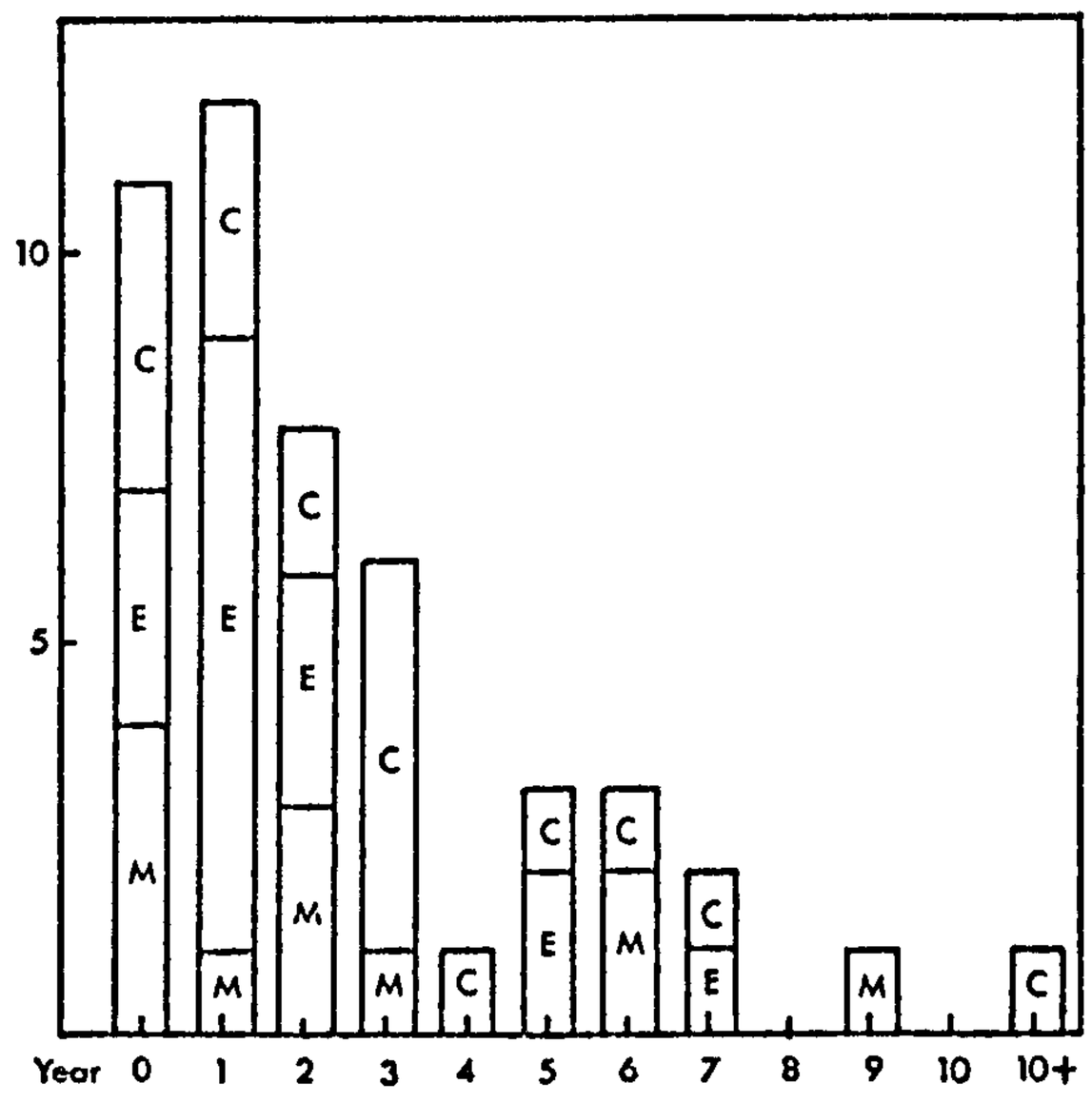


Figure 3: Publication of specifications in other forms of literature, chronological from date of application (C=Chemical; E=Electrical; M=Mechanical) [99]

A further study of the patent/non-patent literature relationship was carried out in the OTAF study referred to earlier[94(8)], this study has also been described by Terapanc[95]. This investigation examined a random selection of 220 US patent specifications issued in 1967 and a sample of 215 patents issued in 1972.

Literature references were determined by author and subject in Science Citation Index, Chemical Abstracts, Electrical and Electronics Abstracts and Engineering Index. Furthermore, to check the effectiveness of these secondary reference sources in picking up all pertinent references, a telephone survey was undertaken with at least one of the inventors of each of the 45 patents of USA domestic origin in the 1972 set of 220 specifications.

The overall results of this investigation showed that 16.0% of patented technology was fully disclosed in other literature, 13.3% was partially disclosed and 70.7% was not disclosed. Differences were found in the different subject areas; an overlap between journal and patents literature was found for 24.3% of the chemical, 5.0% of the electrical and 5.0% of the mechanical cases.

In a more recent study Allen and Oppenheim[100] studied the overlap of Canadian and US patent literature with journal literature. A random sample of 300 US and 100 Canadian patents published in 1968 were examined. These workers searched the same journals (partly online) as the Liebesny team. The results obtained indicated that 6.0% of the US patents and 11.0% of the Canadian patents also appeared in the journal literature. As with the earlier studies differences were found in respect of the subject area: 6.1% of chemical patents, 6.0% of mechanical patents and 11.3% of electrical patents appeared in the journal literature.

Allen and Oppenheim also studied the time lag between the priority date for a patent and subsequent publication in another form of literature as well as the time lag with publication of the patent. The results indicated that most items in other forms of literature appeared 1 to 4 years after the priority date of the patent, a result in agreement with that of Liebesny et al. Most items in the Allen and Oppenheim study appeared in journal literature 1 to 3 years before the patent was published and 19% after the patent appeared. This is significant since both USA and Canada are so-called "slow publishing" countries for patents; indeed Allen and Oppenheim showed that for USA applications most patents appeared 3 to 4 years after priority date, and for Canada most appeared 4 to 5 years after priority date.

Data for the appearence of journal articles in chronological relationship to patent specifications would probably have been quite different

if Liebesny et al. and Allen and Oppenheim had studied patents issuing form the "quick publishing" countries (i.e., publication 18 months from priority date) such as France or West Germany, or if consideration had been given to "foreign" counterparts, or equivalent patents, to the specifications used in their studies.

Marcus[101] has observed that patents contain more experimental detail than most journal articles and gives this as an added reason for R&D workers to be aware of patents information.

A series of papers[100,102-109] emanating from the Centre for Information Science, The City University, has demonstrated the importance of patents as sources of information and the coverage of patents by abstracting services in a wide variety of subject areas.

Schiffels[110] has discussed the reasons for the dissemination needs of patent information, the types of information required and the characteristics of users and potential users. He has pointed out that there exists a need for patent information marketing and that official bodies, such as patent offices, should play a key role in making patent information available.

A comprehensive bibliography of patents information has been given in a recent NATO/AGARD publication on patents as an information resource[111].

The implication of the various studies reviewed above is obvious: ignore the patents literature and there is a strong risk that you would miss the technology that is relevant to your work. If not being aware of such technology leads to less productive R&D, or to a faulty business decision, then failing to adequately review the patent literature can be very costly.

7: PATENTS AS A MEDIUM FOR TECHNOLOGICAL FORECASTING

According to Hausser[112], an advantage of using patent information that has hitherto been neglected is its reliability as a pointer to technical information regarding new developments long before their effects are felt in the market.

Taking the transformation of the clock and watchmaking industry as an example, Hausser has endeavoured to evaluate the usefulness of such information, especially as this industry has undergone a remarkable transformation since 1975. Many undertakings which had formerly made mechanical clocks and watches, or their components, were taken by surprise by the advent of electronically controlled products. However, the early warning signs of these developments would have been clearly discernable in the patent documents. The first patent document published in West Germany in 1970 concerned the Hamilton Watch Company's "Pulsar" wristwatch, which appeared on the market soon afterwards but could still be considered, because of its "fancy" price, a technical toy. But from 1971 onwards, there appeared patent documents describing clocks with liquid crystal display and minimal power consumption which subsequently appeared on the market, from about 1976 onwards in very large numbers at very low prices. Hausser stresses that the 5 year period which saw such a striking increase iin the number of patent documents in this technology should have sufficed for the taking of appropriate measures and for the avoidance of heavy financial losses incurred by certain companies.

Hausser also points out that a similar situation is arising in the technology of video and data recording. Although these technologies are also showing remarkable advances, evidence of activity in this area can be identified in the patent literature from as long ago as 1970.

Kronz and Grevink[76] have stated that the patent literature is perhaps the truest mirror of the state of advancement of technology and of the progress of R&D in all fields of human endeavour; they used the term "patent literature" to cover all the various ways in which an attempt is made to gain a monopoly in ideas, i.e., patent specifications, published patent applications, utility model (registered design) specifications and inventors' certificates.

The authors emphasised that trends in technology and invention can be followed over a number of years and that it was possible to identify trends in technology, e.g., fast growing fields, fields where the growth is slowing down, foreign dominated fields, national dominated fields, etc. For example, in the Netherlands the number of applications for cycloaliphatic compounds showed a continual rise, but this was due to foreign filings, whereas the "national/residential" filings decreased in number. Similarly, a decrease of numbers of applications in France in the field of pig-iron processing was noted; for the same technology in West Germany the ratio of national to foreign applications was seen to be falling steadily.

The data was also used to collect together and group a number of IPC classes and sub-classes relating to one particular branch of industry or commerce. It was found that, from the point of view of "patent concern", the machine industry ranks before the electrical industry, and the electrical industry before the chemical industry; furthermore, the manufacture of metallic articles is as much concerned with inventions and applications as the rubber industry and the working of plastics.

In an extension of their studies Kronz and Grevink[113] carried out a statistical analysis of the published patent applications in six of the EEC Member States during the period 1969 to 1975. They followed the general trend of filing of patent applications in the EEC, in Japan and in the USA; the areas of major technological importance for the patent filing activities in the EEC, and the technological areas showing a steady rise or fall in annual number of applications filed in the EEC. They also attempted to link patents statistical data to the activity in some industrial fields.

In this second study the authors arrived at similar conclusions to their previous work. However, they were much more specific in identifying areas of technology where significant changes of patenting activity were taking place; again these areas were defined in terms of the IPC. Kronz and Grevink pointed out that the objective of their study was to help prepare the basis in Europe for a wider and more reliable use of statistical data in investigations concerning problems such as policy in R&D, innovation and technology transfer.

Ivanov[114], in discussing the use of patent information in technology forecasts, has stated that the extent and scope of contemporary progress in science and technology and its impact on the economic, political and social life of the community requires the development of a technique for reliable scientific forecasting. He gives this as the reason for present worldwide interest in the forecasting of trends in science and technology; this forecasting technique is gradually becoming an independent applied discipline. Ivanov states that the use of patents as an important element of the general information base for forecasting is dicatated by the following reasons:

(1) First of all, a survey of patent literature enables one to obtain a detailed and systematic idea of the world state of the art, and of the trends and prospects of a given branch of industry. The distinctive features of patent information compared with other kinds of technical information are that patents are the most up-to-date, the most reliable and the most complete source. Furthermore, in principle, a patent as a legal document is not supposed to contain unreliable data. Patents contain concrete solutions of technical problems, and special indexing systems facilitate their retrieval from the mass of information. Finally, their language is in theory more concise, informative and formalised; thus it is easier to use patents for abstracting and even for machine translation. These advantages are of particular significance for the elaboration of mid-range forecasts for normative purposes, where an especially high level of confidence is required which cannot be reached by the average valucs of intuitive estimates in the interquartile range (as for example in "consensus" or "Delphi" techniques) but rather by careful consideration of factual information.

(2) Secondly, patent literature provides one of the most representative mass-scale sources of information. The need for legal protection of industrial property rights for inventions as a basis for further exclusive rights for commercial exploitation impels all organisations involved in R&D activities to patent their results as extensively as possible.

(3) Thirdly, patents contain, in addition to technical information, extremely important bibliographic data, which permits a superposition of schemes representing general technological development and

industrial structure. By giving information on priority dates and the inventor's and patent owner's names and addresses they permit the linking of the "technical side" with the existing possibilities for the introduction of inventions into industry, which depend on the technological policy and the patent owner's resources, i.e., the forecasting of the level not only of developments, but also of industrially manufactured technology.

According to Ivanov this makes patents applicable for use in most of the inernationally recognised forecasting techniques, especially the mid-range techniques, i.e., for 4 to 10 years, with the object of finding the next "stratum" of technology which will replace the existing one. In particular, patent information may be used for the forecasting techniques shown in Table 3. This set of forecasting techniques is cited according to Hayden[115]. In the table, the differences in significance relate to the use of patents in the elaboration of a forecast. For an extension of a forecaster's knowledge and experience, patents are important irrespective of the forecasting technique used. For long-range forecasting, i.e., for periods greater than 10 years, Ivanov states that account should be taken of the possibility of the appearence of technological solutions which are new in principle; whereas in short-range forecasting, i.e., less than 4 years, the current general economic situation can become the decisive factor for the utilisation of innovations.

De Jonge[116] has drawn attention to the fact that graphical representation of the number of patent families in the year of first filing, or of the cumulative number of patent families since a certain point in time, gives useful information regarding the inventions made in a field of coherent subjects. He concludes that a statistical evaluation of the numbers of scientific and/or technical papers does not give as good a base for R&D policy decisions as a corresponding evaluation of patents literature.

Perhaps the widest use of patents for technological forecasting has been by the US Patents and Trademark Offfice; this use has been described by Marmor[77] and by Marmor, Lawson and Terapane[96].

The USPTO has built up an enormous computerised database of patents information; the uses and benefits of the database are not limited to patent search file maintenance and improvement. The existence of the

Forecasting Technique	Decisive	Significant	Small	Optional
1 Expert Forecasts				
1.1 Individual intuitive forecasting		x		
1.2 "Consensus"			x	
1.3 "Delphi"			x	
2 Extrapolation Techniques				
2.1 Linear extrapolation		x		
2.2 Development trends according to curves		x		
2.3 Envelope curves		x		
2.4 Correlation and regression analysis			x	
2.5 Determination of "thresholds" of technology changes	x			
2.6 "Substitution curves"	x			
2.7 "Outstripping-delay"	x			
2.8 Rate of "diffusion of technology"		x		
3 Systems Analysis				
3.1 Examination of the state of the art	x			
3.2 Examination of hypothetical futures		x		
3.3 Study of the impact		x		
4 Analysis by Parameters				
4.1 Evaluation of theoretically possible limits		x		
4.2 Estimation of "perfection contour"		x		
4.3 Detection of unique properties		x		
5 Mathematical Modelling				
5.1 Matrices "investment-output"			x	
5.2 Historical and genetic models				x
5.3 Biological development analogy				x
6 Auxiliary Techniques				
6.1 Relevance tree		x		
6.2 Morphological box			x	
6.3 Flow-charts	x			
6.4 "Life-cycle" curves	x			
6.5 Estimations of demand expectations		x		
6.6 Dynamic forecasting				x
6.7 Technological tracing	x			

Table 3: Degree of Necessity of Use of Patents for the supply of Information for Forecasting Purposes (from Ivanov[114])

base, augmented by a variety of other bibliographic data, has enabled the establishment of a programme specifically aimed at those in the non-patent community.

This program, called "Technology Assessment and Forecast", began in 1971. It sprang from the knowledge that within the patent file can be found almost all major technological advances that have occurred in the USA during the period since the first US patent was granted in 1790, and from the realisation that this file has significant potential as a resource for determining the history, development and current status of technology.

Data utilised include information about all US patents, such as the technology to which each patent is directed, its title, the inventor's name and residence, ownership (both specifically and by type), filing and issue dates, IPC and domestic patent classsifications as well as search and citation information. Also data about the patents of other countries and facts concerning the technological characterisation of pending patent applications has recently been added. More recently, relationships between the US patent classification system and the Standard Industrial Classification (SIC) have been added to the data-base. This latter addition permits, for the first time, broad scale use of patent data in economic studies.

OTAF (Office of Technology and Assessment Forecast, the Department within USPTO responsible for the programme) uses the database in two principal ways. Firstly, it periodically issues general distribution publications; ten of these issued between 1973 and 1981[94]. These publications have included reports on highly active technological areas; areas experiencing high levels of patenting by foreign (i.e., non-USA) residents; profiles of patenting patterns of the residents of selected foreign countries and US states; review of patenting activity of the most active patent assignees; and comparisons of patent activity in selected SIC categories. In addition, several of the publications have examined the patenting trends in high-interest energy technologies.

The second principal use of the OTAF database is in the preparation of special reports, tailored to individual needs. These reports, which are provided on a cost reimbursable basis, have been utilised by many USA government agencies and a large number of private sector organisa-tions.

It is not possible in this thesis to describe in any detail all the OTAF publications. Each of the reports contains reviews and assessments of patenting activity in a dozen or more areas. However, as an example of these reviews, the reports on prostaglandin compounds may be considered as typical of the reports of interest to one industry sector, i.e., the pharmaceutical industry.

Prostaglandins are pharmacologically active lipids, widely distributed in animal and plant tissue, and are among the most potent pharmaceutical agents known. They elicit multiple responses and have a broad spectrum of activity. In doses as small as 10 ng/kg these compounds can affect the reproductive, cardiovascular, respiratory, nervous, renal, gastrointestinal, endocrine and/or metabolic systems as well as the sensory organs and skin. Hence, prostaglandins are useful in treating a wide variety of diseases, including asthma, ulcers and hypertension. Additionally, they have uses as labour inducing, abortive and antifertility agents.

Due to this potency and broad activity spectrum, the prostaglandins have experienced phenomenal patenting activity in recent years: since 1971 patenting activity has been growing at an average annual rate of 84% which, for the USA, is about 34 times the average for all technologies.

The first OTAF report on these compounds appeared in the Fifth Report published in August, 1975[94(5)]. The report surveyed the patents by geographical location of the patentees and then gave a review of the main thrust of the technology in terms of isolation of the compounds from natural sources, semi-synthetic and synthetic derivatives and provided a patent bibliography.

The report concluded by oberving that the (then) most recent effort in the technology involved development of compounds which alter more than a single site of the naturally occuring prostaglandins, especially alkylation at 15- and/or 16-positions.

An update of the first report was given in the Seventh Report published in March, 1977[94(7)]. The report was similar in conent and format to the previous one and reviewed the patent data available up until the end of 1976. At its conclusion the report comments on "Future Trends" and observes that patent activity appears to be directed to matching

specific compounds to a specific use with sufficient potency, duration and specificity to obtain useful drugs.

Prostaglandins were also the subject of an OTAF Special Report[117] which surveyed the patent activity in the period until the end of 1978. This Special Report takes the form of computer generated listings and analyses all USA patents in the technology. Analyses by types of ownership (corporate, foreign, etc.), geographic location of owner, number of patents per year by corporate ownership are provided as well as detailed lists by corporation giving patent numbers and titles.

A comparison of economic and patent data was presented in the OTAF Sixth Report published in June, 1976[94(6)]. In this report patent activity data, developed through the use of the USPTO Classification/ SIC concordance, were used for comparison, in six selected industries, with R&D expenditures and the number of R&D scientists and engineers employed in those industries. The object of the report was to inform workers in economics and related fields of the availability of useable patent data and, perhaps, to stimulate thinking as to how this data might be employed.

The selected industries were: Food, Chemicals, Fabricated Metal Products, Machinery, Electrical and Communications Equipment and Scientific Instruments (SICs 20, 28, 34, 35, 36 and 38 respectively).

The patent data used included only those US patents which were assigned (owned) at the time of issue to USA organisations. Patents were not included which, at the time of issue, were: not assigned (i.e., owned by the inventor); assigned to foreign (i.e., non-USA) organisations; or assigned to individuals. This was done since the economic data used related only to the R&D expenditures and manpower of USA industry and/or Government.

An important feature of the comparisons made was the use of patent data distributed on the basis of the dates on which the patent applications were filed, rather than on the dates on which the patents were granted (i.e., published). The application date distribution more accurately approximates the period when the patented technology was developed.

In making the economic/patent data comparisons, the economic data was lagged by two years. The rationale for this was that R&D funds spent

in a given year, or R&D manpower used in a given year, is not likely to result in a patent application within the same year, given development time, time needed for patent application preparation, etc.

The time lag chosen - two years - was an estimate of the time taken to develop a patentable invention and to file an application for a patent for that invention. A year was allowed for R&D efforts to develop the invention and to draw up the patent application. Also, since an applicant has up to a year to file for an application, a second year was added to the lag time.

The results of the review indicated that over the time period (1965 to 1973), in each industry covered, there had been a decrease in the number of patents obtained per $1M. of R&D invested and an increase in the professional man-years required for each patent obtained. In other words, more resources (money and man-power) are going in and fewer patents are coming out.

In trying to offer explanations for this observation the report poses three questions:-

(1) Has the great increase in technological complexity brought about a corresponding increase in the amount of effort, i.e., resources, required to "invent" something patentably different?
(2) Has the character of patents changed over time? Are they now generally more comprehensive, including bigger "chunks" of increasingly complex technology?
(3) Is USA industry becoming less patent-minded? If so, why and what implications (technological and commercial) does this have in view of the dramatic increase in foreign patenting in the USA?

The report did not try to answer these self-imposed questions, but offered them as stimulants to workers in economics and related fields. It is understood that OTAF had not done any further work in this area by the end of 1981[118].

The Semiconductor Group of the Japanese Patent Office have used patent and assignment data for technology trend analysis in the field of semiconductors[119]. The philosophy behind their approach was that assignment data can be used to measure the number of firms obtaining patents in a given technology; this information is an indicator of the

interest in the technology. Hence, a profile of corporate patent activity indicates the trend of interest in a technology.

When this trend is correlated with that of the patent activity, which is an indicator of technological activity, the "maturity" of a technology can be assessed. For example, a technology in which both patent activity and corporate activity are increasing shows increased technological activity and interest. Thus, the technology is probably in a development stage.

Conversely, a technology having decreased patent and corporate activity (decreasing technological activity and interest) can be said to be in a fully mature or declining stage. The possible correlations between patent activity and company activity, and the appraisal of these correlations is given in Figure 4 and Table 4.

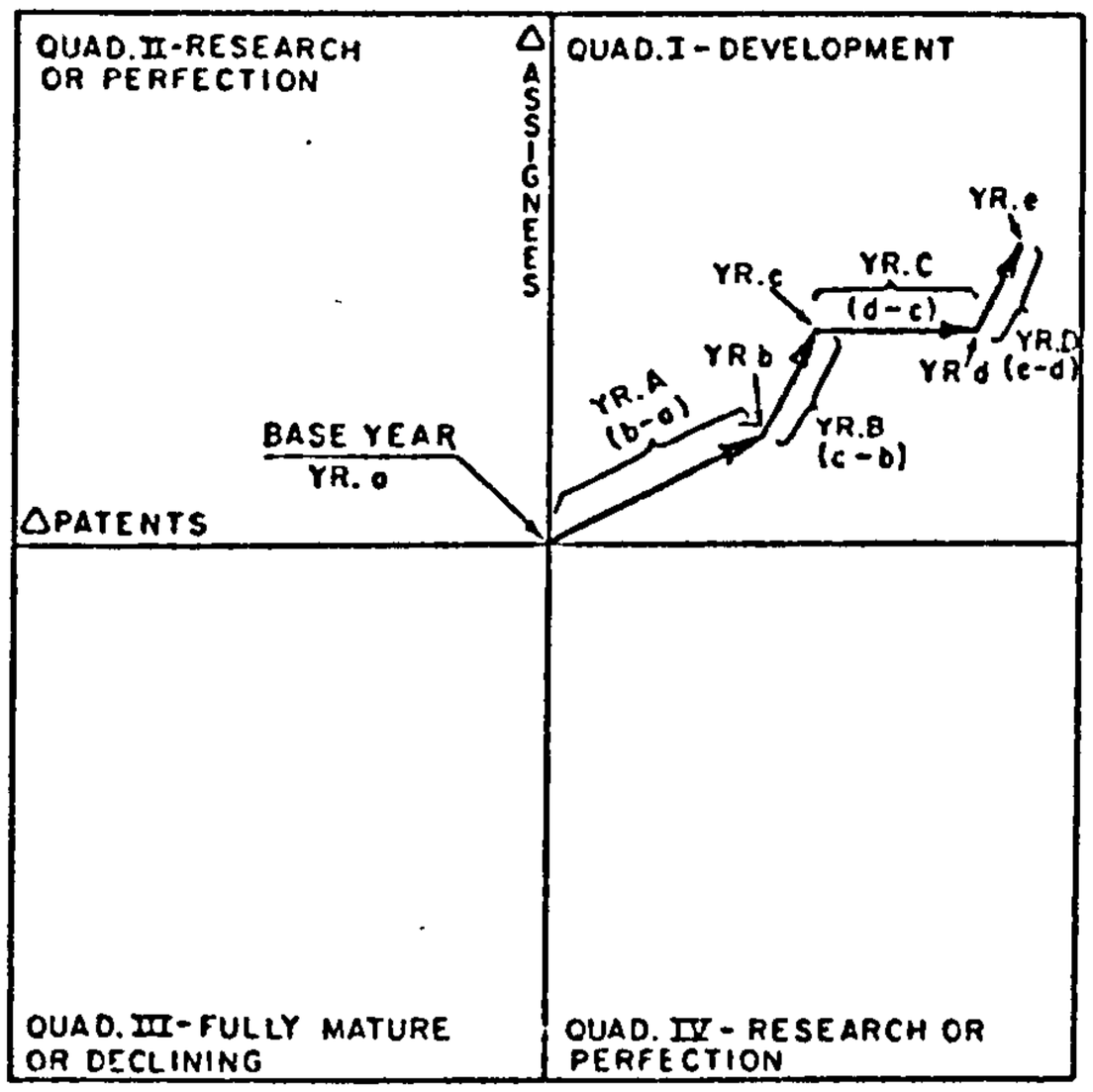


Figure 4: Vector Analysis of Patenting Activity

Figure 4 illustrates, for a hypothetical technology, a graphical mode of depicting with vectors the trend of activity in that technology. Each year of technological activity is represented by a vector having scalar values which represent the change in the number of patented applications (X-axis) and the change in the number of different assignees (Y-axis) for that year from the previous year. The base of the vector for the first year of the analysis period is situated at the origin of the graph, which represents the initial year, while the terminating point of the vector is located at the patent and assigness data points for the following year. When the vectors pertaining to a particular

technology are placed end-to-end, as in Figure 4, the result is a dynamic vectoral pattern of the rate of change of that technology over the time period of interest.

The quadrant of the graph towards which a particular vector is directed is indicative of the status of the technology as of the end of the year represented by that vector. Table 4 presents the technological trends and the concomitant appraisals indicated by each quadrant.

Quadrant of Graph	Patent Activity	Company Activity	Appraisal
I	Increasing	Increasing	Development stage
II	Deceasing/ Stable	Increasing/ Stable	Research or perfection stage
III	Decreasing/ Stable	Decreasing	Fully mature or declining stage
IV	Increasing	Decreasing/ Stable	Research or perfection stage (or a notable invention by a single firm)

Table 4: Trends indicated by Vector Graphics

To ascertain the trends indicated by the vector graphics, the relative magnitudes and directional changes of the vectors are compared to determine the degree to which a certain vector indicates a particular trend. Vectors with proportionately larger magnitudes provide a greater, and therefore more certain, indication of the direction of technological change than vectors of relatively small magnitude.

Equally pertinent is the relative direction of the vector. The amount of angular deviation by the vector from the bisecting line of a quadrant is indicative of the degree to which that vector denotes a particular trend. Thus, the closer a vector is to being parallel to a line bisecting a particular quadrant (i.e., being directed at n /4 degrees, n being an odd integer), the greater the accuracy of the trend appraisal derived from the quadrant towards which the vector is directed.

Such vector analysis can be extended by considering the probability of the vectors crossing and forming a closed pattern. Figure 5 depicts

another hypothetical technological trend vector diagram with the vector for the last period of interest, year D, intersecting with the first vector, which represents the first year of the trend analysed. This closing of vectors represents the return of a technology to a state of activity it had previously occupied.

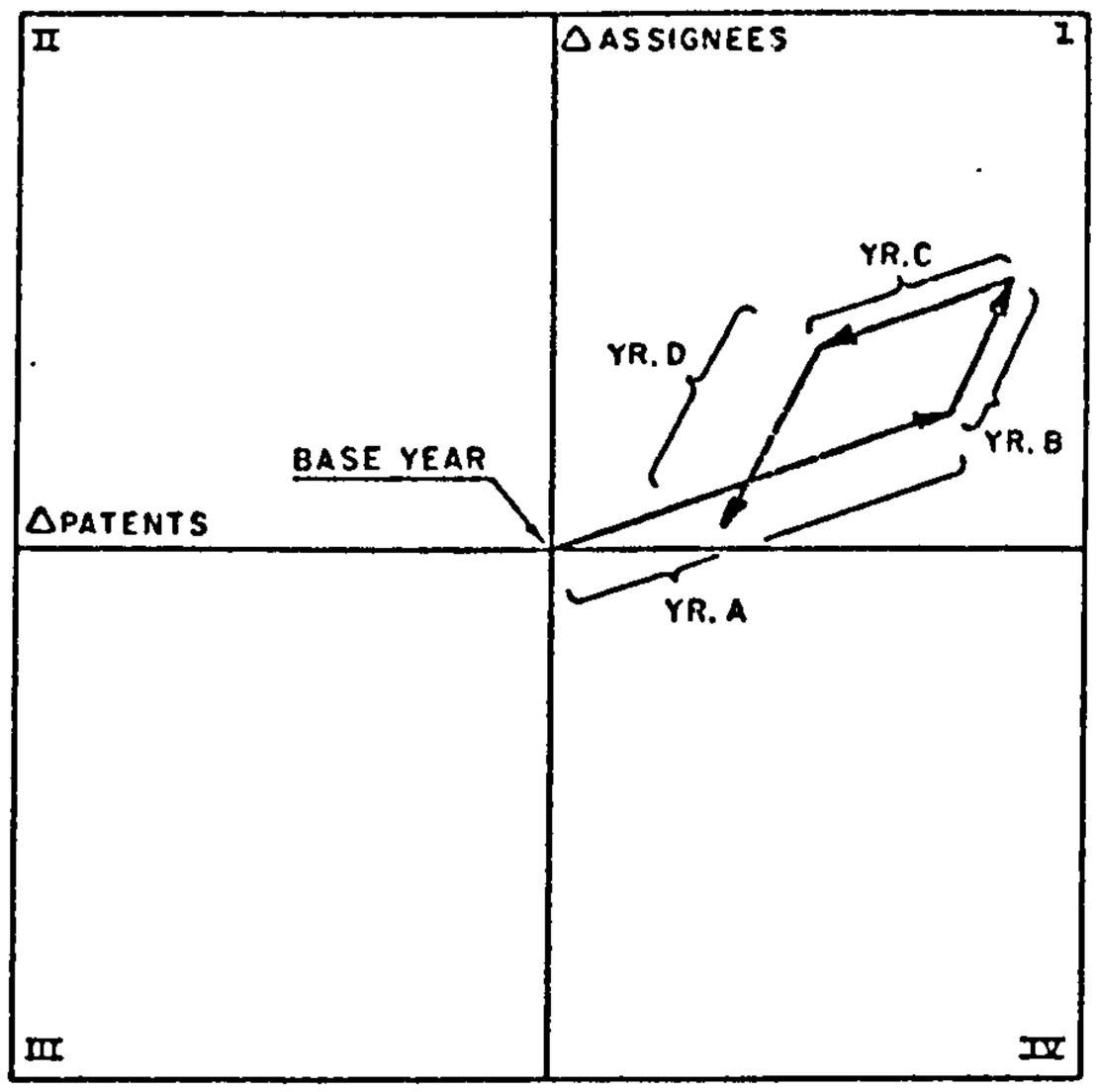


Figure 5: Closing Pattern of Vectors

Such a reversion to a prior state of activity indicates the strong tendency of that technology towards stability or towards maturity. Where a technology is not reverting towards a previous activity state, as indicated by a vector pattern having little or no probabilty of closing (e.g., as in Figure 4), a strong tendency towards either development or decline is suggested - development by vectors directed towards Quadrant I and decline by vectors directed towards Quadrant III.

Applying these techniques to semiconductor patents filed in Japan from 1965 to 1969, the authors concluded that semiconductor technology, as a whole, was approaching a stage of maturity. On the other hand, there was observed a trend towards research and development on integrated circuits and their production and increases in output of silicon devices in Japan.

A patent analysis on computer memory components using the same technique of vector analysis was published in the OTAF Seventh Report in March, 1977[94(7)]. The results obtained were compared with a forecast prepared by the MITRE Corporation in 1973 for the Canadian government, and which covered memory systems which were in existence or which were

predicted to be developed by 1985[120]. A comparison of the results obtained by both surveys is shown in Table 5.

	Phase	
Technology	Patent Analysis	Mitre Report
Magnetic Core	Mature and declining	Declining
Magneto optics	Stable research or perfection	Research and development
Semiconductor	Mature and declining	Development; with increased use forecast
Superconductor	Research and development	Laboratory curiosity; commercial production doubtful
Ferroelectric	Fully mature and slightly declining	Research and development; no significant use expected
Cathode Ray Tube	Declining	Research or perfection
Planar film	Mature and declining	Declining
Plated wire	Mature and declining	Declining
Magnetic bubble	Research and development	Research and development
Domain tip propagation	(No assessment due to lack of adequate statistics)	Research and development
Charge coupled devices	Research and development	Research and development
Holographic	Declining	Research and development; many difficult problems to solve, limited probability will be in use in 1985

Table 5: Comparison of Assessment Results for Computer Memory Technology obtained by OTAF Vector Patent Analysis and MITRE Report

Marmor[121], in describing the work of OTAF, has commented that patent document collections, chronologically arranged and technically categorised, represent unique records of technological change. Continuously generated and catalogued, patent literature can be drawn upon as valuable input to technology assessment processes, both from a current

and an historical perspective. Marmor observes that comprehensive patent information packages can be developed and tailored to benefit corporate strategists, policy analysts, educators, entrepreneurs, future innovators and the like.

Mlodzik[91], has used Section B (Farmdoc) of Derwent's Central Patents Index file as available online to assemble, analyse and make available meaningful information about the research and development activities and expenditures of companies active in the field of non-steroid anti-rheumatic drugs. She states that the publicly available data can furnish information of particular value to marketing managers and research strategists - information which is not normally extracted from patent literature. As an important feature of her studies an attempt was made to determine if the patent data might suggest changes in corporate interests and perhaps reveal proprietary-like information.

Patent data was supplemented by market share information derived from marketing journals for the period 1972 to 1978. From this data trends in the patenting activities of several companies, both in terms of the number of CPI-defined basics and equivalents (see Chapter 10 below), were obtained. The results showed different patterns of activity by the companies investigated. However, the differences in numbers of patents by the companies could not be interpreted as indicators of whether they were a reflection of the patent policies of the companies or of R&D effort.

Mlodzik points out that the important inventions are usually patented in several countries. It would be possible, therefore, by listing the chemical structures from these patents in a table, to review the new structures in the technology concerned. Among these structures one would find the new drugs of the future. Of course, as Mlodzik states, the ones of priority must be non-toxic and without side-effects, they must be stable, etc.; but one would probably find a few of them on the market in approximately ten years.

Using the IFI Data Base of US Patents - 1950 through 1976, maintained on magnetic tape by IFI/Plenum Data Company of Arlington, Va., Allcock and Lotz[82,83], using conventional computer processing techniques, extracted data on the number of US patents issued in 1976 by various USPTO classifications.

The first observation that these workers were able to make from their results was that a relatively small number of corporations own a major proportion of all assigned patents. For their further studies they selected 125 companies each of which received 65 or more patents in 1976. These 125 companies owned 24,210 patents; this amounted to 42% of all the assigned patents and averaged 194 patents per company. Of the 125 companies, 90 (72%) were USA based whilst the remaining 35 (28%) were non-USA based.

For five of the corporations, Allcock and Lotz compared the annual research budgets for 1972 with the number of patents obtained in 1976. They chose 1972 research budgets on the assumption that US patents issue about 4 years after the research work was carried out (cf. the OTAF studies referred to earlier in which a two year lag period from application date was used). They also assumed that one-half of an organisation's research budget was spent on projects unlikely to generate patentable inventions. A review of their results indicates that the costs of obtaining patents are extremely high. However, from the wide spread of the average costs per patent calculated ($120,000 for Xerox Corporation to $475,000 for Westinghouse Corporation) no simple conclusions could be made.

As a feature of their studies, Allcock and Lotz tried to determine if publicly available data, i.e., patent information, might suggest changes in corporate interests and reveal proprietary-like information. For this they adopted two approaches. In the first they compared USPTO classifications for patents issued in 1976 with those issued in 1975 for each of the 125 companies. In this way they were able to identify potentially new technology. They point out that whilst the issuance of one or two patents in a new class may not represent a change of substance, a new class producing multiple patents may well signal a significant change in research activity. As an example of their findings 21 patents issued in USPTO Class 418 (Rotary Expansible Chamber Devices) for the Caterpillar Tractor Company in 1976, whereas this company had no patents assigned to Class 418 in 1975. The authors point out that changes in patent activity such as this should be of considerable help in evaluating future trends for the companies concerned.

For their second approach, Allcock and Lotz compared the average number of patents issued in the previous five years in a company's major areas of interest with those issued in 1976. Ciba-Geigy, with 508 patents in

1976, was chosen for this analysis. The USPTO Classes in which this company was most active were: 8, 71, 260, 424 and 428. By comparing the changes in the percentage of total issues in these classes, it was apparent that the greatest change occured in Class 428; the percentage of patents issued in this class increased by over 300% over the previous five years. In looking at the Ciba-Geigy patents in Class 428 the investigators found that all related to textile treating and finishing; this indicated an apparently new emphasis that competitors might wish to follow.

Allcock and Lotz also looked into the possibility of predicting corporate mergers from patent information. They state that it should be possible to review a company's patent profile and compare this with other companies' profiles to locate candidates for possible acquisition. Again using Ciba-Geigy as a model (the two Swiss firms of Ciba AG and Geigy AG merged in 1970), they studied the patents assigned, by USPTO class, in the ten year period from 1967 to 1976 for the original independent companies and for the merged corporation. A calculation of the total patent issues for each company showed that 94% of all Ciba's patents were in classes common to those of Geigy's patents and 98% of Geigy's patents were in classes common to Ciba's patents. They conclude that the patent histories of these two companies suggests the merger which came about.

Windsor has used bibliometric analyses of patent and non-patent literature to predict the clinical fates of developing drugs[84,85]. For his studies he recorded in chronological sequence of publication date all patents and journal articles (the former information being derived from Section B of Derwent's CPI service) relating to Minoxidil, an antihypertensive vasodilator drug marketed by Upjohn Company. Windsor then expressed this sequence of publications as a binary vector assigning "1" for a patent and "0" for a non-patent article. The decimal equivalents for standardised vector lengths were claimed to provide scalar values for comparing one drug with another.

In order to incorporate equivalent patents into his calculations, Windsor used fuzzy subsets, with the number of attempts required to achieve transitive closure being the values for comparison. Windsor concludes that bibliometric studies of this nature can be used to predict the clinical fates of drugs, although he does state that the evidence he presents does not conclusively show this.

In commenting on Windsor's work Osinga[122] points out that a statistical relationship between two sets of figures does not prove anything about the causal relation between the facts behind the sets of figures: one might cause the other, or the reverse may be true, or both may be caused by a third one. Osinga stresses that the fate of a drug may either be determined by the bibliometric traits, or the bibliometric traits are determined by the clinical fate of the drug, or both are determined by some other factor. It is not possible to distinguish between the three possibilities on a statistical basis. In Osinga's opinion the bibliometric traits do not determine the fate of a drug, but that the reverse is true. In such a case the bibliometric traits will be apparent in the literature only after some time, and prediction on this basis is not possible.

8: BIBLIOMETRICS AND PATENTS

Bibliometrics has been defined by Pritchard[123] as "the application of mathematics and statistical methods to books and other media of communication", and paraphrased by Fairthorne[124] as "quantitative treatment of the properties of recorded discourse and behaviour appertaining to it".

Information science literature abounds with bibiometric studies conducted on the characteristics of journal literature in certain disciplines and subjects; much of this work has been reviewed by Narin and Moll[125]. A great number of these studies have employed Bradford's Law and the Bradford-Zipf Distribution to estimate efficiency values and completeness of journal collections. Some such studies have been concerned with primary journals and others with secondary, or abstracting and indexing, publications in both humanities and hard science subjects.

Bibliographies of bibliometrics have been compiled by Pritchard[126], Hjerppe[127] and Vlachy[128]; a recent issue of Library Trends[129] was entirely devoted to papers on bibliometrics, several of the contributions being reviews.

Although Clark[130] in 1976 advocated that patents deserve bibliometric study both for their own sake, and because their formality could be exploited, no reports on the application of bibliometrics relating to collections of patents data on specific technologies have been found in the literature. Clark studied the obsolescence of patent literature as indicated by the age distribution of patent-to-patent and periodicals-to-patent citations.

Bibliometric Laws and Distributions

Two basic laws of bibliometrics have been developed: Bradford's Law and Lotka's Law. Bradford's Law is based on the distribution of publications (usually journals) in a particular discipline or articles in a set of journals. Lotka's Law is based on the number of authors publishing in a discipline or other defined field.

Lotka's Law

Productivity in terms of scientific publication was described by Lotka in 1926[131]. Lotka's Law of Scientific Productivity is an inverse square law claiming that the number of authors of n papers in a population is about $1/n^2$ of the number of authors of one paper, or:

$$p(n)=K/n^2$$

where p is the number of authors producing n papers, and where K is a constant characteristic of a particular subject area.

The factor for predicting the number of papers in a field like chemistry was found to conform to $1/n^2$ of the number of authors writing only one paper. That is, if 100 authors wrote only one paper, only 25 would write two papers and only 11 would write three papers, etc.

Table 6 on the next page summarises a number of studies which have been carried out to verify Lotka's Law; the table does not list all such studies - only a selection.

Bradford's and Zipf's Laws

Zipf, a linguist, was interested in the frequencies with which different words are used[143]. He demonstrated that, if the words appearing in any reasonably long piece of text are counted and ranked in order of frequency of occurence, this frequency is proportional to the rank order. For example, a word ranked tenth in terms of frequency of usage is employed one tenth as often as the word ranked first.

Zipf analysed the number of different words and the frequency with which each occured in different texts and plotted these on logarithmic paper. Figure 6, taken from Zipf's book, shows such a graph for the vocabularies in James Joyce's Ulysses and a combined sample of American newspapers; these had 29,899 and 6,002 different words out of totals of 260,430 and 43,989 words respectively.

According to Zipf this sort of rank-frequency relationship is obeyed by a wide range of social phenomena. He argues that it is a result of a natural tendency to use more frequently those intellectual tools with which one is best acquainted and which are more flexible. The rank-

Author	Reference Number	Data	Authors' comments
Lotka	131	Chemical Abstracts	Exponent = 1.888
Lotka	131	Auerbach's Tables	Exponent = 2
Stoddart	132	Royal Geographic Soc. Index	Exponent is close to unity
Schorr	133	Map Librarianship	"Fits Lotka"
Schorr	134	Legal Medicine	"Does not fit Lotka"
Schorr	135	Library sciences journals	Postulates exponent = 4
Voos	136	Information science journals	Postulates exponent = 3.5
Murphy	137	History and technology journal	"Fits Lotka"
Frost	138	Geo Abstracts authors	Exponents ranging from 1.23 to 2.35
Rogge	139	Anthropology literature	"Fits Lotka"
Radhak-rishnan & Kernizan	140	Computer science authors	Postulates exponent = 3
Potter	141	University of Illinois library catalogue	Postulates exponent = 2.09
McCallum & Godwin	142	Library of Congress MARC tapes	Postulates exponent = 2.343

Table 6: Some Studies of Lotka's Law

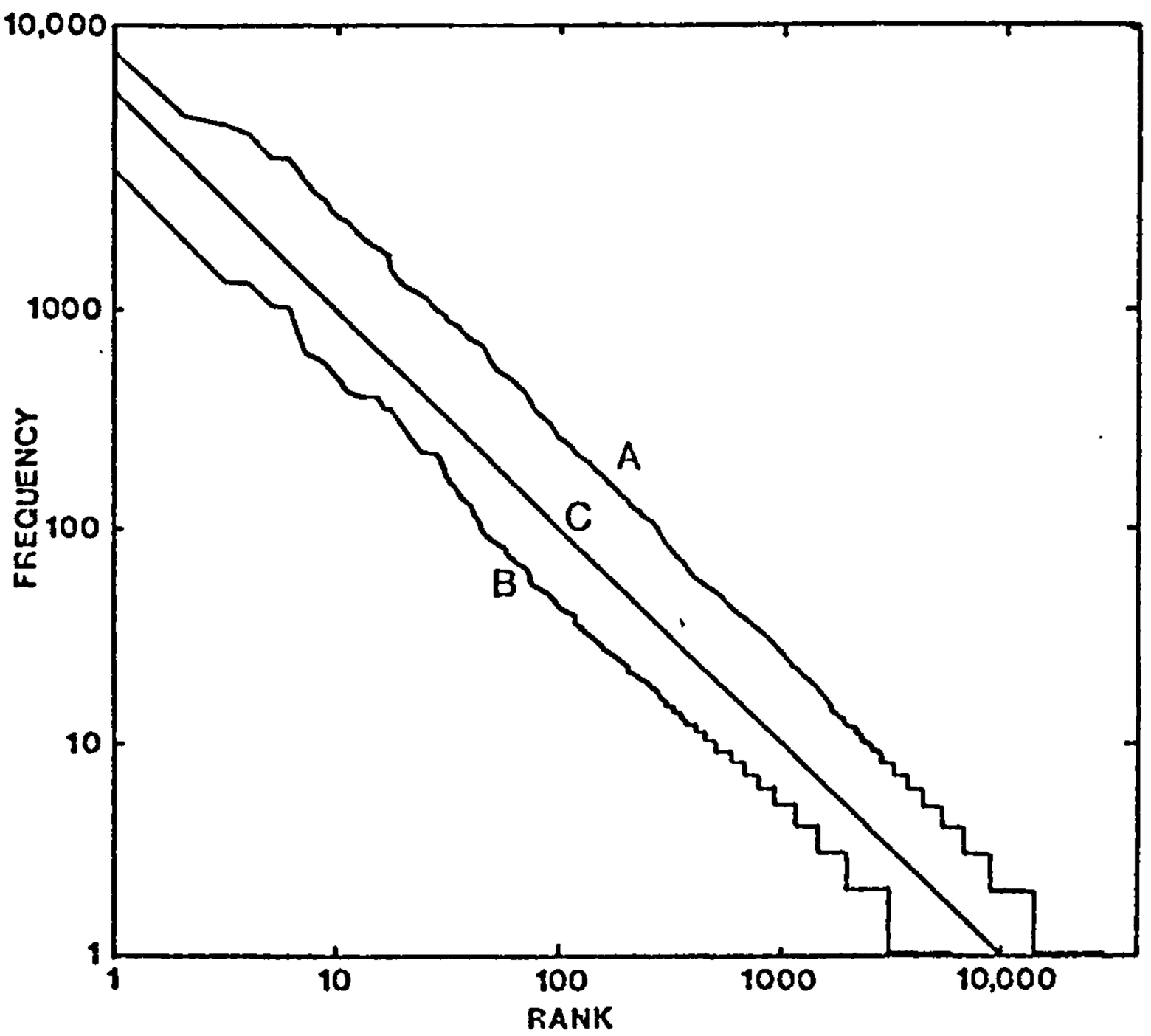


Figure 6: Rank-frequency distribution of words:
(A) James Joyce's "Ulysses"; (B) American newspapers;
(C) Ideal plot with slope of -1

order relationship therefore reflects the operation of some "principle of least effort"; in fact Zipf never demonstrated that this principle leads mathematically to his law.

Zipf's Law may be expressed thus: if words are ranked according to their frequency of occurence (f), the nth ranking word will appear approximately k/n times, where k is a constant, or:

$$f(n)=k/n$$

Bradford first published his observations of the increasing scatter of relevant journal articles on a given topic (the topic chosen was engineering) in 1934[144] and later in 1948 summarised these observations[145] by relating the number of journals in the nuclear, or most productive, zone to the numbers of journals in sucessively less productive zones containing equal numbers of papers. He stated that if a core of n journals contains A articles relevant to a discipline, and if kn journals (k>1) are required for a second zone with an additional A articles, then k^2n journals are required for the third zone with A articles, and, finally, $k^{m-1}n$ journals for the mth zone with A articles. Vickery[146] pointed out that in his graphical formulation of the data, Bradford placed the cumulative numbers of journals in the ratio $1:k:k^2.....$, rather than the zonal numbers in that ratio as his verbal formulation indicated.

The theory and application of Bradford's Law have been extensively studied by Brookes[147-151], Leimkuhler[152,153] and Aiyepeku[154]. Wilkinson[155] has analysed the disparities Vickery pointed out and has concluded that, of the two Bradford Law formulations, the graphical one is in closer accord with existing data. Drott[156] has reviewed the theory and empiricism of Bradford's Law whilst Wyllys[157] has published a similar review of Zipf's Law.

Relationships between the Laws of Bibliometrics

The Bradford distribution and the Zipf distribution have frequently been linked, first by the statistician Kendall[158]. Indeed, Bradford's Law is often called the Bradford-Zipf Law. Kendall showed that the Bradford distribution falls into a general type called the Yule distribution by Simon[159].

Coile[160] briefly described the applications of Simon's Yule distribution to scientific productivity, thus linking Bradford-Zipf to Lotka as well.

Brookes has long worked with the Bradford distribution and interprets it strictly. Showing the close relationship between Bradford and Zipf, Brookes[147] implied that only his lack of complete data caused a deviation from a straight line and the resultant droop characteristic on the upper part of the S-curve observed in the graphical representation of Bradford (see Figures 15 to 18).

In a later paper, Brookes[149] explained the initial concave curve of the Bradford distribution as a representation of the higher density of the nuclear zone. He believed this higher density to be caused by the restrictive effect of competition for the limited space in the nuclear journals. Brookes affirmed that "whenever a droop has been observed, it has always been possible to indicate either some selectivity or some omissions".

O'Neill[161] disagreed with Brookes, contending that the extent of the characteristic droop is dependent on the sample size, with larger samples having a more prominent droop.

In a key paper, Fairthorne[124] described and interpreted a series of frequency distributions in terms of work published by Mandelbrot[162]. Some of the frequency distributions Fairthorne described are empirical, others are theoretical. While Fairthorne provided seven references to Mandelbrot's work, he never actually described the research. Although Fairthorne's paper is important for its collection and description of a wide variety of frequency distributions, it does not succeed in clarifying, for the average reader, the differences and the similarities between these distributions.

More recently, Bookstein[163] has attempted to clarify and resolve the relationships between the Bradford, Zipf and Lotka distributions.

Current mathematical research on bibliometric laws and frequency distributions has tried to define theoretical models of the mechanics responsible for the empirical laws and distributions. Naranan[164] has attempted to arrive at a theoretical justification for the basic laws by deriving a power law relationship between the number of journals and

their articles on a particular subject. Naranan claims that a power law relationship also extends to the relationship between citations and articles and to the relationship between citations and journals.

Price[165] has attempted to show that all of these bibliometric distributions are related to the concept of "cumulative advantage" processes in which success breeds success but failure is not penalised. Both Naranan's and Price's hypotheses seem logical.

The relationship between Bradford's and Zipf's Laws can be seen if the latter is slightly rephrased. Instead of relating frequency of word usage to rank order, one asks the question: how many words (N) occur exactly f times in a text? The answer follows from Zipf's Law: $N = 1/f^2$. But Bradford's Law can also be written in a power law form: the number of journals J containing exactly p articles on a specified subject is given by $J = 1/p^2$. Lotka's Law states that the number of scientists who produce x papers is proportional to $1/x^2$. This Law, too, can be assimilated to Zipf's Law, if one generalises the latter, and supposes that there is a general bibliometric distribution following an inverse power law (i.e., proportional to $1/x^n$). The value being attached to n will depend on the bibliographical property being measured. The three laws all have n=2, in the form in which they have been defined. However, these are postulated average values; empirically determined values may differ appreciably. Power law distributions of this type all have the same general implication, which is that a small proportion of the items under consideration, e.g., journals, scientists, are responsible for a large proportion of the desired products, e.g., research papers, and vice versa most of the items considered make little contribution to the total products.

The Bradford-Zipf Law is now well established in the field of bibliometrics. It has been tested on a large number of bibliographies in many disciplines and has been shown to usually apply to the observed data. However, hitherto it has only been tested on journal literature or on samples containing primarily journal literature; it has not been tested against data sets containing only patent literature.

Scientific Productivity and Frequency Distributions

Whilst Lotka's Law has been widely used in investigations of scientific productivity in several disciplines, in recent years other researchers

have attempted to find other frequency distributions which fit the collections of empirical data gathered from the journal literature.

For example Shockley[166] suggested a lognormal distribution; Williams[167] examined a geometric distribution and Fisher[168] a logarithmic series distribution in a study of the publication pattern of biologists. Hersh[169] has used a power series to describe scientific productivity. Price[165] has proposed a cumulative advantage distribution related to a Beta function derived by Yule[170] and which was described by Simon[159].

Coile[171] has shown how various frequency distributions may be derived from Pareto's Law and, furthermore, shown how they are interrelated. Coile tested seven theoretical distributions against twenty-six collections of data on author productivity.

Rao[172] has tested eleven theoretical frequency distributions against five sets of scientific publishing data. The frequency distributions tested, as well as those used by Coile are shown in Table 7.

Coile found that the Singh-Maddala and, especially, the Weibull theoretical distributions most closely fitted the observed data where using the Kolmogorov-Smirnov Test[173] for "goodness of fit". Whilst these two distributions had not previously been used in studies of scientific productivity, the principal reason for the ability of these functions to obtain a better fit than the other functions tested is that they contain, unlike the other distributions, three parameters. This is to be expected since the greater the number of variables taken into consideration, the greater the likelihood that the mathematical model will fit the observed data; thus the three parameter frequency distributions should, by definition, provide a better fit than those which consider only two parameters.

The Weibull distribution has been used in research on reliability[174], whilst the Singh-Maddala function was developed as an econometric model to describe the distribution of incomes in the USA[175]. Coile[171] was not able to distinguish any particular values of the three parameters which might be associated with a discipline.

Amongst the two-parameter distributions studied by Coile, the Simon-Yule function gave the best fit to observed data when tested by the Komogorov-Smirnov Test.

Theoretical Frequency Distribution	Coile	Rao
Lotka	Yes	No
Simon-Yule	Yes	No
Price's Pareto-type	Yes	No
Williams' Geometric	Yes	Yes
Fisher's Logarithmic	Yes	Yes
Shockley's Lognormal	Yes	Yes
Poisson	Yes	Yes
Sirgh-Maddala	Yes	No
Weibull	Yes	No
Borel-Tanner	No	Yes
Negative Binomial	No	Yes
Cumulative	No	Yes
Truncated Negative Binomial	No	Yes
Truncated Poisson	No	Yes
Zeta	No	Yes
Sinh Transformation	No	Yes

Table 7: Studies using Frequency Distributions by Coile[171] and Rao[172]

Rao[172] found that the Negative Binomial distribution fitted all his data sets when tested by the χ^2 "goodness-of-fit" test and has shown that the Negative Binomial distribution describes a pattern of scientific productivity under the "success-breeds-success" phenomenon described by Price[165]. Rao found that the Borel-Tanner distribution[176], derived as a model of queuing situations, was the only other function which fitted all five data sets; however the χ^2 values obtained for Borel-Tanner were not as low as those for the Negative Binomial.

Whilst previous studies have shown that on the one hand frequency distributions may be applicable in bibliometric studies, they have indicated on the other hand that Lotka'a Law is not proven and that other distributions may provide better models for the observed data. The application of such distributions in bibliometrics have hitherto included studies of doubtful validity, and there is thus a need for further work in this area.

None of the investigations of frequency distributions and scientific productivity identified in the literature of bibliometrics has been concerned with patents. It was thus considered appropriate to test sets of patents data in different technologies with various functions.

9: CITATION ANALYSIS AND PATENTS

An essential part of research appears, particularly in the sciences, in the list of references pointing to prior publications. As Ziman observes, "a scientific paper does not stand alone; it is embedded in the 'literature' of the subject"[177]. A reference is the acknowledgement that one document gives to another; a citation is the acknowledgement that one document receives from another[178]. In general, a citation implies a relationship between a part or the whole of the cited document and a part or a whole of the citing document[179]. Citation analysis is that area of bibliometrics which deals with the study of these relationships.

Although citation analysis techniques have not been used in this study, the techniques are becoming more popular and significant interest in their application to patents is growing. It is, therefore, thought appropriate to make mention of them here. The fundamental principles of citation analysis have been given by Narin[178], whilst Smith[180] has focussed on the development of citation analysis as a bibliometric research method, uses and abuses of the method and prospects for the future - although in her paper, she has not commented upon its application to patents.

Traditionally, scientific papers contain references to the earlier literature. The reason such references are referred to are varied[181]; since they are dependant on an author's personal choice, they often contain errors and omissions[182]. Over the years, a large body of work on citation studies has appeared in the information science literature (see, for example, the bibliography on bibliometrics by Hjerppe[127]). Such studies have involved the analysis of citations made in scientific papers from a number of viewpoints. The number of such studies increased considerably following the start of publication of Science Citation Index (SCI) by the Institute for Scientific Information, in 1963, and its subsequent computerisation. This service made the carrying out of citation studies far easier than previously[183].

In the scientific literature, citation analysis adds many dimensions to elementary paper counting. Counting scientific papers is an objective measure of research activity; it does not provide much information about impact of the work[184]. Citation frequency measures add a quality dimension to a publication count. Citation frequency is relatively

highly correlated with almost all peer based indicators of quality or impact in science and, in fact, Jones has found that as an indicator of scientific quality, counting citations is a more effective and better indicator than counting papers[185].

Citations provide many other capabilities to science indicator data also. For example, they provide linkage measures, demonstrating in a quantitative way how different research institutions and countries depend upon each other. Using citation network techniques one can show whether a country's applied research heavily cites its own basic research or other countries' basic research, one can look at linkages between basic and applied research, and also look at information flow among universities, industries and governmental laboratories[186].

The nature of the citation distributions also have added valuable insight into perceptions of productivity and efficacy in the scientific process. Lotka[131] and Shockley[166] showed that scientific productivity is highly concentrated, with typically 50% of the research papers being produced by 20% of the researchers. When citations are added to this analysis, these distributions become even more highly non-linear and skewed. For example, in a very detailed study of one laboratory by Narin[186], he found that 4% of the professional staff produced half of the papers, and that an even smaller 3% of these researchers received half of the citations. Thus, Narin concludes, bibliometrics adds a quantitative dimension to the general observation that productivity is highly concentrated in a relatively small number of key people.

One of the most interesting types of studies to be carried out using citation data is the study of citation networks. A citation network is built up by obtaining one or more relevant articles and noting and reading the references cited in these articles. Science Citation Index (or the equivalent publications covering the Social Sciences, or the Humanities) is then used to take a step forward in time by noting later items which cite earlier articles. A network is contructed after several such iterations, connections being shown by lines connecting published items. Having created such a citation network, key events are identified, together with their chronology, their interrelationships and their relative importance. It is thereby possible to observe historical and sociological processes at work and it is easy to identify the work that has had the greatest impact on the subject. This technique is sometimes called the historiograph approach, and has

received some attention in the information science literature. It is generally agreed that although a chronological listing of articles can give some clues to the development of a subject, such historical citation networks or maps produce better results[188,189]. The maps are difficult to keep clear and aesthetically pleasing, and some work has gone into algorithmic techniques for creating such displays[190-192].

A large number of citation networks have been created, predominately by Cawkell[193-196], by Garfield[187-188,190-192,197] or by the two working together[198]. Bernal[199], who was the first person to use this technique, used a small map in 1953 to trace the antecedants and consequences of Pasteur's discovery of molecular asymmetry. The subjects covered by such historiographs vary widely, but mostly have been confined to science and technology.

The validity of historiograph technique in the creation of an accurate historical description of a scientific field can be tested by constructing and then comparing two networks on the same subject. One network is prepared from a standard historical account and the other using citation relationships[190]. May[200] argued that a historiograph will not give a faithful map of the history of a subject, so clearly the technique does need to be tested out in this way. Such a test has been carried out by Garfield and his co-workers[201] who compared citation data on DNA and the genetic code with a historiograph prepared from a book by Asimov. They found close parallels between the two maps; however, Oppenheim[202] has pointed out that the two DNA historiographs were not created independantly. The papers representing the key events in the historical account by Asimov were identified, and these were the papers used to initiate the citation network. The results must therefore be regarded as inconclusive.

Until recently, very little work has been carried out using these techniques on patents, although a number of authors have hinted it might be a useful application. Cawkell[195] has suggested that patent citations could be used to trace scientific developments as has been achieved with journal articles. Garfield[203] considered United States patent references to be a valuable and relevant source of further information on a subject. Patent citations have been mentioned as a means of surveying technological innovations for forecasting future developments as well as perceiving links between inventions203. This lack of study of patent citations can be attributed to three main factors.

Firstly, in sharp contrast to journals, relatively few countries' national patent specifications publish citations. Secondly, there is no convenient source of patent citation data analagous to ISI's journal citation data. (At one time, Science Citation Index included US patents as source documents[204] but this practice was dropped many years ago). Thirdly, citations in patent specifications do not serve the same purpose as citations in journal articles. Patent citations are made by the examiner to warn the applicant of related work which affects the novelty of his invention. Depending on the examiner, such citations can be very relevant or of peripheral interest only[204]. Patent citations are not made for the various reasons[181,205,206] that journal citations are made.

Although the lack of a suitable data base has held back the field of patent citation analysis, the idea of studying the information in patent citations is not new, and was first published by Seidel in 1949[207] in respect of the US Patent Office.

In an editorial, Seidel proposed that "the Patent Office adopt a system of citations to colligate issued patents with later patents". Subsequently, Hart endorsed the proposal mentioning that "such a system ... would furnish a network of paths to dissipate the inevitably artificial boundaries of classification"[208].

A systematic attempt at bibligraphic tracing of patents was described by Reisner[209]. She reported an experiment abstracting references from 3,250 patents of interest to IBM attorneys. Tracing through the data base citation network, she recovered 43 of the 60 patents submitted for testing. In 1972, Gerson[210] reported on a computer-aided classification and retrieval system for United States patents, based on a clustering of patents by similarities in citations received. This is one of the earliest papers to discuss patent citations from an analytic point of view. A 1974 study of the Franklin Pierce Law Center[211] examined the uses of patents as technology/science indicators. Linkages between important "basic" patents and the scientific literature were shown. Their study was based on a relatively small sample of patents.

As indicated earlier one of the most important of the citation analysis techniques is the historiograph approach developed by Garfield[187,190, 193,197]. In this approach, a graphic display of citation data that shows key scientific events in chronological order is prepared by

linking one paper to another that it cites with a straight line. Papers that have been highly cited by other papers and therefore presumably of importance, can easily be identified by this graphic technique. In addition to the DNA study referred to above[190]. The historiograph method has been more recently applied to the history of amorphous semiconductors[194], and of bridge design[195]. These are technologial subjects, but journal articles only were considered.

Ellis, Hepburn and Oppenheim[212] have used the historiograph approach with patents as a means of mapping technological history and identifying major developments. These authors chose five subject areas for their study: electrophotography, semi-synthetic penicillins, tobacco substitutes, Ziegler-Natta catalysis and hovercrafts; US patents relating to these technologies were used.

They found that in many cases the citation networks revealed key patents and the important clusters. Sometimes, due to either the diffuseness of the origins of a field, or apparent misreferencing, or technologies with a short patent history, the key clusters were not identified.

Ellis et al. conclude that the technique of mapping historiographs of patent citation data could, if successful, have considerable potential in two main areas:

1. They could identify key developments in the history of technological progress. Historians of science have a ready made tool in journal citation patterns for identifying key events in the development of a scientific theory, but no analogous tool for technology has been developed to date.

2. If co-citation studies in the networks prove successful, such studies could be used to identify smaller subject areas of current interest within the main subject field. This could be valuable for future analysts and organisations involved in high-risk investments for identifying topics of high current importance.

Oppenheim[202] has reported the results of some studies designed to evaluate patent citation networks as a method of identifying key turning points in the development of a technological subject. Nine subject areas were chosen - cardiac pacemakers, quadraphonic systems,

fibre optics devices, ring pull cans, underwater holography, alkene and alkyne disproportionation, hovercraft, magnetic bubble memories and prostaglandins. Oppenheim found that although frequently the technique identified the key starting patent neatly and precisely, there were several instances of failure. These can usually be attributed to one of several factors - the subject has no clear starting patent, or for some reason the patent history is confused, or because of bad cases of mis-citation by the U.S. patent examiners. Because of these difficulties, it is concluded that results from a patent citation network are not sufficiently reliable to be used alone for identifying key events in the development of a technology.

Oppenheim also described the development of a program for inputting citation data (for both patents and journal articles) and for plotting them out.

Nun and Oppenheim[213] described work on a citation network starting from ten U.S. patents and comprising 1204 journal articles and 43 patents in the field of prostaglandins. A journal citation network was created independently from 85 recent articles on the subject. It was found that the two networks were virtually identical except that the former included patents and was therefore more complete. It was found that the most highly cited references were those widely regarded as being key turning points in the development of the subject.

Their results demonstrated that in a subject field which incorporates patentable subject matter, a patent/journal citation network is fuller and more reliable than a patent citation network or a journal citation network on their own.

Results obtained from the creation of a patent citation network on X-ray tomography have been described by Dunlop and Oppenheim[214]. Previously such networks had been created by noting the patents and journal articles cited in a given starting patent. In their work, Science Citation Index was used to 'recycle' the network by identifying further journal articles. This recycling technique added some new references to the network, but did not fundamentally alter the characteristics of the network. It was concluded that whilst a reliable patent citation network can be created by the simple techniques previously used, use of Science Citation Index makes a more complete network.

A critical piece of information related to the use of patent citations was generated in a recent study by Carpenter, Narin and Woolf[218], in which they tried directly to determine whether more citations were received by patents associated with important technological advances than by a set of randomly selected patents. That is, in essence a direct test of the hypothesis that technological importance would be associated with high citation rate.

In their study the patents selected as important were patents associated with inventions which had received an Industrial Research and Development "IR-100" award. The IR 100 awards are given by the journal Industrial Research and Development and "honour the 100 most significant new technical products - and innovators responsible for them - developed during the year". Patents related to the 1969 and 1970 awards were used for their product set patents, in order to ensure that there was sufficient time for the patents to be cited fully by subsequent patents. The set of patents serving as controls were chosen so that the number of control patents issued in each year was the same as the number of product patents. This equalised the time distributions for the control and product patents. Within each cited year the control patents were chosen randomly. The number of citations to these product and control patents by examiners of subsequently issued patents was then determined. Table 8 shows these citation distributions. It is noted that the product set patents were more than twice as frequently cited (significance level of 0.0001) as the randomly selected set of 102 control patents. This finding provides strong evidence supporting the hypothesis that patent citation data can be used in technological indicators development and in technological policy analysis, since it clearly implies that the location and analysis of groups of highly cited patents can provide a valid indicator of patent areas of technical importance.

Using the references from US patents to scientific journal articles, Carpenter, Cooper and Narin[216] have demonstrated that these citations provide a mechanism whereby the major parameters of a linkage model explore the utilisation of basic research in technological advances.

The US patent files were selected as the appropriate vehicle for the analysis since the patent process met several critera. First, the patent files are external to science and thus cannot be said to be affected by the scientific community itself. Second, the patent files

Second, the patent files demonstrate active utilisation of science by current technology, and not archival usage. Third, the patent files can be searched without any a priori selection of scientific topical areas. Thus the patent files provide a documented source of information on technological uitilisation of basic research. In the US patent system the applicant references imbedded in the text and examiner references on the front page of the specifications provide parallel and complementary views of the pertinent linkages to the research literature.

N = Number of Citations	Number of Patents Receiving N Citations: Product set Patents	Control set Patents
0	11	31
1	12	23
2	12	17
3	15	12
4	12	6
5	3	5
6	7	3
7	5	1
8	4	
9	2	
10	4	3
11		1
12	4	
13	4	
14	1	
15	1	
16		
17	1	
18	1	
19	1	
Total Patents	100	102
Total Cites	494	208
Cites/Patent	4.94	2.04

Table 8: Citation Distribution for Product set and Control set of Patents from Carpenter, Narin and Woolf[215]

Carpenter, Cooper and Narin[216] investigated four aspects of the patent to science citation linkages: (1) the extent to which patent applicants and examiners utilised research findings as evidenced by their citation of the science literature; (2) the nature of the cited research activity: are the citations referring to basic research or applied work, to a wide or narrow swath of scientific investigation, or to old or recent papers; (3) the acknowledged source of financial support for the research cited by the applicant/examiner, and (4) the performers

of the cited research. Furthermore, these authors limited their work to two areas: gas lasers and prostaglandins. Nevertheless their results indicate an intimate relationship between current science and patents.

More recently, Narin[217] has reported on an extension of these studies using the same data sets of US patents plus data relating to chemical-analytical processes, electrical-field effect devices, electrical-light responsive semiconductors, mechanical semiconductor manufacturing and mechanical medicinal applicators.

The results of this second study demonstrate extensive utilisation of fundamental scientific literature by patent applicants and examiners. More than half of the journal references in the selected patents are to the more basic scientific journals, as opposed to the engineering and technological literature. It was also found that the time between publication of a journal article and the patent application citing that article was relatively short, typically two to five years. This citing age is typical of the amount of time that elapses between the publication of a scientific article and its citation by other scientific articles.

In addition the scientific articles cited by patent applicants and examiners lie quite clearly within the central core of the scientific literature.

Thus in many aspects the swath of the literature cited and the nature of the citing by patent applicants and examiners appears to be quite similar to the swath and nature of the article cited by scientists themselves when publishing in the open journal literature. This clearly indicates that the process of reduction to practice in the industrial community continues to require recent basic science, and that the support of such science is a necessary prerequisite for the continuing emergence of new technology.

Studies at the Battelle Pacific Northwest Laboratories on researches into technology indicators, using patents data derived from the US Patent Office OTAF database, have concentrated on relationships between numbers of patents and the age of the material they cite; these studies have been reported by Campbell[218] and Nieves and Campbell[219]. These workers studied the approximately 3000 citations (to science

literature and to patents) on some 800 US patents concerned with catalytic converters and obtained an indicator of technological progress which they term "immediacy".

US Patent Law requires that patents cite documents that have priority over them. "Immediacy" measures the age of the closest prior art in those documents, whether it is in technical and scientific papers or in patents. The Battelle studies conclude that if the closest prior art is very immediate, i.e., very recent, the implication is that the case in question is a rapidly growing technology. Conversely, if the patents cite only old material the area concerns minor variation on old technological themes.

10: DERWENT PUBLICATIONS LIMITED AND ITS PATENTS INFORMATION SERVICES

For many years, Derwent Publications Limited have been collecting, abstracting, coding, indexing and cross-referencing patent documents into a series of products which enable its clients to make maximum use of patents data.

Derwent was established in the early 1950s. At that time there was a delay of about half a year between the publication of details about British patent specifications in the Official Journal (Patents) and the issue of the Abridgments compiled by the examiners and published by the Patent Offfice. Accordingly, in the belief that there would be a demand for rapidly published abstracts of Bristish patent specifications, British Patents Report commenced publication in 1951. The company was set up at that time for the purpose of issuing these abstracts. The name of the company was then Derwent Information Services; the name was changed to the present one in 1963.

Abstract journals of the patent specifications of various countries where then introduced progressively: German Patents Report in 1953, Belgian Patents Report and Commonwealth Patents Report (covering India, South Africa and Australia) in 1955, and French Patents Abstracts in 1961. Subsequently, due to an amendment of the Australia Patents Act, the Commonwealth patents lost some of their advantage of early availability, and due to an amendment of the French patent laws the early availability of French documents was increased. Accordingly, when processing of French patents was commenced in 1961, publication of Commonwealth Patents Report was discontinued and Indian and South African patents were included in French Patents Abstracts (Indian patents are no longer abstracted by Derwent, but the South African documents continue to be covered in French Patents Abstracts).

In its Patents Abstracts Publications, as this series of country coverage abstracting services is known, Derwent, from the beginning, consistently concentrated on early availability, easy readability (patents in all languages are published in the form of an English language abstract by Derwent), and low cost. Basically it dealt only with chemical subjects. However, of the national patents abstracts journals those for the United Kingdom, and subsequently (from 1961), West Germany and USSR covered all technical fields.

As far as Japanese patents are concerned, in 1961 a contract was entered into whereby Nippon Gijutsu Boeki Company Limited were made Derwent's general agents in Japan, and, on a proposal from Derwent, this company undertook the compilation of abstracts of Japanese patents in the chemical technologies resulting in the issue of Japanese Patents Report from 1962.

At that time, apart from the Patents Abstracts Publications, Derwent issued a series of Derwent Patents Journals with titles: Fine Chemicals Plastics, Petrochemicals and Metallurgical; as well as Derwent Patents Bulletins with titles: Polychemicals, Pharmaceuticals, Paper, Photography and Graphic Arts, Metals, Nuclear Power, Chemical Processes and Organic Chemicals. These publications comprised abstracts collected for each technical field and sub-divided by country, the abstracts originating from the Patents Abstracts Publications series, i.e., abstracts originally issued by country were repackaged and issued by subject matter.

The foregoing describes only the compilation of English language abstracts with the emphasis on rapid availability and easy readability together with a simple index. However, claboration of the means of retrieval to achieve a real documentation service was first performed in the 1960s with Farmdoc. The motivating reasons behind the intiation of this service are interesting since they set the pattern through which other services were subsequently launched by Derwent. Derwent had, by 1962, progressively launched new publications dealing with the patent documents of a number of countries; by that time a publication dealing with Netherlands documents had been added to the series, and plans had been formulated to progressively add further country documents to the portfolio.

However, a group of leading European pharmaceutical companies approached Derwent indicating that, whilst the then existing series of publications was most useful to them, the products lacked certain features and they would have liked wider country coverage. The most important features of a desired service were stated to be: copies of patent specification claims to be supplied automatically, copies of complete specifications, linking of members of the same "family", indexes by subject matter and patentee and methods for chemical structure and pharmacological activity subject matter searching. Derwent set about formulating a pooled patents information service for the pharmaceutical

industry which would incorporate these features and held a meeting with potential subscribers to discuss its proposals in Milan early in 1963 (hence the name Farmdoc for "farmaceutici" rather than "Pharmdoc" for "pharmaceutical").

The proposed service was found to be acceptable to the potential users and the service was initiated later that year; by the end of the first six months of operations there some thirty users in Europe, North America and Japan. The service was important from Derwent's point of view since it established the template upon which later introduced services were modelled. The service has changed little over the past nineteen years and now exists as part (Section B) of Derwent's Central Patents Index which is described more fully below.

The success of Farmdoc led, in 1965, to the introduction of a companion service, called Agdoc (now Section C of Central Patents Index) which dealt with patents relating to agricultural chemicals in a similar fashion to the pharmaceutical coverage of Farmdoc.

Both Farmdoc and Agdoc used a fragmentation code for the encoding and subsequent retrieval of structual and biological activity data for compounds. The code, based upon assigning to the 960 positions on a standard 80-column punch card a specific meaning such as benzene ring, or thio acid group or anti-rheumatic activity, remained in use until 1981 when, largely as a result of greatly increased use of online retrieval and the consequent fall in the demand for punch cards on the one hand, and the greater flexibility of the online system which was not limited to the number of possible available codes (960 per card) on the other hand, the code was revised. Because the former code often necessitated the punching of more than the usual maximum of three holes in any card column, the code was known as a "multipunch" code.

Following the success of these documentation services, Derwent was approached by ICI Limited to see whether a similar service could be introduced for patents dealing with plastics, polymers and monomers. ICI offered Derwent a multipunch code which they had developed. As a result of this cooperation Derwent was able to launch Plasdoc (now Section A of Central Patents Index) in 1966.

It was clear from the success of these systems that Derwent had the right formula for patents documentation services. Plans were laid to

launch a new service every eighteen months or so: Chemdoc (covering general chemicals), Dyedoc (dyestuffs), Textdoc (textiles), Metaldoc (metallurgy, etc. However, in 1968 Derwent was approached by E. I. Du Pont de Nemours & Company, who indicated that whilst they were well served by the then existing Derwent services they did not want to wait until well into the 1970s before all "chemical" patents were covered; furthermore, the technology was being fragmented amongst the different services offered by Derwent and they wanted an overall integrated patents information system. The Du Pont approach to Derwent was for the latter to introduce a specialised service just for Du Pont to replace that company's internal system which was called Central Patent Index. The significance of this is that when Derwent launched its service in 1970, it derived its name from the Du Pont system by adding an "s" to the word "patent".

Derwent was not in favour of producing a service just for one client, but proposed a service which would (a) appeal to a number of clients, and (b) preserve the identity of the already existing documentation services whilst allowing for expansion of coverage and the ability for any particular client to subscribe to just that part of the overall service which met the particular client's patents information requirement profile.

The service, Central Patents Index (CPI), took some time to develop and was eventually launched at the beginning of 1970. By 1982 there were more than 750 clients from all over the world subscribing to CPI, ranging from those buying just a few of the products available for any one section of the service to those buying the complete service with all available product options. The service is described in more detail below. When CPI was introduced the publications in the Derwent Patents Journals and Derwent Patents Bulletins series were withdrawn.

In the late 1960s and early 1970s BIRPI (the French language acronym for the United International Bureau for the Protection of Intellectual Property), now known as WIPO (World Intellectual Property Organisation) sought to introduce, with the cooperation of industrial organisations such as Derwent, in a joint venture, a patents information and indexing service which would cover the entire output of the world's patent offices.

After many years of fruitless negotiations, Derwent decided to launch its own service, although this would not cover as many countries as the WIPO service intended, nor would it have the "authority" of a WIPO-sponsored service. Accordingly Derwent started publication of World Patents Index in 1974; this service covered all technologies for the patent documents of the countries covered (initially only 12 countries but later extended to 24 plus the PCT and EPO documents, and with the exception that for Japan only chemical cases were covered). Meanwhile, WIPO in conjunction with the Austrian government established INPADOC in Vienna - an organisation founded with the object of providing an "official" service in collaboration with the Patent Offices.

Derwent's World Patents Index comprises lists, issued weekly and cumulatively, of the documents covered; the lists are arranged by patentee, subject matter [using the IPC (International Patent Classification)], patent number, Derwent accession (or patent family) number and priority data. No abstracts are provided. The launch of the service represented a major and significant step forward for Derwent inasmuch as this was the first of its products to be fully phototypeset, a process which simultaneously provided machine readable data to form the basis of a wholly computerised patents information service.

Having broadened its subject coverage for a number of countries, the next logical step for Derwent was to to extend its abstracting activities beyond the chemical services and the non-chemical abstracts provided for just UK, West Germany and USSR. Consequently, in 1975, a new series of subject-matter orientated publications providing abstracts for general, mechanical and electrical patents was commenced. The series of publications were collectively entitled World Patents Abstracts by Subject and, at the same time, the former series known as Patents Abstracts Publications were renamed World Patents Abstracts by Country.

Derwent's next step forward came in 1976 with the launching of online access to the database it had compiled from Central Patents Index (together with its precursors Farmdoc, Agdoc and Plasdoc) and World Patents Index. Initially the company had entered into an agreement with Tymshare Inc. of the USA to place the files online; however, after partially loading the files, Tymshare revised its business plans and decided to withdraw from providing a host computer for online database "spinning". Subsequently Derwent allowed SDC Search Service, a division of System Development Corporation (SDC) of Santa Monica, California,

to load the files and make them available to registered users for online retrieval. In October 1979 the files were also loaded onto a computer in Tokyo to allow Japanese users to gain online access; the Tokyo computer is run by a Japanese subsidiary of SDC. Subsequently in July 1981, a partnership was formed (Derwent-SDC Search Service) to mount the files on a host computer in the United Kingdom; this service became operation early in 1982. By July 1982 the Derwent files, which also included those for the company's non-patents information services, were being used for more than 2,500 hours, with more than 150,000 off-line printed citations and 450,000 online printed citations, per month.

Derwent's next venture in patents information services was to launch a specialised documentation service for the electrical and electronics industries. This service, Electrical Patents Index, was also modelled on the successful already established formula, but was not as sophisticated as Central Patents Index inasmuch as some features, such as copies of complete specifications on microfilm, were not provided. The service commenced publication in May, 1980.

An account of recent developments in Derwent's services, and some indications of future activities, have been given by this author and Oppenheim[220].

Ownership of Derwent

Derwent was founded by, and is very much the brainchild of, its Chairman and Managing Director, Montagu Hyams. Until 1968, Mr Hyams and his wife owned the company, but in that year they sold 51% of the shares to Thomson Publications Limited, a subsidiary of The Thomson Organisation. Over the following years The Thomson Organisation purchased further shares in the company and, by 1980, owned 84%; the remaining 16% being held by the Hyams family. Following a reorganisation and restructuring of The Thomson Organisation in 1979, Derwent became a part of Thomson Data Limited; this company in turn is a part of Thomson Information Services which is a division of International Thomson p.l.c. Montagu Hyams, in addition to being Chairman and Managing Director of Derwent, is also Chairman of Thomson Data Limited and serves on the board of Thomson Information Services.

In 1981 a subsidiary company (or rather a "cousin" company as it is part of Thomson's North American operations), Derwent Incorporated, was established in the USA. At the time of this study the main product of Derwent Inc. was an online service based upon magnetic tapes from the USPTO; the tapes contain full details of all US patents and the data-base created therefrom is loaded onto SDC's computers in the USA to provide online access.

Range of Coverage of Derwent Patents Services

At the time of this study Derwent services covered the documents issued by the following 24 national patent offices:- Austria, Belgium, Brazil, Canada, Czechoslovakia, Denmark, Finland, France, East Germany, West Germany, Hungary, Israel, Italy, Japan, Netherlands, Norway, Portugal, Romania, South Africa, Soviet Union, Sweden, Switzerland, United Kingdom and USA. The "international" PCT and European patents are also covered. The quasi-patent literature articles published in the journal Research Disclosure are also included. Commencing in 1983, Australian patents are to be covered in the Derwent system once again.

For each document issuing authority, all the patent documents, irrespective of subject matter, were taken into the services. The sole exception was Japan where, for reasons of economy (abstracting of Japanese documents into English being excessively expensive) only chemical - and later electrical cases were covered.

An indication has been given above as to when the various technologies were first covered by Derwent; just as these technologies were phased into the system over a number of years, so too were the different countries. This matter will be dealt with more fully in the description of Central Patents Index given below.

From these sources Derwent, at the time this study was commenced, was taking into its services approximately 10,000 documents with 150,000 multi-lingual pages, each week.

The Major Derwent Services

World Patents Index (WPI) - contains titles and bibliographic details, without abstracts, in the printed form as weekly gazettes which cover all countries and are issued in four sections according to subject:

Chemical, Electrical, General and Mechanical. The coverage of each section is defined in terms of the International Patent Classification (IPC).

World Patents Abstracts (WPA) - this service offers English language abstracts in individual weekly country reports under the following titles: Belgian Patents Report, British Patents Abstracts, French Patents Abstracts, German Patents Abstracts (covering examined documents), German Patents Gazette (covering unexamined documents), Japanese Patents Report (covering examined documents), Japanese Patents Gazette (covering unexamined documents), Netherlands Patents Report , PCT Patents Report, European Patents Report, Soviet Inventions Illustrated and United States Patents Report. The French, Japanese and Netherlands publications cover only chemical cases.

Additionally, WPA offers abstracts arranged by subject matter in a series of journals with the following titles: Human Necessities, Performing Operations, Transport, Construction, Mechanical Engineering, Instrumentation, Computing, Electronic Components, Circuitry and Communications, Power.

Central Patents Index (CPI) - provides alerting, documentation and retrieval of chemical-related patents in a variety of subject defined Alerting Bulletins, Basic Abstracts Journals, Profile Booklets, coded cards, microfilm, microfiche and magnetic tapes. A fuller description is given on following pages.

Electrical Patents Index (EPI) - provides, for the electrical and electronics industries, rapid current awareness with weekly abstracts bulletins and selective subject coverage by a range of profile booklets. Retrospective searching is handled by a choice of coded abstracts, microfiche indexes and magnetic tapes.

Online Search Service - The Derwent online database is in two parts: WPI which covers documents entered as basics prior to the end of 1980 and subsequent equivalents to basics within that period, and WPIL for all basics and associated later equivalents processed since the beginning of 1981. The database (WPI and WPIL) includes the special coding features of CPI and EPI as well as abstracts for those basics included in WPIL. The database may be accessed from computers in California, Tokyo and Woking using the System Development Corporation ORBIT IV

software package. Searching is carried out interactively, i.e., in a conversational mode, with the computer and the searcher taking turns on the users remote access terminal. At the time of this study the files contained over two million patent families, representing some four million patent documents.

Searching is straightforward and search statements may include any of the bibliographic features such as patent numbers, priority details, title terms, words in the abstracts, company names, IPCs, Derwent classification and special codes for CPI and EPI. Answers to searches are obtained as citations which may be printed in a variety of formats either online at the users terminal or offline at the host computer for onward mailing to the user. The searches may incorporate all forms of Boolean logic ("and", "or" and "not") and may be conducted over subsets of the file selected by the searcher in terms of either subject matter or chronology. The computer files are updated with the latest information each week; during the updating procedure records of recently issued equivalents are added to the records of the corresponding basics. This need to update previously loaded records represents one of the major unique features of the WPI/WPIL files. Most bibliographic files enter a record and that record remains unaltered other than corrections of any errors; however, for the patent files additional information only new issued equivalents is continually added to earlier processed (basic) records. The ability to achieve these pseudo-corrections in large numbers required the development of special "mod" (modification) files and amendments to the ORBIT program suite.

During the early part of 1981, at the time the file was divided into WPI and WPIL, the files were completely reloaded onto the host computers so as to give greater flexibility of searching and additional alternative print-out formats. One feature of this is the ability to sort citations into desired sequences prior to offline printing, for example by patentee code or by priority date; this feature was not available at the time of the original online retrievals conducted for this study. Had it been available much of the keyboarding and computer listing of relevant data could have been avoided. (Indeed it was partly as a result of the work which this studied required that the offline sorting feature was recognised as a desirable system improvement.)

In addition to the descriptive brochures which the company issues, descriptions of the Derwent services have been published by Hyams[221-226], this author[227-228], Pope[229], Mayer, Angus and Mariucci[230], a Japanese study group[231], Kaback[232,233], Bankowski[234], Oppenheim[235] and Kimio[236]. Various aspects of the services have been described by a number of authors, mostly Derwent employees, in the proceedings of a conference sponsored by Derwent and held in 1978[237].

Other authors such as Saunderson[238], Helliwell[239], Johns and Ryno[240], and Vincent[241], have described how Derwent services are used in industrial information departments. Other articles, such as those by Kaback[242], Carpenter, Jones and Oppenheim[243] and Silk[244], have described Derwent's classification and coding systems.

The use of the online system has been described by Oppenheim[245], Grant-Smith, Anderson and Jackson[246], Bechtel[247], Kaback[248], Walton[249], and Herz[250]. Johns et al.[251] have reported on Derwent's effectiveness in identifying patent families. Kaback[252] has given a review of the various user aids issued by Derwent.

Derwent's Non-Patents Information Services

Following the success of the Farmdoc service, Derwent was approached in 1964 by two groups of industrial organisations in an effort to get the company to produce a companion service which would cover the pharmaceutical journal literature rather than patents. The first of these groups comprised Sandoz Limited and F. Hoffmann-La Roche & Company Limited, both of Basel, Switzerland. These companies had developed between them a system of keyword indexing of journal articles for retrieval; the system is known as "Codeless Scanning" and was offered to Derwent as an incentive to commence a service. The second group was the Pharmadokumentationsring e.V., a consortium - at that time - of some seven European and one USA pharmaceutical companies. This group had developed a fragmentation coding system, employing multi-punching of 80-column punch cards, known as the "Ring Code". The group had also developed an abstracting and exchange system between themselves.

The Pharmadokumentationsring code was also offered to Derwent. Using these systems, and adding Derwent's unique know-how and production techniques, a service was launched in mid 1964 which is known as

Ringdoc. This service selects, abstracts and codes articles from some 750 technical journals which yield about 40,000 items per year.

Once again, the success of one of its services led Derwent to introduce further publications. Fashioned in a manner similar to Ringdoc, which deals exclusively with articles of relevance to the pharmaceutical industry, Vetdoc and Pestdoc were initiated in 1966. Vetdoc covers the non-patent literature dealing with veterinary medicine, whilst Pestdoc covers the literature of agricultural chemicals such as pesticides and herbicides.

In 1975 Derwent acquired the rights to publish Teilheimer's "Synthetic Methods of Organic Chemistry", input to an enlarged coverage being obtained by virtue of the company's extensive coverage of chemical journals for its other services as well as its unique coverage of patents. At the same time the Pharmadokumentationsring e.V. offered Derwent their coding system for chemical reactions and the company was able to commence its Chemical Reactions Documentation Service (CRDS) and Journal of Synthetic Methods as successor to Teilheimer's publication.

The Ringdoc, Pestdoc, Vetdoc and CRDS files are also mounted on the host computers used for online access to the patents files.

In July 1982, Derwent added to its portfolio of information products an abstracting, and corresponding online service, entitled Biotechnology Abstracts. This service covers both patent and journal literature documents and was launched to meet the growing needs for information in the increasingly important biotechnology area.

Central Patents Index (CPI)

Main features of CPI

CPI is a sophisticated abstracting and retrieval service dealing with chemical patents under twelve major subject matter categories.

On a current basis, for each category, CPI takes the form of a booklet giving 100-120 word abstracts (see Figure 8) of all current inventions arranged in country of document sequence; a week later, the same abstracts, arranged by Derwent classification; and, the following week, a

booklet giving detailed, coded abstracts of all first disclosure or "basic" patents (see Figure 9).

Retrieval is possible through the provision of cumulated indexes, manual code cards, magnetic tapes for in-house usage and online access. At the time this study was commenced punch coded cards were also available, but have since ceased to be produced. Abstracts and complete patent specifications are also available as microfilm records.

Basics and Equivalents

In the production of CPI, the filing details and classification are recorded on magnetic tape for each new document. The priority information is then matched by computer against a master file containing all previously processed document data; there are built-in checks to guard against input errors. In this way the documents are divided about equally into those which relate to entirely new inventions, or "basics" and those for which corresponding patents have already been published, or "equivalents". Meaningful, text-edited, are prepared and input for all basics.

The whole of the computer input for any one week is blended with all the information ever included on the master file in a "merge and update" computer session.

As a result, all the new basics are automatically assigned CPI accession (or patent family) numbers, entered into the system and detailed abstracts prepared. For any new equivalent, the patent number and any new IPCs are posted against the CPI accession number of the family to which it belongs. At the same time, tapes are generated for the phototypeset production of the various indexes, abstract headings and abstracts. Subsequently, structure coding is carried out for basic patents disclosing chemical or polymer features, as well as deep classification, or "manual coding" for all basic documents.

Country Coverage

Because the laws under which patents are issued vary from country to country, applications made at the same time in different countries may be published (laid Open to Public Inspection, or OPI) at different times. Slow publishing documents have usually been through the process

of novelty searching and are published approximately 2 to 3 years after filing in the form of a printed specification as accepted after amendment where necessary. The specifications normally contain a small number of narrow, well defined, claims of proven novelty.

Fast publishing documents are normally the so-called "new law" quick disclosures, published approximately six months after filing, or 18 months from the earliest priority date, as typewritten documents in the same form as filed, without examination. Usually they contain a large number of broader-than-justified claims, often of doubtful novelty.

The countries covered for CPI (and for WPI), the numbers issued, and the date of introduction into the service are as follows:-

(a) "Major" countries

	Average total number OPI per week (1982)	Year first included in CPI
(i) Fast Publishing		
Belgium	100	1963
European (unexamined)	500	1979
PCT	75	1978 (Dec.)
France	500	1963
Germany, W. (unexamined)	750	1968
Japan (Kokai)*	2090	1972
Netherlands (unexamined)	125	1963
South Africa	125	1963
Sweden**	135	1974 (Sept.)
UK (unexamined)	500	1978
(ii)Slow Publishing		
Canada	430	1963
European (examined)	120	1980
Germany, E.	150	1963
Germany, W. (examined)	460	1963
Japan (Koho)	340	1963
Netherlands (examined)	60	1963
Soviet Union	1500	1963
UK (examined)	500	1963
USA	1300	1963

(b) "Minor" countries

(i) Fast Publishing		
Brazil	190	1976 (Jan.)
Denmark	110	1974 (Nov.)
Finland	60	1974 (Nov.)
Italy	100	1978 (Jan.)
Norway	80	1974 (Dec.)
Portugal	30	1974 (Nov.)

(ii) Slow Publishing

Austria	80	1975 (Mar.)
Czechoslovakia	175	1975 (Mar.)
Hungary	85	1975 (May)
Israel	40	1975 (Mar.)
Romania	60	1975 (Mar.)

Total number patents per week = 10,905
*Only chemical patents from Japan were included prior to 1981
**Prior to 1979 Sweden was treated as a "minor" country

Since 1978, articles, about 15 each week, from the publication Research Disclosure have been included in the service. Additionally covered in the pre-CPI services, but discontinued at the start of CPI in 1970, were Australia (to be included again from 1983), Eire and Italy (Italian documents were only included in Plasdoc); subsequently Italy was re-introduced as a "minor" country in 1978 (January).

Classification

Patents included in CPI are assigned to one or more of the CPI sections A to M:-

CPI Section	Subject	Basics in 1981
A (Plasdoc)	Polymers	39,000
B (Farmdoc)	Pharmaceutical	9,200
C (Agdoc)	Agricultural, Veterinary	5,300
D	Food, Cosmetics, Detergents	13,700
E (Chemdoc)	General Chemical	18,900
F	Textiles, Paper, Cellulose	8,700
G	Printing, Coating, Photography	9,600
H	Petroleum, Fuels	8,000
J	Chemical Engineering	15,200
K	Nucleonics, Explosives	2,500
L	Refractories, Cement, Electro(in)organic	22,100
M	Metallurgy	25,800

On average each basic is assigned to 1.55 Sections. These twelve sections are broken down into 135 well-defined classes, which serve to divide the subject matter simply and unambiguously into a number of profiles for alerting, SDI and scanning purposes. Full details of the classification for Section B (Farmdoc) are as follows:-

Scope: All specifications stated to be of pharmaceutical or veterinary interest, as well as those relating to compounds for use as intermediates in the manufacture of drugs or veterinary products.

All steroids, alkaloids, vitamins, vaccines and antibiotics are covered automatically. Also compositions used for diagnosis and analysis in the pharmaceutical and veterinary fields.

Inventions dealing with bactericides and fungicides are included when these substances are for internal or topical application. However, when they are used for other purposes (such as in detergent compositions, disinfection of textiles, lubricating oil additives, etc.) they are not covered in this section.

Patents dealing with the production of tablets, pills, capsules, suppositories, etc., are included. Also, devices for specifically dispensing pharmaceuticals such as syringes, tamper-proof closures and calendar pill-boxes, aerosols, etc., are included.

In the classification given below, the order of priority is B1 before B2, B2 before B3, and so in in the same compound.

Classes: B1 : Steroids
B2 : Fused ring heterocycles
B3 : Other heterocycles
B4 : Natural products - peptides, analytical processes for body fluids
B5 : Other organics - aromatics, aliphatics, organo-metallics, general compositions
B6 : Inorganics
B7 : General - tablets, dispensers

CPI Products

The abstracts, indexes, etc., which are available as part of CPI are shown in Figure 7 (note, however, that punch cards are no longer available). Further details are available from the relevant Derwent brochures.

Manual Code Classification

The manual code classification is far deeper than the arrangement according to CPI class, and is similar in structure to a national patent office classification, but is strengthened to take care of chemicals and polymers.

The manual code classes may be likened to keywords, a hierarchical system being used. For example, adhesive tapes are broadly classified

ABSTRACTS	Alerting	Bulletins (Country Order)	A	B	C	D	E	F	G	H	J	K	L	M	
		Bulletins (Classified)	A	B	C	D	E	F	G	H	J	K	L	M	
	Documentation	Basic Abstracts Journals	A	B	C	D	E	F	G	H	J	K	L	M	
		Profile Booklets	A*	B*			E			H*					
		Microfilm	A	B	C	D	E	F	G	H	J	K	L	M	A-M
PATENT COPIES	Basic Patents	Printed		B	C										
		Microfilm	A	B	C	D	E	F	G	H	J	K	L	M	
CARDS	Company Code	Printed	A	B	C	D	E	F	G	H	J	K	L	M	
	Manual Code	Printed	A	B	C	D	E	F	G	H	J	K	L	M	
		Microfilm	A	B	C	D	E	F	G	H	J	K	L	M	
	Punch Code	Cards		B	C		E								
		RIN Service		B	C		E								
INDEXES	Alerting Bulletins	Patentee	A	B	C	D	E	F	G	H	J	K	L	M	A-M
		Accession Number	A	B	C	D	E	F	G	H	J	K	L	M	A-M
		Patent Number	A	B	C	D	E	F	G	H	J	K	L	M	A-M
		CPI Class **	A	B	C	D	E	F	G	H	J	K	L	M	
	Basic Abstracts Journals	Patentee	A	B	C	D	E	F	G	H	J	K	L	M	
		Accession Number	A	B	C	D	E	F	G	H	J	K	L	M	
		Patent Number	A	B	C	D	E	F	G	H	J	K	L	M	
		Manual Code	A	B	C	D	E	F	G	H	J	K	L	M	
	Quarterly COM Microfiche	Patentee	A	B	C	D**	E	F+G***		H+J+K			L+M		A-M
		Accession Number													A-M
		Patent Number													A-M
		Priority													A-M
		IPC													A-M
	Quarterly Printed	Accession Number													A-M
		Patent Number													A-M
MAGNETIC TAPES	Weekly or Monthly	Bibliography Data													A-M
		Manual Codes													A-M
		Multipunch Codes	A	B	C		E								

* Part coverage only
** Alerting Bulletins (Country Order) only
*** Sections, D, F and G combined

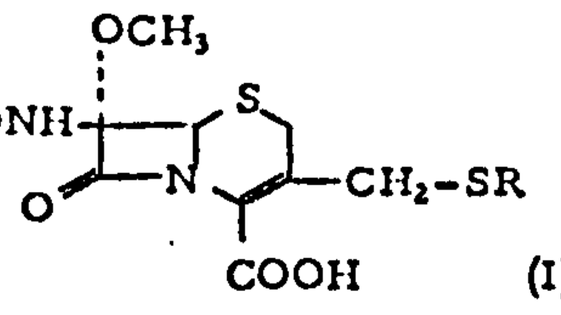
Figure 7: Scheme to show which products (and for which Sections) are available for CPI

YAMA ★ B02 30715B/16 ★J5 4032-694
Cephem-4-carboxylic acid derivs. prodn. - by contacting D-aminoacid oxidase active mycelium with 7-beta-(5-aminovaleramide)-7-alpha-methoxy delta-cephem-4-carboxylic acid

YAMANOUCHI PHARM KK 12.08.77-JA-096711

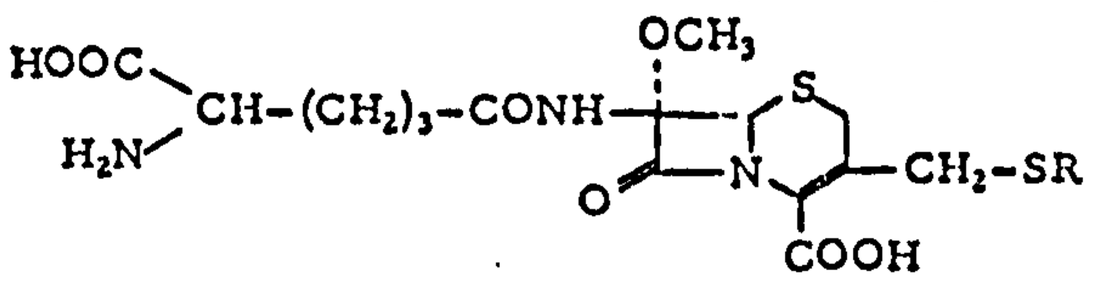
C02 (10.03.79) C12d-09 C12d-13

Prepn. of 7β-(4-carboxybutyramide)-7α-methoxy-Δ^3-cephem-4-carboxylic acid deriv. of the formula (I):



(I)

(where -SR is nucleophilic gp.), comprises contacting mycelium possessing D-amino acid oxidase activity or its extract with 7β-(5-amino-5-carboxyvaleramide)-7α-methoxy-Δ^3-cephem-4-carboxylic acid of formula (II) or its salt, in the presence of hydrogen peroxide.



(II)

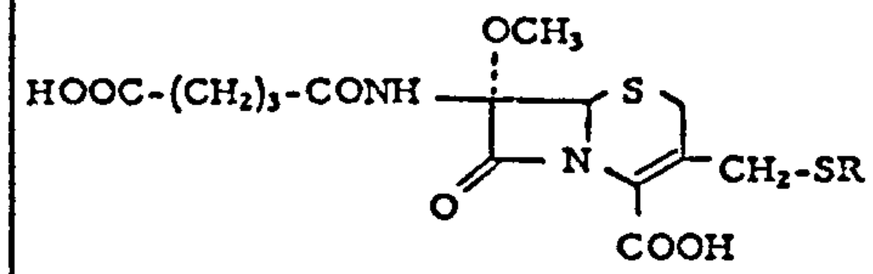
(II) is converted to (I) in high yield. 12.8.77 as 096711.
(9pp68)

Figure 8: Typical Alerting Abstract

30715B/16 B02 C02 YAMA 12.03.77
YAMANOUCHI PHARM KK *J5 4032-694
12.03.77-JA-096711 *(10.03.79)* C12d-09 C12d-13

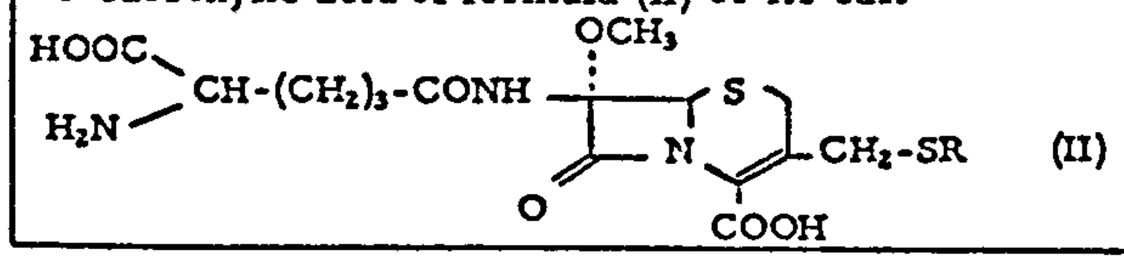
Cephem-4-carboxylic acid derivs. prodn. - by contacting D-aminoacid oxidase active mycelium with 7-beta-(5-aminovaleramido)-7-alpha-methoxy delta-cephem-4-carboxylic acid

Preparation of 7β-(4-carboxybutyramido)-7α-methoxy-Δ^3-cephem-4-carboxylic acid derivative of formula (I)



(I)

(-SR=nucleophilic gp.) comprises contacting mycelium possessing D-aminoacid oxidase activity or extract thereof with 7β-(5-amino-5-carboxyvaleramido)-7α-methoxy-Δ^3-cephem-4-carboxylic acid of formula (II) or its salt



(II)

in presence of hydrogen peroxide.

ADVANTAGE/USE

(II) is a starting material for preparation of cephalosporin antibiotics, and prepared by fermentation. (I) is more easily isolated and purified than (II). (I) is produced in high yield.

DETAILS

R is pref. 1-methyl tetrazol-5-ylthio, 1,3,4-thiazol-2-ylthio, 5-methyl-1,3,4-thiadiazol-2-ylthio or 5-carboxymethylthio-1,3,4-thiadiazol-2-ylthio. Suitable mycelium possessing D-amino acid oxidase activity is derived from Trigonopsis variabilis IFO 0755, IFO 0671, or Gliocladium, Aspergillus and Fusarium strains.

EXAMPLE

Streptomyces organonensis was inoculated into a nutritional culture medium, and incubated to produce 7β-(5-amino-5-carboxyvaleramido)-3-(1-methyl-1H-tetrazol-5-yl)-thiomethyl-7α-methoxy-Δ^3-cephem-4-carboxylic acid. The fermentation broth was filtered. The filtrate was refined by contacting with ion exchange resin and eluting. Activated mycelium of Trigonopsis variabilis and aq. H_2O_2 were added to the eluted fractions with antibiotic activity, and the reaction mixt. was allowed to stand at 37°C for 2 hrs. The mycelium was removed by filtration, and 7β-(4-carboxybutyramido)-7α-methoxy-3-(1-methyl-1H-tetrazol-5-yl)-thiomethyl-Δ^3-cephem-4-carboxylic acid was isolated from the filtrate by extraction and chromatography.(9ppW68).

Figure 9: Typical Basic, or Documentation Abstract

in group A12 under "applications"; generically in sub-group A12-A under "all adhesives and binders"; and specifically in code "A12-A1".

On average an invention is assigned to three or four codes. In all, there are about 4,000 manual codes in CPI, each one having an average of just under 60 documents assigned to it per year.

The details of the Section B (Farmdoc) manual codes relating to Aromatics, Cycloaliphatics (mono- and bi-cyclic only) and Aliphatics are shown in Figure 10; the full description of the code is given in Derwent's Instruction Manual 3.

Patentee Codes

The patentees from all patents entered into the Derwent system are assigned a four or five character code related to the patentee name. These codes are then used in place of the patentee names for the generation of patentee indexes and may be used for retrospective retrieval using such indexes, the company code cards (unit abstract records) or the online files.

Codes are applied to every company listed as a patentee, up to a maximum of four patentees being coded for any one document. In cases where a company and an individual are joint patentees, only the company name and code are recorded; where several individuals are joint patentees, only the first name mentioned is used to generate a patentee code.

From 1963 to 1969 all patentees, even individuals, were assigned distinct four-letter codes. Except for the codes assigned to individuals, these codes still apply. Since 1970, only the more prolific patentees newly encountered have been assigned unique "standard" codes, the remainder being treated as "non-standard" as described below.

For larger companies, all recognisable subsidiaries are assigned the same code; for example, Chloride Group Limited, Chloride Batteries Limited, Chloride Lorival Limited and Chloride Batterijen BV are all assigned the code "CHLO". Subsidiaries with substantially different names may also be assigned the same code; for example, American Home Products Corporation, J. Wyeth & Brother Limited and Ayerst McKenna & Harrrison Limited are each assigned the code "AMHP". When a company

B10 AROMATICS AND CYCLO ALIPHATICS (MONO AND BICYCLIC ONLY); ALIPHATICS

In B10 cpds are coded according to the type of functional gp present (if any). Order of priorities, whereby only one card is applied to a specific cpd., is A > B -- > J and 1 > 2 > 3 etc. Thus B10-A1 is highest, and B10-J2 lowest, priority code.
Symbol 'X' represents a halogen.

B10-A Rarer chemical groups, general

1 Sulphonium, iodonium, free radicals, carbonium, oxonium, etc.
2 Halogen bonded to Hal, N or O [h]
3 Nitrogen oxide, nitroso [a]
4 Peroxide, polysulphide
5 Nitrate, nitrite [a]
6 Quinone [b]
7 Sugar [a b g]
8 Amide of sulphur acid [a]
9A Sulphuric(ous) acid [a b] **
9B Sulphonic acid, general [a b] **
9C Other S acids, [a b] **
10 Sulphone, sulphoxide, [a]
11A Thiocarbonic acid [b] **
11B Carbonic acid [b] **
12A Dithiocarbamic acid [b] **
12B Monothiocarbamic acid [b] **
12C Carbamic acid [b] **
13A (Iso)thiourea**
13B (Iso)urea, general [i] **
13C -- Unsubstituted urea*
13D -- Other (iso)urea cpds.*
14 (Iso)cyanate, thiocyanide [a]
15 (Iso)cyanide
16 Azide, azo, diazo(nium)
17 Biguanide, guanidine, amidine
18 Hydroxylamine
19 Hydrazine
20 Imine
21 Quat. ammonium (bis or poly) [c]
22 Quat. ammonium (mono) [c]
23 Acetal, ketal [a]
24 Imide [a]
25 Acid anhydride, halide (carboxylic only) [a h]

B10-B Amines

1A Polyamines, at least 1 amine aromatic**
1B Polyamines with no amine aromatic**
2A Amino-acid, – ester or – amide (amine aromatic) **
2B Amino-acid, – ester or – amide (amine not aromatic), general [a] **
2C -- Mixtures contg. at least 3 naturally occurring amino acids*
2D -- Sulphur-containing amino acids (incl. amides and esters of the acid group(s))*
2E -- Ring-containing amino acid with free acid group or salt*
2F -- Ring-containing amino amide*
2G -- Ring-containing amino ester*
2H -- Opt. esterified or etherified hydroxy amino acids (incl. amides and esters of the acid group(s))*
2J -- Other amino acids (incl. amides and esters of the acid group(s))*
3A Amino-phenol, – alcohol or – ether (amine aromatic) [a] **
3B Amino-phenol, – alcohol or – ether (amine not aromatic) [a] **
4A Other aromatic amines**
4B Other non-aromatic amines**

B10-C Carboxylic acids (CA)

1 Thio-CA
2 Poly-CA
3 CA with phenol or phenolic ester or ether gp(s). [a]
4 Other CA, general [i]
4A -- Cycloaliphatic CA*
4B -- Hydroxy, aldehyde or ketonic CA (or ethers thereof) with an aromatic ring*
4C -- Other CA with aromatic ring*
4D -- Acyclic hydroxy, aldehyde or ketonic CA and acyclic ether thereof*
4E -- Other acyclic mono-CA*

B10-D Aldehydes and carboxylic amides [a]

1 Aldehydes [a]
2 Carboxylic amide, thio
3 Carboxylic amides

B10-E Hydroxy compounds [a]

1 Thiophenols
2 Phenols
3 Thioalcohols
4 Alcohols, general [i]
4A -- Alcohols contg. – OH attached directly to alicyclic ring*
4B -- Alcohols contg. carbocyclic ring(s)*
4C -- Polyalcohols and ethers and esters thereof*
4D -- Other alcohols*

B10-F Ketones [a]

1 Thioketones
2 Ketones

B10-G Carboxylic esters and nitro [a]

1 Thiocarboxylic esters
2 Carboxylic esters
3 Nitro

B10-H Ethers and halogens [a]

1 Ethers [a]
2A F, linked to aromatic ring**
2B F, not linked to aromatic ring**
2C Br or I, linked to aromatic ring**
2D Br or I, not linked to aromatic ring**
2E Cl, linked to aromatic ring**
2F Cl, not linked to aromatic ring**

B10-J Hydrocarbons

1 –C:C–, may form part of alicyclic ring**
2 Others**

Notes

a Oxygen atoms may be replaced by S.
b Includes all derivs., except those with higher priority.
c Where a patent claims amines and their quat. amm. salts, only code of parent amine given. Thus to obtain all relevant quat. amm. cpds., two searches must be made.
d For acidic or basic salts see the parent cpds. (i.e. amines, acids, etc.)
e For all cyclic derivs. of the gps. listed above see B1 to B7.
f For gps. not listed above, the highest priority segment of the gp is used as its coding feature. For example, semicarbazones are coded B10-A13B, and not also B10-A19 or B10-A20.
g Sugars contg free ketonic or aldehyde function are coded in open chain (not cyclic) form. In example, glucose is B10-A7, but methyl glucoside is B7-A2.
h Halides of acids other than carboxylic (B10-A25) or those contg N-X or O-X bond (B10-A2) are assigned code of the parent acid. For example a sulphenyl halide is B10-A9C, a chloroformate B10-A11B and a carbamoyl halide B10-A12C.
i These generic codes are only used for general disclosures which would otherwise require several specific codes. When a specific search is made, any corresponding 'i' generics must also be searched.

Figure 10: Part of the CPI Manual Code for Section B

changes its name, the standard code is retained, so that Bayer AG, formerly Farbenfabriken Bayer AG, continues to be coded as "FARB".

When two companies with standard codes merge, one code is retained and the other abandoned; e.g., Ciba-Geigy AG is coded "CIBA", and the code "GEIG" is no longer used, in this case having been converted on the files to "CIBA" during a major updating of codes in 1975 (at which time the company code was rationalised so that only one code was applied to any particular patentee).

For each of the 13,500 standard codes, Derwent stores a standard name on a dictionary file. Where several subsidiaries, or associates, of a company exist, the standard name is usually the name most frequently met with on patent documents; it is not necessarily the name of the parent company. Part of the list of standard company names is given as Figure 11.

For non-standard patentees, Derwent usually (at least for 95% of cases) takes the first four letters of the first significant word (ignoring such words as Societe, Firma, etc.) of the name as the code. Such non-standard patentee codes terminate with a hyphen (-), except for individuals where an oblique (/) is used. For Soviet names a translation is made of significant words and the codes terminated with an equals sign (=). Full details of the code are in Instruction Manual 2.

Fragmentation, or Multipunch Code

At the time that the retrievals were carried out for this study, a punch card code was used in CPI to deal with structural and special property concepts of chemicals. For the "chemical" sections of CPI (i.e., Sections B, C and E), details of the fragmentation code used were given in Instruction Manual 3, the Chemical Retrieval Manual. The code used for polymer concepts (in CPI Section A) is described in Instruction Manual 4 (Plasdoc Retrieval Manual).

In an ancilliary service to the punch card codes, the RIN (Ring Index Numbers) system, unique registry numbers are assigned for any ring systems which were not completely coded by a single unambiguous punch card position in the chemical code. For those systems recorded in the

```
AACH   AACHEN GERRESHEIMER GMBH
AACH  =GEVETEX TEXTILGLAS
AAGR   AAGRUNOL                NV
AAIC   AAI                     CORP
AARB   AARONSON BROS           LTD
AARH   AARHUS OLIEFABRIK       A/S
AARI   RICE A A                INC
AARN   AARON R                 ETAB
AAWK   ALWO ALTENBURGER VEB
AAWK  =VEB ALWO ALTENBURGER
ABBE   ABBEY CHEMICALS
ABBE  =ABBEY SPORTS CO LTD
ABBM   ABBOTT MACHINE          CO
ABBO  *ABBOTT LABORATORIES
ABBQ   ABBEY QUILTING          LTD
ABBU  *ARBUZOV ORG PHYS CHEM
ABBU  =INST ORG FIZ KHIM ARBUZO
ABBV   ABBYVILLE               CORP
ABCO   ABCOR                   INC
ABCO  =ABCOR WATER MANAGEM
ABEC   AB ELECTRONIC COMP      LTD
ABEE  =ABEL SOC ETAB
ABEE   SOC ETAB ABEL
ABEK   ABEKAWA KOGYO           KK
ABEN   AB ENGINEERING          CO
ABEX  *ABEX                    CORP
ABIC  *ABIC                    LTD
ABIC  =ABIC CHEMICAL LAB
ABIS   ABISAN                  CORP
ABIT   ABITIBI PAPER CO        LTD
ABIT  =ABITIBI POWER & PAPER
ABLO   FABRICA PROD QUIMIC
ABMA   ABRASIVE METAL PROD     INC
ABMA  =ABRASIVE PRODUCTS
ABME   AB METAL PRODUCTS       LTD
ABPL   AB PLASTICS             LTD
ABRD   ABRASIVE DEV            LTD
ABRI   ABRIL IND WAXES         LTD
ABRS   ABRAHAMS & SONS PTY     LTD
ABUA   ABU                     AB
ACCE   ACCELERATED IND         INC
ACCF *=ACCUMULATEURS FIXES     SOC
ACCF  =SAFT BATTERIES LTD

ACCF  =SAFT SOC ACCUMUL FIXES
ACCF  *SOC ACCUMUL FIXES       TRAC
ACCL   ACCLES & POLLOCK        LTD
ACCM   ACCMETA                 SA
ACDE   ATEL CONSTR D'EPLUCHES

ACTP   ACTIPHARMA SOC CIV
ACTP  =SOC CIV ACTIPHARMA
ACTV   ACTIVIT OCTROOIEN M     NV
ACTV  =OCTROOIEN ACTIVIT M
ADAI   ADAM CO                 INC
ADAL   ADAMANT LAB
ADAM   ADAM CONSOL IND         INC
ADAP   ADAMS PAPER CONVERT     CO
ADAS   ADAMS C & CO            LTD
ADAU   ADAMSON UNITED          CO
ADCO  @AD CHEM CO       -NOW   ADCP
ADCO   ADCOTE CHEMICALS        INC
ADCP  - SEE ADCO (B)
ADCP  +AD CHEMICAL             INC
ADDI   ADDI-COLOR              AG
ADDR  *ADDRESSOGRAPH-MULTI     CORP
ADEC   ADELAIDE CHEM & FER     LTD
ADEK   ADEKA-ARGUS IND         KK
ADEK  =ADEKA-ARGUS KOGYO       KK
ADEL   ADAMS ELECTRONICS       INC
ADEW   ADELAIDE & WALLAROO
ADHE   ADHESIVE TAPES          LTD
ADHE  =INDUSTRIAL SEALANTS
ADHK   ADHEYA KAKO             KK
ADHR   ADHERE KAKO             KK
ADIN   ADHESIVES NUNEZ S L     IND
ADIN  =NUNEZ ADHESIVES S L
ADIS   ADIS CHEMICAL           KK
ADIS  =ADIS KASEI              KK
ADME   ADMEL INTERNATIONAL
ADMS   ADAMS L                 LTD
ADON   ADONSELL                LTD
ADOX   ADOX FOTOWERKE
ADRE  =ADREMA PITNEY-BOWES
ADRE   ADREMA-WERKE            GMBH
ADRS   ANDERSON & SON D        LTD
ADSC   ADS CHEMICAL            CO
ADSE   ATELIERS SECHERON       SA
ADVA   ADVANCE GLOVE MFG       CO
ADVA  @ADVANCE GROWTH- NOW     ADVC
ADVC  - SEE ADVA (B)
ADVC  +ADVANCE GROWTH CAPI     CORP
ADVE   ADVERTISING PUBLICI     LTD
ADVF   ADVANCE FINISHING       INC
ADVI   ADVANCE INDUSTRIES      INC
ADVP   ADVANCE PROC SUPPLY     CO
ADVR   ADVANCE RESEARCH        CO
AEBW   ALLGEMEINER ELEKTRO
AECR   AERO CHEM RES LAB       INC
```

Figure 11: Part of the WPI/CPI List of Standard Patentee Codes

American Chemical Society's Patterson Ring Index the number used in that publication was assigned, otherwise a Derwent-assigned number was used.

The scheme for encoding fused ring heterocyclic compounds (card columns 17 to 28) is shown in Figure 12. Details of the definitions of part of card column 26 and card column 28 are shown in Figure 13, and the complete coding of Cephalothin in Figure 14 in order to illustrate the code.

In 1981, after the retrievals for this study were conducted, a majcr revision of the chemical coding system took place and a new chemical code introduced. The principal feature of this revised code is that it is independent of the limitations of punch cards, i.e., to combinations of the 960 possible positions, an advance brought about by the flexibility of the online system and the disappearence of the need to supply subscribers with punch coded cards per se. The removal of the punch card format limitations has led to the use of codes for increased numbers of features and thus an increase in the specificity of the code. During a major revision of the online files early in 1982, the former assigned codes were converted to the new codes. The RIN system, as mentioned above, continues to be assigned without any change.

HETEROCYCLICS [FUSED RING]

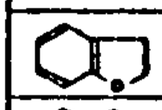
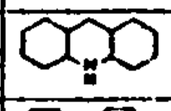
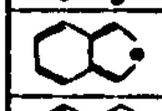
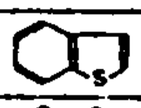
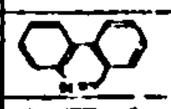
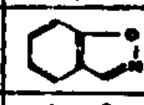
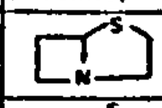
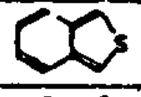
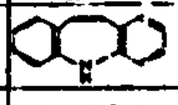
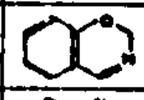
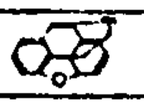
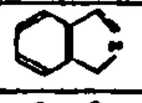
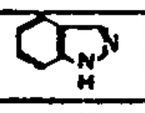
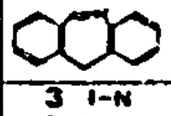
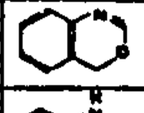
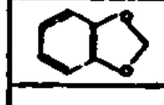
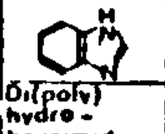
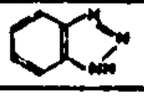
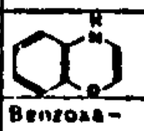
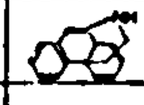
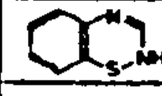
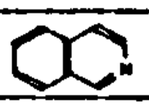
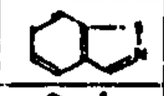
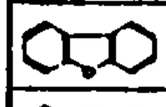
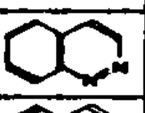
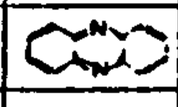
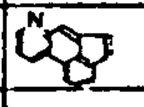
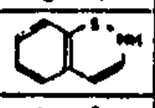
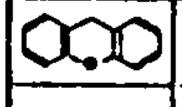
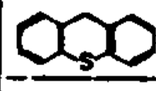
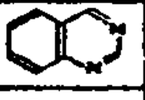
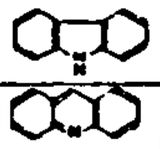
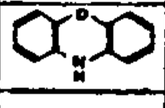
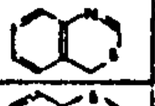
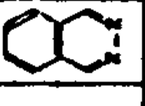
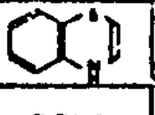
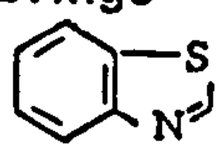
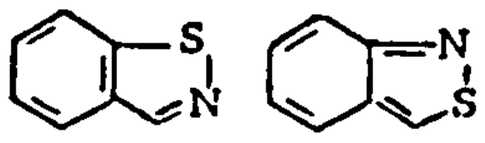
	17	18	19	20	21	22	23	24	25	26	27	28
12		⟩3 ⟩2-O	2⟩2-O+S	Tropanes.	Pyrido-pyridines	Pyrazolo-pyridazines		3 2-N		3 ⟩3 O+N	Benzothia-zepines (-ocines)	3 2S+1N
11			⟩3⟩2-O+S	Quinuclidines	Benzodia-zepines (-ocines)	Pyrazolo-pyrimidines		3 3-N		4 ⟩1N+⟩1-O		Azapheno-thiazines
0				2 1-N	2 2-N	Imidazo pyrimidines						3 1S+2N
1	2 1-O				2 3-N Both 5-memb.	1236-Tetra-& hexahydro-purine		3 4-N		5 1-O+2-N	2 S+N	3 ⟩4-S+N
2		2 1-S				Pyrazino-pyrimidines	3 1-N Natom angular	3 ⟩3-N		⟩5 ⟩1O+⟩1-N	2 2S+1N	4 ⟩1-S+⟩1-N
3	Benzodioxins	2 2-S	Di(poly)hydro quinolines.	Di(poly) hydro - benzimid-azoles.	Imidazo-pyridines	Pyrimido-pyrimidines	3 1-N		Benzoxa-zepines (-ocines)			⟩5 ⟩1-S+⟩1-N
4	2 2-O ⟩3-O	2 ⟩3-S		Pyrrolo-pyridines	Pyrazolo-pyridine	Pyrazino-pyridazines	Carbolines	4 1-N	2 O+N		2 1S+2N	2 ⟩1S+⟩1-O +⟩1-N
5			Di(poly)hydro isoquinolines		Pyrrolo-pyrimidines	2 4-N			2 ⟩3-O+N		2 ⟩4 S+N	3 ⟩1-S+⟩1-O +⟩1-N
6			Benzazepines		Pyrido-pyrimidines	2 ⟩5-N	Dipyrido [a,c]-benzenes	4 ⟩2-N				⟩4 ⟩1-S+⟩1-O +⟩1-N
7	3 1-O	⟩3 1-S	Benzazocines		2 3-N			Yohimbanes			3 S+N (same ring)	Fused ring Heterocyclic General
8	3 2-O	⟩3 ⟩2-S	Indolizines Quinolizines		Pyrazolo-pyrazines		Dibenzodiaz-epines (-ocines)	⟩5 ⟩1+N	3 O+N		3 S+N not same ring	Spiro
9	POLY	POLY	POLY	POLY	POLY	POLY	POLY	POLY	POLY	POLY	POLY	POLY

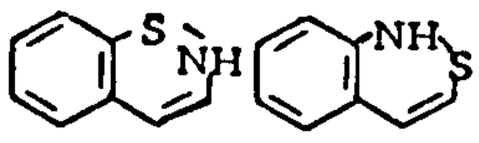
Figure 12: Part of the Multipunch Code for Section B showing schematically the Meanings of each position in card columns 17 to 28

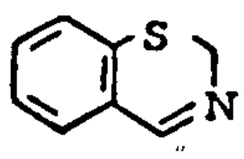
SOLE HETEROS S & N

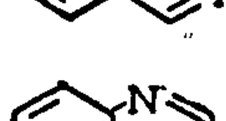
With 2 rings

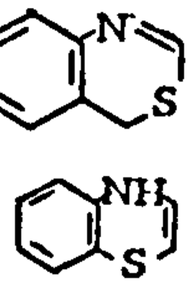
26 3 .. 

4 .. 

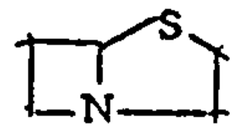
5 .. 

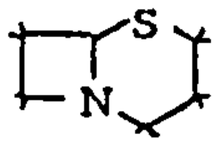
6 .. 

7 .. 

8 .. 

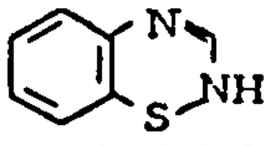
27 & ..benzothiazepines (-ocines)

– .. May be unsatd. 

0 .. May be unsatd. 

1 ..others, 1–S & 1–N

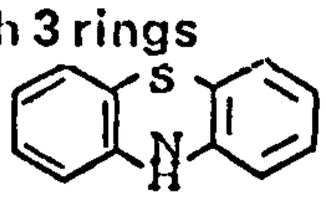
2 ..with 2–S & 1–N

3 .. 

4 ..others, 1–S & 2–N

5 ..others

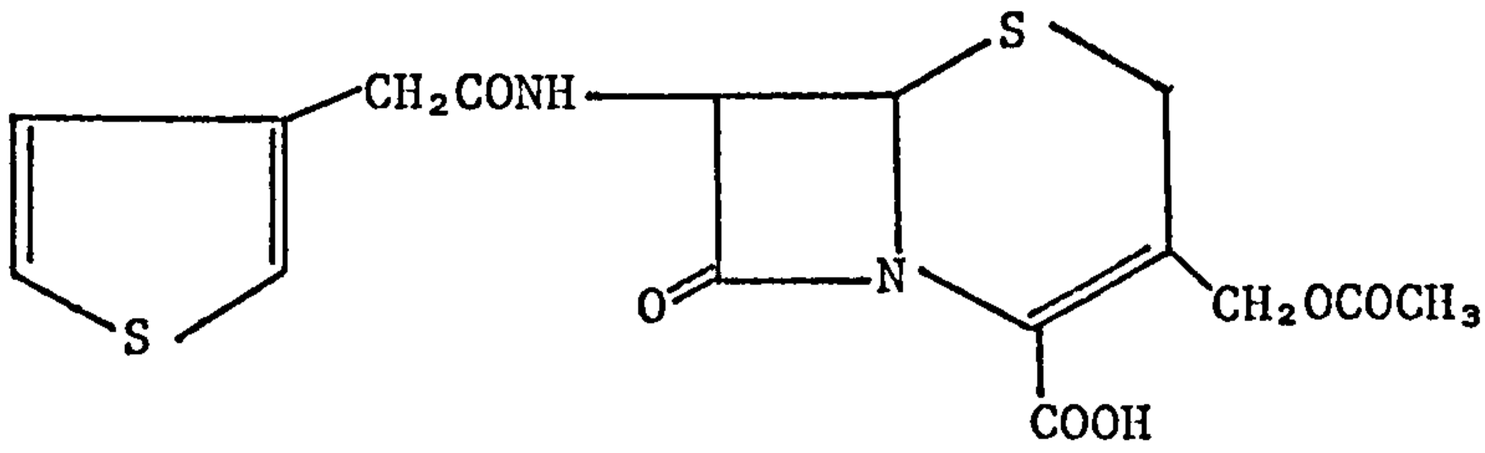
With 3 rings

6 .. 

7 ..with 1–S & 1–N in same ring, excl. 27/6

8 ..with 1–S & 1–N not in same ring

Figure 13: Detailed Explanation of the Multipunch Code for CPI Section B for part of Column 26 and for Column 27



Cephalothin

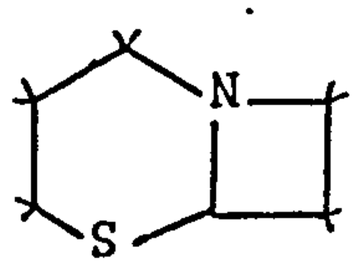
Card Column	Position	Explanation
1	3	Antibiotic - cephalosporin type
27	0	Fused heterocyclic ring system, sole hetero atoms S and N, saturated or unsaturated:- 
30	0	Mononuclear heterocycle, sole heteroatom one S or N, furan or thiophene :- 
47	12	One carboxylic acid group (-COOH) linked through C-atom in heterocyclic group
48	5	Carboxamide group (-CONH) linked through N to C-atom in heterocyclic ring
50	12	One oxo group (=O) linked to C-atom in heterocyclic ring
51	1	Ester group ($-CH_2OCO-$) linked through C-atom to an aliphatic carbon ($-CH_3$)
58	1	Antibacterial
59	11	One fused ring heterocyclic system
61	12	One monocyclic heterocycle
62	11	No aromatic rings present
62	0	No alicyclic rings present
64	11	Natural product coded in Sections B and/or C
68	12	Section B control punch
71	3	"Basic Group" = heterocyclic fused ring

Figure 14: Complete Multipunch Coding for Cephalothin

11: METHODOLOGY AND RESULTS

Cephalosporins Data Analysis

Two sets of Cephalosporins patents data sets were retrieved as described in Appendix I. The original set was retrieved in October 1979; this was supplemented with a set of updating data two years later.

The original data set was analysed through a series of computer generated lists as described in Appendix I. The data obtained from these lists was subsequently amended with the information from the update retrieval.

The computer generated lists and supplemental data were used to prepare a series of tables as follows:

Table 9 : Patentee Names and Countries for Proprietary Companies
Table 10 : Patentees and Countries for Academic Institutes
Table 11 : Patentees and Countries for Not-for-Profit Organisations
Table 12 : Patentee Names for Private Inventors
Table 13 : Patentees (excluding private inventors) Listed by Country of Domesticity
Table 14 : Patentees Ranked by Earliest Priority Date
Table 15 : Patentees Ranked by Earliest Publication Date
Table 16 : Patentees Ranked by Number of Cephalosporin Patents
Table 17 : Patentees (excluding private inventors) Ranked by Total Number of Patents in Database pre-1980
Table 18 : Patentees (excluding private inventors) Ranked by Total Number of Patents in CPI Section B pre-1980
Table 19 : Patentees (excluding private inventors) Ranked by Percentage of Total pre-1980 Patents in CPI Section B
Table 20 : Patentees (excluding private inventors) Ranked by Percentage of Total CPI Section B Patents which are for Cephalosporins
Table 21 : Classification of Cephalosporin Patents into Types of Invention

Tables 17 - 21 inclusive contain data in respect of the original Cephalosporin data set only.

PATENTEE NAME	COUNTRY
Abbott Laboratories Inc.	USA
Ajinomoto KK	Japan
Akzo NV	Netherlands
Albert Rolland SA	France*
Alfa Farmaceutici SpA	Italy
Alza Corporation	USA
American Cyanamid Company	USA
American Home Products Corp.	USA
Amstar Corporation	USA
Antibiotics SA	Spain
Aries Associates SA	France
Asahi Chemical Industries KK	Japan
Astra Pharmaceutica AB	Sweden
Ausonia Farmaceutici SRL	Italy*
Banyu Pharmaceutical Company Limited	Japan
Bayer AG	Germany
Beecham Group Limited	UK
Biochemie GmbH	Austria
Boehringer Mannheim GmbH	Germany
Boehringer Sohn GmbH, C.H.	Germany
Bristol Myers Company	USA
Bristol-Banyu KK	Japan
Carlo Erba SpA	Italy
Caw Industries Inc.	USA
Chemie Grunenthal GmbH	Germany
Chemische Fabriken von Heyden GmbH	Germany
Chugai Pharmaceuticals KK	Japan
Ciba-Geigy Limited	Switzerland
Clin-Midy SA, Laboratoires	France
Connlab Holdings Limited	Canada
Craf Sud SpA	Italy
Cusi SA, Laboratorios	Spain
Daiichi Seiyaku Company Limited	Japan*
Dainippon Pharmaceuticals KK	Japan
Dobfar SpA	Italy
Dow Chemical Company	USA
du Pont de Nemours & Company, E.I.	USA
Dynamit Nobel AG	Germany
Eiken Kagaku KK	Japan
Eisai Company Limited	Japan*
Eli Lilly & Company	USA
Ethicon Inc.	USA
Farmitalia SpA	Italy
Fermion Oy	Finland
Ferrer & Cia. SA, Laboratorios	Spain
Fisher Scientific Company	USA
Forest Laboratories Inc.	USA
Fujisawa Pharmaceutical Industries KK	Japan
Gallardo SA, A.	Spain
Gema SA	Spain
Gist-Brocades NV	Netherlands
Glaxo Group Limited	UK
Grelan Pharmaceutical Company Limited	Japan*
Hodogaya Chemical Industries KK	Japan

Table 9: Patentee Names and Countries for Proprietary Companies
(*From Cephalosporins update set only)

PATENTEE NAME	COUNTRY
Hoechst AG	Germany
Hoffmann-La Roche Company Limited, F.	Switzerland
ICI Limited	UK
ISF Italseber SpA	Italy
Instituto Luso-Farmaco SarL	Portugal
Instituto de Farmacologia Espanola SA	Spain
Intellectual Property Development Corp.	USA
Ist. Biochim. Ital. de Loredana Lorenzini SAS	Italy
KRKA-Farmacevtica	Yugoslavia
Kaneko Pharmaceuticals Limited	Japan
Key Pharmaceuticals Corporation	USA*
Kissei Pharmaceutical Company Limited	Japan
Kommanditbolaget Kockums Chemicals AB	Sweden
Kureha Chemical Industries KK	Japan
Kyoto Ceramic Company Limited	Japan*
Kyowa Hakko Kogyo KK	Japan
Lafarqium SA, Laboratorios Farmaceutico Quimico	Spain
Landerlan SA, Cia. Internationale Farmacia	Spain
Lark SpA	Italy
Leo Pharmaceutical Products AB	Sweden
Lepetit SpA	Italy
Liofilizaciones Esterilizaciones y Sinteses SA	Spain*
Lumac International NV	Netherlands Antilles
McDonnell Douglas Corporation	USA
Meiji Seika KK	Japan
Merck & Company Inc.	USA
Merck AG, E.	Germany
Merrell-Toraude SA, Laboratoires	France
Miles Laboratories Inc.	USA
Mitsubishi Chemical Industries KK	Japan
Mitsubishi Petroleum Company Limited	Japan
Mitsui Toatsu Chemicals Inc.	Japan*
Mundipharma AG	Switzerland
National Patent Development Corporation	USA
Nelson Research & Development Company	USA
Nikken Chemicals Company Limited	Japan
Nikko Chemicals Industries KK	Japan
Nippi Inc.	Japan
Nippon Chemifar Company Limited	Japan
Nippon Kagaku KK	Japan
Nippon Shinyaku KK	Japan
Nisshin Flour Milling Company Limited	Japan
Novo Industries A/S	Denmark
Ohta Seiyaku KK	Japan
Organon NV	Netherlands
Otsuka Pharmaceuticals KK	Japan
Parke Davis & Company	USA
Pencillin Assays Inc.	USA*
Pfizer Inc.	USA
Pharmacia AB	Sweden
Pharmaco Inc.	USA
Pierrel SpA	Italy

Table 9: Patentee Names and Countries for Proprietary Companies, continued
(*From Cephalosporins update set only)

PATENTEE NAME	COUNTRY
Plantex Limited	Israel*
Procter & Gamble Company	USA
Proter SpA	Italy
Purdue Frederick Company	USA
R & L Molecular Research	Canada
Recherches et Industries Therapeutique SA	Belgium
Rhone-Poulenc SA	France
Richardson-Merrell	USA
Roussel-Uclaf SA	France
Sandoz Limited	Switzerland
Sankyo Company Limited	Japan
Sanraku-Ocean KK	Japan
Sawai Seiyaku KK	Japan*
Scherico Limited	Switzerland
Schering AG	Germany*
Seoul Pharmaceutical Industries KK	S. Korea
Shionogi Limited	Japan
Showa Denka KK	Japan*
Sigma-Tau SpA	Italy
Smith, Kline & French Laboratories Inc.	USA
Snam-Progetti SpA	Italy
Societe Chemie et Biologie	France*
Societe Omnium-Chimique SA	Belgium
Sparamedica AG	Germany
Squibb & Sons Inc., E.R.	USA
Stada Arzneimittel GmbH	Germany
Sumitomo Chemical Company	Japan
Sutures Inc.	USA
Syntex Corporation	USA
Takeda Chemical Industries	Japan
Tanabe Pharmaceutical Company	Japan
Teijin KK	Japan
Teikoku Chemical Industries	Japan
Teikoku Hormone Manufacturing Company	Japan
Thekan SA, Laboratoires	France
Thomae GmbH, Dr. Karl	Germany*
Tobishi Pharmaceutical Company	Japan
Toho Pharmaceutical Laboratories Company	Japan
Toho Yakuhin Kogyo KK	Japan
Tokyo Tanabe KK	Japan
Toray Industries Inc.	Japan
Toshin Chemical Industries KK	Japan
Toyama Chemical Industries KK	Japan
Toyo Jozo KK	Japan
Toyobo KK	Japan
Unilever BV	Netherlands
Union Carbide Corporation	USA
Upjohn Company	USA
Verronmay Limited	UK*
Viridis, Etablissements	Leichtenstein
Wakamoto Pharmaceutical Company	Japan
Warner-Lambert Company	USA
Wellcome Foundation Limited	UK
Yamanouchi Pharmaceutical Company	Japan
Yoshitomi Pharmaceutical Industries KK	Japan

Table 9: Patentee Names and Countries for Proprietary Companies, concluded
(*From Cephalosporins update set only)

PATENTEE NAME	COUNTRY
Antibiotics Research Institute	USSR
Baylor College of Medicine	USA
Institute Recherche Scientifique	France
Instytut Przemyslu Farmaceutyczneco	Poland
Massachusetts Institute of Technology	USA
Osaka University	Japan
Politechnica Gdanska	Poland
Priorov Traumatolog	USSR
Purdue Research Foundation	USA
Purdue University	USA
Queens University	Canada
Regents of the University of California	USA
Woodward, R. B., Prof.	USA
Yeda Research & Development	Israel

Table 10: Patentee Names and Countries for Academic Institutes

PATENTEE NAME	COUNTRY
Agence Nationale de Valorisation	France
Chinoin Gyogyszer	Hungary
NASA	USA
National Research & Development Corporation	UK
Research Corporation	USA
Sagami Chemical Research Centre	Japan
Sendai Institute of Heterocyclic Chemistry	Japan*
Zaidan Hojin Sangyo Kagaku KK	Japan
Zaidan Hojin Seikan-Kai	Japan

Table 11: Patentee Names and Countries for Not-for-Profit Organisations
(*From Cephalosporins update set only)

Ansberg, S. E.	Levine, B. B.*	Peters, H. V.*
Banker, G. S.	MacLaren, S. A.	Petrzilka, T.
Bocher, D.	Marx, R.	Prugnard, R. L.
Charm, S. E.	Masuda, G.	Romano, A.*
Crast, L. B.	Metcalf, B. W.	Sakakida, T.
Gregor, H. P.	Miyauchi, Y.*	Scheicher, H.
Higashikawa, T.	Naito, T.	Stapley, E. O.
Ito, S.	Ogura, H.	Takino, H.
Jackson, B. G.	Panoz, D. E.*	Treuner, V. D.
Keck, J. M.	Pereira da Luz, A.	Yamada, S.

Table 12: Patentee Names for Private Inventors
(*From Cephalosporins update set only)

COUNTRY	PATENTEE NAME
Austria	Biochemie GmbH
Belgium	Recherches et Industries Therapeutique SA
	Societe Omnium-Chimique SA
Canada	Connlab Holdings Limited
	Queens University
	R & L Molecular Research
Denmark	Novo Industries A/S
Finland	Fermion Oy
France	Agence Nationale de Valorisation
	Albert Rolland SA*
	Aries Associates SA
	Institute de Recherches Scientifiques
	Laboratoires Clin-Midy SA
	Laboratoires Merrell-Toraude SA
	Laboratoires Thekan SA
	Rhone-Poulenc SA
	Roussel-Uclaf SA
	Societe Chimie et Biologie*
Germany, W.	Bayer AG
	Boehringer Mannheim GmbH
	C.H. Boehringer Sohn GmbH
	Chemie Grunenthal GmbH
	Chemische Fabriken von Heyden GmbH
	Dr. Karl Thomae GmbH*
	Dynamit Nobel AG
	E. Merck AG
	Hoechst AG
	Schering AG*
	Sparamedica AG
	Stada Arzneimittel GmbH
Hungary	Chinoin Gyogyszer es Vegyeszeti Termekek Gyara RT
Israel	Plantex Limited*
	Yeda Research & Development
Italy	Alfa Farmaceutici SpA
	Ausonia Farmaceutici SRL*
	Carlo Erba SpA
	Craf Sud SpA
	Dobfar SpA
	Farmitalia SpA
	ISF Italseber SpA
	Istituto Biochimico Italiano di Loredana Lorenzini SAS
	Lark SpA
	Lepetit SpA
	Pierrel SpA
	Proter SpA
	Sigma-Tau SpA
	Snam-Progetti SoA
Japan	Ajinomoto KK
	Asahi Chemical Industries KK
	Banyu Pharmaceutical Company Limited
	Bristol-Banyu KK
	Chugai Pharmaceuticals KK

Table 13: Patentees (excluding private inventors) listed by Country of Domesticity
(*From Cephalosporins update set only)

COUNTRY	PATENTEE NAME
Japan, continued	Daiichi Seiyaku Company Limited*
	Dainippon Pharmaceuticals KK
	Eiken Kagaku KK
	Eisai Company Limited*
	Fujisawa Pharmaceuticals Industries KK
	Grelan Pharmaceutical Company Limited*
	Hodogaya Chemical Industries KK
	Kanebo Pharmaceuticals Limited
	Kissei Pharmaceutical Company Limited
	Kureha Chemicals Industries KK
	Kyoto Ceramic Company Limited*
	Kyoto Yakuhin Kogyo*
	Kyowa Hakko Kogyo KK
	Meiji Seika KK
	Mitsubishi Chemical Industries KK
	Mitsubishi Petroleum Company Limited
	Mitsui Toatsu Chemicals Inc.*
	Nikken Chemicals Company Limited
	Nikko Chemical Industries KK
	Nippi Inc.
	Nippon Chemifar Company Limited
	Nippon Kagaku KK
	Nippon Shinyaku KK
	Nisshin Flour Milling Company Limited
	Ohta Seiyaku KK
	Ono Pharmaceuticals KK
	Osaka University
	Otsuka Pharmaceuticals KK
	Sagami Chemical Research Centre
	Sankyo Company Limited
	Sanraku-Ocean KK
	Sawai Seiyaku KK*
	Shionogi Limited
	Showa Denko KK*
	Sumitomo Chemical Company
	Takeda Chemical Industries
	Tanabe Pharmaceutical Company KK
	Teijin KK
	Teikoku Chemical Industries
	Teikoku Hormone Manufacturing Company
	Tobishi Pharmaceutical Company
	Toho Pharmaceutical Laboratories Company
	Toho Yakuhin Kogyo KK
	Tokyo Tanabe KK
	Toray Industries Inc.
	Toshin Chemical Industries
	Toyama Chemical Industries KK
	Toyobo KK
	Toyo Jozo KK
	Wakamoto Pharmaceutical Company KK
	Yamanouchi Pharmaceutical Company
	Yoshitomi Pharmaceutical Industries KK
	Zaidan Hojin Sangyo Kagaku KK
	Zaidan Hojin Seiken-Kai

Table 13: Patentees (excluding private inventors) listed by Country of Domesticity, continued
(*From Cephalosporins update set only)

COUNTRY	PATENTEE NAME
Korea	Seoul Pharmaceutical Industries KK
Liechtenstein	Etablissement Viridis
Netherlands	Akzo NV
	Gist-Brocades NV
	Organon BV
	Unilever BV
Netherlands Antilles	Lumac International NV
Poland	Instytut Przemyslu Farmaceutyczneco
	Politechnika Gdanska
Portugal	Instituto Luso-Farmaco SARL
Spain	A. Gallardo SA
	Antibioticos SA
	Cia. Internationale Farmacia Landerlan SA
	Gema SA
	Instituto de Farmacolgia Espanola SA
	Laboratorios Cusi SA
	Laboratorios Farmaceutico Quimico Lafarquim SA
	Laboratorios Ferrer & Cie SA
	Liofilizaciones Esterilizaciones y Sinteses SA*
Sweden	Astra Pharmaceutica AB
	Kommanditbolaget Kockums Chemical AB
	Leo Pharmaceutical Products AB
	Pharmacia AB
Switzerland	Ciba-Geigy Limited
	F. Hoffmann-La Roche Company Limited
	Mundipharma AG
	Sandoz Limited
	Scherico Limited
UK	Beecham Group Limited
	Glaxo Group Limited
	ICI Limited
	National Research & Development Corporation
	Verronmay Limited*
	Wellcome Foundation Limited
USA	Abbott Laboratories Inc.
	Alza Corporation
	American Cyanamid Company
	American Home Products Corporation
	Amstar Corporation
	Baylor College of Medicine
	Bristol Myers Company
	Caw Industries Inc.
	Dow Chemical Company
	E.I. du Pont de Nemours & Company
	E.R. Squibb & Sons Inc.
	Eli Lilly & Company
	Ethicon Corporation
	Fisher Scientific Company
	Forest Laboratories Inc.
	Intellectual Property Development Corporation
	Key Pharmaceuticals Inc.*
	Massachusetts Institute of Technology

Table 13: Patentees (excluding private inventors) listed by Country of Domesticity, continued
(*From Cephalosporins update set only)

COUNTRY	PATENTEE NAME
	McDonnell Douglas Corporation
	Merck & Company Inc.
	Miles Laboratories Inc.
	NASA
	National Patent Development Corporation
	Nelson Research & Development Company
	Parke Davis & Comapay
	Penicillin Assays Inc.*
	Pfizer Inc.
	Pharmaco Inc.
	Procter & Gamble Company
	Purdue Frederick Company
	Purdue Research Foundation
	Purdue University
	Regents of the University of California
	Research Corporation
	Richardson-Merrell Inc.
	Smith, Kline & French Laboratories Inc.
	Sutures Inc
	Syntex Corporation
	Union Carbide Corporation
	Upjohn Company
	Warner-Lambert Company
	Woodward, R. B., Prof.
USSR	Antibiotics Research Institute
	Priorov Traumatolog
Yugoslavia	KRKA-Farmacevtica

Table 13: Patentees (excluding private inventors) listed by Country of Domesticity, concluded
(*From Cephalosporins update set only)

PATENTEE NAME	Earliest Priority Date	RANK
National Research & Development Corp.	02.02.55	1
Eli Lilly & Company	16.11.59	2
Glaxo Group Ltd.	06.04.60	3
Pfizer Inc.	28.06.60	4
Merck & Company Inc.	11.07.60	5
Smith, Kline & French Laboratories Inc.	15.08.60	6
Ciba-Geigy Limited	25.07.61	7
Bristol Myers Company	16.08.61	8
Farmitalia SpA	25.07.62	9
E.R. Squibb & Sons Inc.	29.10.62	10
Astra Pharmaceuticals AB	14.12.62	11
Bayer AG	27.02.63	12
Fujisawa Pharmaceutical Industries KK	13.04.63	13
Jackson, B.G.	05.03.65	14
Aries Associates SA	21.06.65	15
R & L Molecular Research	28.06.65	16
Roussel-Uclaf SA	03.08.65	17
Woodward, R.B., Prof.	10.09.65	18
Organon NV	24.11.65	19
Ajinomoto KK	16.09.66	20=
Toyobo KK	16.09.66	20=
American Cyanamid Company	15.02.67	22
Beecham Group Limited	07.03.67	23
Leo Pharmaceutical Products AB	10.03.67	24
Parke Davis & Company	11.05.67	25
Research Corporation	22.06.67	26
Societe Omnium-Chimique SA	28.07.67	27
Institute de Recherches Scientifiques	01.08.67	28
Gist-Brocades NV	07.08.67	29
Bristol-Banyu KK	28.11.67	30
National Patent Development Corp.	13.08.68	31
Banker, G.S.	03.09.68	32=
Purdue University	03.09.68	32=
American Home Products Corp.	16.09.68	34
Osaka University	02.04.69	35
Yamanouchi Pharmaceutical Company	22.09.69	36
Sankyo Company Limited	19.11.69	37
Syntex Corporation	19.01.70	38
Takeda Chemical Industries	11.02.70	39
Akzo NV	18.02.70	40
Laboratoires Thekan SA	23.02.70	41
Chemie Grunenthal GmbH	30.05.70	42
Regents of the University of California	22.06.70	43
Toyama Chemical Industries KK	17.10.70	44
Kyowa Hakko Kogyo KK	11.12.70	45
Toyo Jozo KK	19.12.70	46
Hoechst AG	28.12.70	47
Caw Industries Inc.	20.01.71	48

Table 14: Cephalosporin Patentees Ranked by Earliest Priority Date
(*From Cephalosporins update data set only)

PATENTEE NAME	Earliest Priority Date	RANK
Chemische Fabriken von Heyden GmbH	22.02.71	49
Union Carbide Corporation	08.03.71	50
Teikoku Hormone Manufacturing Company	22.03.71	51
Upjohn Company	12.04.71	52
Snam-Progetti SpA	28.04.71	53
Alfa Farmaceutici SpA	13.08.71	54
F. Hoffmann-La Roche Company Limited	03.01.72	55
Sakakida, T.	05.01.72	56
Yeda Research & Development	18.01.72	57
Crast, L.B.	31.01.72	58
Takino, H.	14.02.72	59
Queens University	10.04.72	60
Sutures Inc.	12.04.72	61
Meiji Seika KK	14.04.72	62
Fermion Oy	12.05.72	63
Sumitomo Chemical Company	31.05.72	64
Treuner, V.D.	01.06.72	65
Purdue Research Foundation	09.06.72	66
Recherches et Industries Therapeutiques SA	22.06.72	67
Shionogi Limited	29.06.72	68
Laboratoires Clin-Midy SA	30.06.72	69
Naito, T.	26.07.72	70
Maclaren, S.A.	03.08.72	71
Bocher, D.	18.08.72	72
Biochemie GmbH	05.09.72	73
Dainippon Pharmaceuticals KK	06.09.72	74
Ist. Biochim. Ital. di Loredana Lorenzini	02.11.72	75
E.I. du Pont de Nemours & Company	11.11.72	76
Masschusetts Institute of Technology	14.11.72	77
Nikken Chemicals Company Limited	02.12.72	78
Novo Industries A/S	27.12.72	79
Yamada, S.	23.01.73	80
Politechnica Gdanska	07.02.73	81
Gema SA	21.02.73	82
A. Gallardo SA	08.03.73	83
Instituto Luso-Farmaco SARL	16.03.73	84
Priorov Traumatolog	09.04.73	85
E. Merck AG	21.04.73	86
Stapley, E.O.	06.06.73	87
Banyu Pharmaceutical Company Limited	11.06.73	88
Kanebo Pharmaceutical Limited	18.06.73	89
Pereira da Luz, A.	02.07.73	90
Carlo Erba SpA	27.07.73	91
Rhone-Poulenc SA	06.09.73	92
Dynamit Nobel AG	28.09.73	93=
Laboratorios Ferrer & Cia. SA	28.09.73	93=
Richardson-Merrell Inc.	07.11.73	95
Teijin KK	28.12.73	96

Table 14: Cephalosporin Patentees Ranked by Earliest Priority Date, continued
(*From Cephalosporins update data set only)

PATENTEE NAME	Earliest Priority Date	RANK
Lepetit SpA	03.01.74	97
Toshin Chemical Industries KK	07.02.74	98
Nikko Chemical Industries KK	08.02.74	99
Ogura, H.	06.03.74	100
ISF Italseber SpA	02.04.74	101
Pharmacia AB	03.04.74	102
Teikoku Chemical Industries	09.04.74	103
Zaidan Hojin Sangyo Kagaku KK	28.05.74	104
Zaidan Hojin Seikan-kai	03.06.74	105
Sparamedica AG	21.06.74	106
Amstar Corporation	03.07.74	107
Asahi Chemical Industries KK	09.07.74	108
Chinoin Gyogyszer	30.07.74	109
ICI Limited	08.08.74	110
Keck, J.M.	21.09.74	111
Nippon Kagaku KK	27.09.74	112
Hodogaya Chemical Industries KK	09.11.74	113
Instytut Przemyslu Farmaceutyczneco	25.11.74	114
McDonell Douglas Corporation	02.12.74	115
Ethicon Inc.	11.12.74	116
Nisshin Flour Milling Company Limited	28.12.74	117
Ito, S.	07.01.75	118
Kissei Pharmaceutical Company Limited	08.01.75	119
Alza Corporation	28.01.75	120
Otsuka Pharmaceuticals KK	21.02.75	121
Laboratorios Cusi SA	03.03.75	122
C.H. Boehringer Sohn GmbH	07.03.75	123
Intellectual Property Development Corp.	12.03.75	124
Sanraku-Ocean KK	18.03.75	125
Antibiotics Research Institute	20.03.75	126
Nelson Research & Development Company	11.04.75	127
Lab. Farmaceutico Quimico Lafarquim SA	14.04.75	128
Chugai Pharmaceuticals KK	24.04.75	129
NASA	30.04.75	130
Boehringer Mannheim GmbH	17.05.75	131=
Instituto de Farmacologia Espanola SA	17.05.75	131=
Proter SpA	27.05.75	133
Wakamoto Pharmaceutical Company	17.06.75	134
Connlab Holdings Limited	23.06.75	135
Dobfar SpA	26.06.75	136
Mitsubishi Chemical Industries KK	16.09.75	137
Pierrel SpA	01.10.75	138
Gregor, H.P.	07.11.75	139
Dow Chemical Company	21.11.75	140
KRKA-Farmacevtica	05.12.75	141
Abbott Laboratories Inc.	08.12.75	142=
Procter & Gamble Company	08.12.75	142=
Ansberg, S.E.	24.12.75	144

Table 14: Cephalosporin Patentees Ranked by Earliest Priority Date, continued
(*From Cephalosporins update data set only)

PATENTEE NAME	Earliest Priority Date	RANK
Mitusubishi Petroleum Company Limited	27.12.75	145
Tokyo Tanabe KK	30.12.75	146
Unilever BV	12.01.76	147
Seoul Pharmaceutical Industries KK	19.01.76	148
Antibioticos SA	20.01.76	149
Fisher Scientific Company	19.02.76	150
Pharmaco Inc.	02.03.76	151
Sagami Chemical Research Centre	04.03.76	152
Agence Nationale de Valorisation	26.03.76	153
Forest Laboratories Inc.	05.05.76	154
Yoshitomi Pharmaceutical Industries KK	06.05.76	155
Cia. Internationale Farmacia Landerlan SA	08.05.76	156
Nippi Inc.	20.05.76	157
Ono Pharmaceuticals KK	27.05.76	158
Eiken Yagaku KK	04.06.76	159
Marx, R.	16.06.76	160
Toko Yakuhin Kogyo KK	21.06.76	161
Establissements Viridis	28.06.76	162
Kommanditbolaget Kockums Chemical AB	29.06.76	163
Lumac International NV	30.06.76	164
Tobishi Pharmaceutical Company	26.07.76	165=
Toho Pharmaceutical Laboratories Company	26.07.76	165=
Nippon Chemifar Company Limited	30.07.76	167
Mundipharma AG	25.08.76	168=
Purdue Frederick Company	25.08.76	168=
Kyoto Yakuhin Kogyo*	26.08.76	170
Nippon Shinyaku KK	19.10.76	171
Masuda, G.	30.11.76	172
Sherico Limited	17.12.76	173
Toray Industries Inc.	07.02.77	174
Higashikawa, T.	10.02.77	175
Stada Arzneimittel GmbH	04.03.77	176
Kureha Chemical Industries KK	13.04.77	177
Miles Laboratories Inc.	20.04.77	178
Warner-Lambert Company	03.06.77	179
Craf Sud SpA	07.06.77	180
Laboratoires Merrell-Touraude SA	01.07.77	181=
Metcalf, B.W.	01.07.77	181=
Petrzilka, T.	18.07.77	183
Prugnaud, R.L.	25.07.77	184
Sandoz Limited	27.07.77	185
Lark SpA	05.08.77	186
Ohta Seiyaku KK	12.08.77	187
Wellcome Foundation Limited	16.08.77	188
Tanabe Pharmaceutical Company	22.09.77	189
Charm, S.E.	21.11.77	190=
Penicillin Assays Incorporated*	21.11.77	190=
Baylor College of Medicine	02.12.77	192

Table 14: Cephalosporin Patentees Ranked by Earliest Priority Date, continued
(*From Cephalosporins update data set only)

PATENTEE NAME	Earliest Priority Date	RANK
Scheicher, H.	16.12.77	193
Daiichi Seiyaku Company Limited*	28.12.77	194
Verronmay Limited*	23.01.78	195
Sigma-Tau SpA	27.01.78	196
Mitsui Toatsu Chemicals Incorporated*	21.03.78	197
Miyauchi, Y.*	31.03.78	198
Levine, B.B.*	20.04.78	199
Peters, H.V.*	23.05.78	200
Liofilizaciones Esterilizaciones y Sintesis*	08.06.78	201=
Albert Rolland SA*	08.06.78	201=
Dr. Karl Thomae GmbH*	28.06.78	203
Sawai Seiyaku KK*	26.08.78	204
Ausonia Farmaceutici SRL*	20.10.78	205
Plantex Limited*	20.11.78	206
Showa Denko KK*	06.12.78	207
Panoz, D.E.*	22.12.78	208
Societe Chimie et Biologie*	04.01.79	209
Schering AG*	10.01.79	210
Key Pharmaceuticals Incorporated*	11.01.79	211
Kyoto Ceramic Company Limited*	13.02.79	212
Eisai Company Limited*	09.04.79	213
Sendai Institute of Heterocyclic Chemistry*	13.04.79	214
Grelan Pharmaceutical Company Limited*	01.06.79	215
Romano, A.*	31.10.79	216

Table 14: Cephalosporin Patentees Ranked by Earliest Priority Date, concluded
(*From Cephalosporins update data set only)

PATENTEE NAME	Earliest Publication Date	RANK
National Research & Development Corp.	07.09.60	1
Smith, Kline & French Laboratories Inc.	10.08.61	2
Pfizer Inc.	06.09.61	3
Glaxo Group Limited	12.02.62	4
Eli Lilly & Company	11.02.63	5
Bristol Myers Company	18.02.63	6
Merck & Company Inc.	05.03.63	7
Ciba-Geigy Limited	15.08.63	8
Farmitalia SpA	12.02.64	9
E.R. Squibb & Sons Inc.	30.06.64	10
Bayer AG	28.08.64	11
Aries Associates SA	13.05.66	12
Astra Pharmaceuticals AB	30.06.66	13
Fujisawa Pharmaceutical Industries KK	10.08.66	14
R & L Molecular Research	23.08.66	15
Roussel-Uclaf SA	17.02.67	16
Woodward, R. B., Prof.	19.02.67	17
Organon NV	25.05.67	18
American Cyanamid Comapny	12.09.67	19
Beecham Group Limited	20.09.67	20
Societe Omnium-Chimique SA	02.01.68	21
Toyobo KK	18.03.68	22
Leo Pharmaceutical Products AB	12.07.68	23
Research Corporation	31.10.68	24
Institute de Recherches Scientifique	06.01.69	25
Gist-Brocades NV	31.01.69	26
Bristol-Banyu KK	19.05.69	27
Parke Davis & Company	22.07.69	28
National Patent Development Corporation	13.02.70	29
American Home Products Corporation	16.03.70	30
Ajinomoto KK	18.03.70	31
Banker, G. S.	30.04.70	32
Yamanouchi Pharmaceutical Company	01.04.71	33
Jackson, B. G.	04.05.71	34
Sankyo Company Limited	27.05.71	35
Osaka University	15.07.71	36
Laboratories Thekan SA	16.07.71	37
Takeda Chemical Industries	10.08.71	38
Akzo NV	17.08.71	39
Purdue University	21.09.71	40
Chemie Grunenthal GmbH	02.12.71	41
Regents of the University of California	15.12.71	42
Toyama Chemical Industries KK	20.04.72	43
Hoechst AG	30.06.72	44
Snam-Progetti SpA	16.08.72	45
Syntex Corporation	22.08.72	46
Chemische Fabriken von Heyden GmbH	21.09.72	47
Teikoku Hormone Manufacturing Company	12.10.72	48
Kyowa Hakko Kogyo KK	25.10.72	49
Sutures Inc.	08.02.73	50

Table 15: Patentees Ranked by Earliest Publication Date

PATENTEE NAME	Earliest Publication Date	RANK
Alfa Farmaceutici SpA	22.02.73	51
Yeda Research & Development	23.03.73	52
Union Carbide Corporation	27.06.73	53
F. Hoffmann-La Roche Company Limited	05.07.73	54
Sakakida, T.	11.10.73	55
Toyo Jozo KK	23.10.73	56
Meiji Seika KK	25.10.73	57
Purdue Research Foundation	11.12.73	58
Naito, T.	18.12.73	59
Recherches et Industries Therapeutiques SA	27.12.73	60
Laboratoires Clin-Midy SA	10.01.74	61=
Shionogi Limited	10.01.74	61=
Sumitomo Chemical Company	22.01.74	63=
Queens University	22.01.74	63=
Ist. Biochim. Ital. di Lorendana Lorenzini	15.02.74	65
Bocher, D.	18.02.74	66
Fermion Oy	05.03.74	67
Biochemie GmbH	07.03.74	68
Novo Industries A/S	16.04.74	69
Dainippon Pharmaceuticals KK	27.04.74	70
Crast, L. B.	28.05.74	71
Nikken Chemicals Company Limited	11.06.74	72
Gema SA	17.06.74	73
Massachusetts Institute of Technology	26.07.74	74
Politechnica Gdanska	14.08.74	75
Yamada, S.	09.09.74	76
A. Gallardo SA	12.09.74	77
Pereira da Luz, A.	16.09.74	78
Instituto Luso-Farmaco SARL	26.09.74	79
MacLaren, S. A.	08.10.74	80
E. Merck AG	21.10.74	81
Carlo Erba SpA	18.11.74	82
Dynamit Nobel AG	16.01.75	83
Stapley, E. O.	28.01.75	84=
Treuner, V. D.	28.01.75	84=
Banyu Pharmaceutical Company Limited	13.02.75	86
Kanebo Pharmaceuticals Limited	15.02.75	87
Richardson-Merrell Inc.	03.03.75	88
Rhone-Poulenc SA	05.03.75	89
Laboratorios Ferrer & Cia SA	02.04.75	90
Lepetit SpA	10.07.75	91
Teijin KK	31.07.75	92
Nikko Chemical Industries KK	26.08.75	93=
Toshin Chemical Industries KK	26.08.65	93=
Ogura, H.	02.10.75	95=
Upjohn Company	02.10.75	95=
ISF Italseber SpA	09.10.75	97
Pharmacia AB	16.10.75	98
Teikoku Chemical Industries	18.10.75	99
E.I. du Pont de Nemours & Company	21.10.75	100

Table 15: Patentees Ranked by Earliest Publication Date
Continued

PATENTEE NAME	Earliest Publication Date	RANK
Chinoin Gyogyszer	17.11.75	101=
Laboratorios Cusi SA	17.11.75	101=
Zaidan Hojin Sangyo Kagaku KK	02.12.75	103
Zaidan Hojin Seikan-kai	12.12.75	104
Sparamedica AG	22.12.75	105
Lab. Farmaceutico Quimico Lafarquim SA	26.12.75	106
Asahi Chemical Industries KK	20.01.76	107
Ito, S.	30.01.76	108
ICI Limited	26.02.76	109
Keck, J. M.	02.04.76	110
Nippon Kagaku KK	03.04.76	111
Hodogaya Chemical Industries KK	18.05.76	112=
Intellectual Property Development Corp.	18.05.76	112=
McDonnell Douglas Corporation	18.05.76	112=
Priorov Traumatolog	20.05.76	115
Instytut Przemyslu Farmaceutyczneco	16.06.76	116
Nisshin Flour Milling Company Limited	12.07.76	117
Kissei Pharmaceutical Company Limited	15.07.76	118
Ethicon Inc.	13.08.76	119
Otsuka Pharmaceuticals KK	30.08.76	120
Boehringer Mannheim GmbH	01.09.76	121=
Instituto de Farmacologia Espanola SA	01.09.76	121=
C.H. Boehringer Sohn GmbH	16.09.76	123
Alza Corporation	28.09.76	124
Sanraku-Ocean KK	29.09.76	125
Caw Industries Inc.	05.10.76	126
Connlab Holdings Limited	18.10.76	127=
Nelson Research & Development Corporation	18.10.76	127=
Chugai Pharmaceuticals KK	02.12.76	129
Wakamoto Pharmaceutical Company	22.12.76	130
Proter SpA	31.12.76	131
Dobfar SpA	11.01.77	132
Pierrel SpA	17.01.77	133
Amstar Corporation	18.01.77	134
Antibiotics Research Institute	24.02.77	135
Kommanditbolaget Kockums Chemical AB	16.03.77	136
Mitsubishi Chemical Industries KK	22.03.77	137
NASA	29.03.77	138
Gregor, H. P.	18.05.77	139
Dow Chemical Company	26.05.77	140
KRKA-Farmacevtica	08.06.77	141
Procter & Gamble Company	21.06.77	142
Abbott Laboratories Inc.	23.06.77	143
Unilever BV	11.07.77	144
Mitsubishi Petroleum Company LImited	12.07.77	145=
Tokyo Tanabe KK	12.07.77	145=
Antibioticos SA	21.07.77	147
Seoul Pharmaceutical Industries KK	27.07.77	148
Sagami Chemical Research Centre	05.09.77	149
Pharmaco Inc.	06.09.77	150

Table 15: Patentees Ranked by Earliest Publication Date
Continued

PATENTEE NAME	Earliest Publication Date	RANK
Mundipharma AG	03.10.77	151=
Purdue Frederick Company	03.10.77	151=
Fisher Scientific Corporation	05.10.77	153
Cia. Internationale Farmacia Landerlan SA	14.11.77	154=
Yoshitomi Pharmaceutical Industries KK	14.11.77	154=
Forest Laboratories Inc.	17.11.77	156
Agence Nationale de Valorisation	25.11.77	157
Ono Pharmaceuticals KK	02.12.77	158
Nippi Inc.	08.12.77	159
Eiken Kagaku KK	10.12.77	160
Ansberg, S. E.	12.12.77	161
Toko Yakuhin Kogyo KK	19.12.77	162
Mark, R.	29.12.77	163
Lumac International NV	02.02.78	164
Tobishi Pharmaceutical Company	13.02.78	165=
Toho Pharmaceutical Laboratories Company	13.02.78	165=
Nippon Chemifar Company Limited	20.02.78	167
Etablissements Viridis	03.03.78	168
Miles Laboratories Inc.	07.03.78	169
Nippon Shinyaku KK	08.05.78	170
Scherico Limited	15.06.78	171
Laboratoires Merrell-Toraude SA	11.07.78	172=
Metcalf, B. W.	11.07.78	172=
Warner-Lambert Company	18.07.78	174
Toray Industries Inc.	29.08.78	175
Takino, H.	04.09.78	176
Stada Arzneimittel GmbH	07.09.78	177
Kureha Chemical Industries KK	17.10.78	178
Higashikawa, T.	28.11.78	179
Craf Sud SpA	04.01.79	180
Lark SpA	14.02.79	181
Sandoz Limited	19.02.79	182
Wellcome Foundation Limited	21.02.79	183
Ohta Seiyaku KK	10.03.79	184
Charm, S. E.	16.03.79	185
Baylor College of Medicine	20.03.79	186
Masuda, G.	27.03.79	187
Prugnard, R. L.	30.03.79	188
Petrzilka, T.	10.04.79	189
Tanabe Pharmaceutical Company	17.04.79	190
Sigma-Tau SpA	16.05.79	191
Scheicher, H.	21.06.79	192
Daiichi Seiyaku Company Limited	23.07.79	193
Verronmay Limited	08.08.79	194
Liofilizacions Esterilizaciones y Sintesis	01.10.79	195
Miyauchi, Y.	06.10.79	196
Albert Rolland SA	13.12.79	197
Peters, H. V.	20.12.79	198
Dr. Karl Thomae GmbH	09.01.80	199
Ausonia Farmaceutici SRL	15.02.80	200=

Table 15: Patentees Ranked by Earliest Publication Date
Continued

PATENTEE NAME	Earliest Publication Date	RANK
Romano, A.	15.02.80	200=
Kyoto Yakuhin Kogyo	16.04.80	202=
Sawai Seiyaku KK	16.04.80	202=
Plantex Limited	28.05.80	204
Mitsui Toatsu Chemicals Inc.	04.06.80	205
Panoz, D. E.	17.06.80	206
Showa Denka KK	19.06.80	207
Schering AG	23.07.80	208=
Key Pharmaceuticals Inc.	23.07.80	208=
Kyoto Ceramic Company Limited	21.08.80	210
Societe Chemie et Biologie	05.09.80	211
Eisai Company Limited	08.10.80	212
Sendai Institute of Heterocyclic Chemistry	31.10.80	213
Grelan Pharmaceutical Company Limited	12.12.80	214
Penicillin Assays Inc.	15.12.80	215
Levine, B. B.	24.02.81	216

Table 15: Patentees Ranked by Earliest Publication Date Concluded

(Note: Publication Dates from 23.07.79 onwards are from Update Set)

PATENTEE NAME	NUMBER OF PATS.	RANK
Fujisawa Pharmaceutical Industries KK	316	1
Eli Lilly & Company	273	2
Takeda Chemical Industries	153	3
E. R. Squibb & Sons Inc.	140	4
Glaxo Group Limited	134	5
Ciba-Geigy Limited	114	6
Bristol Myers Company	109	7
Merck & Co. Inc.	103	8
Smith, Kline & French Laboratories Inc.	88	9
Sankyo Company Limited	87	10
Yamanouchi Pharmaceutical Company	82	11
Beecham Group Limited	65	12
Toyama Chemical Industries KK	59	13
Meiji Seika KK	50	14
Shionogi Limited	47	15
Roussel-Uclaf SA	46	16
American Home Products Corporation	45	17=
Asahi Chemical Industries KK	45	17=
Teijin KK	42	19
Sumitomo Chemical Company	41	20
Hoechst AG	37	21
Bayer AG	36	22
Toyo Jozo KK	32	23
Aries Associates SA	31	24=
Chemische Fabriken von Heyden GmbH	31	24=
Banyu Pharmaceutical Company Limited	29	26
Zaidan Hojin Sangyo Kagaku KK	26	27
Pfizer Inc.	24	28=
Yeda Research & Development	24	28=
Gist-Brocades NV	22	30
Nippon Kagaku KK	20	31
Farmitalia SpA	18	32=
Laboratoires Merrell-Toraude SA	18	32=
Rhone-Poulenc SA	18	32=
National Research & Development Corporation	17	35
Toyobo KK	16	36
Hoffmann-La Roche Company Limited	15	37=
Kanebo Pharmaceuticals Limited	15	37=
Kyowa Hakko Kogyo KK	14	39
E. Merck AG	13	40=
Woodward, R. B., Prof.	13	40=
Leo Pharmaceutical Products AB	12	42
Dainippon Pharmaceuticals KK	11	43
American Cyanamid Company	10	44=
Novo Industries A/S	10	44=
Richardson-Merrell Inc.	10	44=
Ajinomoto KK	9	47=
Astra Pharmaceuticals AB	9	47=

Table 16: Patentees Ranked by Number of Cephalosporin Patents
(*From Cephalosporins update set only)

PATENTEE NAME	NUMBER OF PATS.	RANK
Hodogaya Chemical Industries Kk	8	49=
Massachussets Institute of Technology	8	49=
Nikken Chemicals Company Limited	8	49=
Parke Davis & Company	8	49=
Nippon Chemifar Company Limited	7	53=
R & L Molecular Research	7	53=
Biochemie GmbH	6	55=
Bristol-Banyu KK	6	55=
Carlo Erba SpA	6	55=
Proter SpA	6	55=
Recherches et Industries Therapeutique SA	6	55=
Syntex Corporation	6	55=
Alfa Farmaceutici SpA	5	61=
Chugai Pharmaceuticals KK	5	61=
Gema SA	5	61=
Osaka University	5	61=
Queens University	5	61=
Teikoku Chemical Industries	5	61=
Antibioticos SA	4	67=
Chemie Grunenthal GmbH	4	67=
Connlab Holdings Limited	4	67=
Daiichi Seiyaku Company Limited*	4	67=
E. I. Du Pont de Nemours & Company	4	67=
Politechnica Gdanska	4	67=
Kissei Pharmaceutical Company Limited	4	67=
Otsuka Pharmaceuticals KK	4	67=
Dr. Karl Thomae GmbH*	4	67=
Toshin Chemical Industries KK	4	67=
Boehringer Mannheim GmbH	3	77=
Caw Industries Inc.	3	77=
Laboratorios Cusi SA	3	77=
Dobfar SpA	3	77=
Dow Chemical Company	3	77=
Fermion Oy	3	77=
A. Gallardo SA	3	77=
Ist. Biochim. Ital. di Loredana Lorenzini SAS	3	77=
Kyoto Yakuhin Kogyo*	3	77=
Mitsui Toatsu Chemicals Incorporated*	3	77=
Mitsubishi Chemical Industries KK	3	77=
Nelson Research & Development Company	3	77=
Pierrel SpA	3	77=
Sagami Chemical Research Center	3	77=
Sakakida, T.	3	77=
Sandoz Limited	3	77=
Snam-Progetti SpA	3	77=
Sutures Inc.	3	77=
Tanabe Pharmaceutical Company	3	77=
Tobishi Pharmaceutical Company	3	77=

Table 16: Patentees Ranked by Number of Cephalosporin Patents, (continued)
(*From Cephalosporins update set only)

PATENTEE NAME	NUMBER OF PATS.	RANK
Upjohn Company	3	77=
Warner-Lambert Company	3	77=
Abbott Laboratories	2	99=
Alza Corporation	2	99=
Ausonia Farmaceutici SRL*	2	99=
Banker, G. S.	2	99=
Chinoin Gyogyszer	2	99=
Laboratoires Clin-Midy SA	2	99=
Eisai Company Limited*	2	99=
Fisher Scientific Company	2	99=
Forest Laboratories Inc.	2	99=
Grelan Pharmaceutical Company Limited*	2	99=
ISF Italseber SpA	2	99=
Lab. Farmaceutico Quimico Lafarquim SA	2	99=
Lepetit SpA	2	99=
Liofilizaciones Esterilizaciones y Sintesis S.A.*	2	99=
Instituto Luso-Farmaco SarL	2	99=
McDonnell Douglas Corp.	2	99=
Mitsubishi Petroleum Company	2	99=
Ohta Seiyaku KK	2	99=
Ono Pharmaceuticals KK	2	99=
Procter & Gamble Company	2	99=
Purdue Research Foundation	2	99=
Regents of the University of California	2	99=
Research Corporation	2	99=
Scherico Limited	2	99=
Schering AG*	2	99=
Sigma-Tau SpA	2	99=
Toray Industries Inc.	2	99=
Etablissements Viridis	2	99=
Yamada, S.	2	99=
Akzo NV	1	128=
Amstar Corporation	1	128=
Ansberg, S. B.	1	128=
Antibiotics Research Institute	1	128=
Agence Nationale de Valorisation	1	128=
Baylor College of Medicine	1	128=
Bocher, D.	1	128=
C. H. Boehringer Sohn GmbH	1	128=
Charm, S. E.	1	128=
Societe Chimie et Biologie*	1	128=
Cia. Internationale Farmacia Landerlan SA	1	128=
Craf Sud SpA	1	128=
Crast, L. B.	1	128=
Pereira da Luz, A.	1	128=
Dynamit Nobel AG	1	128=
Eiken Kagaku KK	1	128=
Ethicon Inc.	1	128=

Table 16: Patentees Ranked by Number of Cephalosporin Patents, (continued)
(*From Cephalosporins update set only)

PATENTEE NAME	NUMBER OF PATS.	RANK
Instytut Przemyslu Farmaceutyczneco	1	128=
Instituto de Farmacologia Espanola SA	1	128=
Gregor, H. P.	1	128=
Higashikawa, T.	1	128=
ICI Limited	1	128=
Institute de Recherches Scientifique	1	128=
Intellectual Property Development Corporation	1	128=
Ito, S.	1	128=
Jackson, B. G.	1	128=
Keck, J. M.	1	128=
Key Pharmaceuticals Incorporated*	1	128=
Kommanditbolaget Kockums Chemical AB	1	128=
KRKA-Farmacevtica	1	128=
Kureha Chemical Industries KK	1	128=
Kyoto Ceramic Company Limited*	1	128=
Lark SpA	1	128=
Levine B. B.*	1	128=
Laboratorios Ferrer & Cia SA	1	128=
Albert Rolland SA*	1	128=
Lumac International NV	1	128=
Marx, R.	1	128=
Masuda, G.	1	128=
Maclaren, S. A.	1	128=
Metcalf, B. W.	1	128=
Miles Laboratories Inc.	1	128=
Miyauchi Y.*	1	128=
Mundipharma AG	1	128=
Naito, T.	1	128=
Nippi Inc.	1	128=
Nisshin Flour Milling Company Limited	1	128=
Nikko Chemical Industries KK	1	128=
Nippon Shinyaku KK	1	128=
National Patent Development Corp.	1	128=
Ogura, H.	1	128=
Organon NV	1	128=
Panoz, D. E.*	1	128=
Penicillin Assays Incorporated*	1	128=
Peters, H. V.*	1	128=
Petrzilka, T.	1	128=
Pharmacia AB	1	128=
Pharmaco Inc.	1	128=
Plantex Limited*	1	128=
Priorov Traumatolog	1	128=
Prugnaud, R. L.	1	128=
Purdue University	1	128=
Purdue Frederick Company	1	128=
Romano, A.*	1	128=
Sanraku-Ocean KK	1	128=

Table 16: Patentees Ranked by Number of Cephalosporin Patents, (continued)
(*From Cephalosporins update set only)

PATENTEE NAME	NUMBER OF PATS.	RANK
Sawai Seiyaku KK*	1	128=
Scheicher, H.	1	128=
Zaidan Hojin Seikan-Kai	1	128=
Sendai Institute of Heterocyclic Chemistry*	1	128=
Showa Denko KK*	1	128=
Societe Omnium-Chimique SA	1	128=
Seoul Pharmaceutical Industries KK	1	128=
Sparamedica AG	1	128=
Stada Arzneimittel GmbH	1	128=
Stapley, E. O.	1	128=
Takino, H.	1	128=
Tokyo Tanabe KK	1	128=
Teikoku Hormone Manufacturing Company	1	128=
Laboratoires Thekan SA	1	128=
Toho Pharmaceutical Laboratories Company	1	128=
Toko Yakuhin Kogyo KK	1	128=
Treuner, V.D.	1	128=
Union Carbide Corporation	1	128=
Unilever BV	1	128=
NASA	1	128=
Verronmay Limited*	1	128=
Wakamoto Pharmaceutical Company	1	128=
Wellcome Foundation Limited	1	128=
Yoshitomi Pharmaceutical Industries KK	1	128=

Table 16: Patentees Ranked by Number of Cephalosporin Patents, (concluded)
(*From Cephalosporins update set only)

PATENTEE NAME	TOTAL NUMBER PATENTS	RANK
Bayer AG	10,330	1
Asahi Chemical Industries KK	8,910	2
E.I. du Pont de Nemours & Company	8,836	3
Ciba-Geigy Limited	8,492	4
Sumitomo Chemical Company	8,157	5
ICI Limited	8,154	6
Teijin KK	7,888	7
Toray Industries	7,416	8
Hoechst AG	7,109	9
Toyobo KK	5,674	10
Union Carbide Corporation	4,481	11
American Cyanamid Company	3,819	12
Merck & Company Inc.	3,401	13
Takeda Chemical Industries	3,355	14
Sandoz Limited	3,332	15
Mitsubishi Chemical Industries KK	2,988	16
Upjohn Company	2,892	17
F. Hoffmann-La Roche Company Limited	2,627	18
Kanebo Pharmaceuticals Limited	2,625	19
Sankyo Company Limited	2,367	20
E.R. Squibb & Sons Inc.	2,303	21
Rhone-Poulenc SA	2,292	22
Ajinomoto KK	2,089	23
American Home Products Corporation	1,991	24
Tanabe Pharmaceutical Industries KK	1,951	25
Kyowa Hakko Kogyo KK	1,894	26
Dyanamit Nobel AG	1,836	27
Shionogi Limited	1,754	28
Fujisawa Pharmaceutical Industries KK	1,738	29
Unilever BV	1,709	30
Rousell-Uclaf SA	1.676	31
Procter & Gamble Company	1,602	32
Kureha Chemical Industries KK	1,598	33
Pfizer Inc.	1,485	34
National Research & Development Corporation	1,482	35
Eli Lilly & Company	1,472	36
Syntex Corporation	1,275	37
Yoshitomi Pharmaceutical Industries KK	1,272	38
NASA	1,268	39
Dow Chemical Company	1,249	40
Smith, Kline & French Laboratories Inc.	1,136	41
Nippon Kagaku KK	1,134	42
Agence Nationale de Valorisation	1,122	43
Dainippon Pharmaceuticals KK	888	44
Abbott Laboratories Inc.	883	45
Akzo NV	872	46
Warner-Lambert Company	832	47
Beecham Group Limited	829	48
Yamanouchi Pharmaceutical Company	823	49
Bristol Myers Company	810	50

Table 17: Patentees (excluding private inventors) Ranked by Total Number of Patents in database pre-1980

PATENTEE NAME	TOTAL NUMBER PATENTS	RANK
Mitsubishi Petroleum Company Limited	790	51
Boehringer Mannheim GmbH	783	52
C.H. Boehringer Sohn GmbH	710	53
E. Merck AG	697	54
Aries Associates SA	675	55
Nisshin Flour Milling Company Limited	639	56
Meiji Seika KK	636	57
Hodogaya Chemical Industries KK	630	58
Sagami Chemical Research Centre	628	59
Parke Davis & Company	603	60
Snam-Progetti SpA	595	61
Wellcome Foundation Limited	556	62
Miles Laboratories Inc.	541	63
Toyama Chemical Industries KK	530	64
Otsuka Pharmaceuticals KK	485	65
McDonnell Douglas Corporation	421	66
Glaxo Group Limited	391	67
Chugai Pharmaceuticals KK	388	68
Richardson-Merrell Inc.	364	69
Chinoin Gyogyszer	359	70
Zaidan Hojin Seikan-kai	345	71
Ono Pharmaceuticals KK	343	72
Farmitalia SpA	340	73
Teikoku Hormone Manufacturing Company	329	74
Nippon Shinyaku KK	304	75
Lepetit SpA	300	76
Research Corporation	298	77
Massachusetts Institute of Technology	263	78
Astra Pharmaceticals AB	248	79
Banyu Pharmaceuticals Company Limited	247	80
Scherico Limited	238	81
Organon NV	219	82
Toyo Jozo KK	210	83
Leo Pharmaceutical Products AB	188	84
Gist-Brocades NV	186	85
Ethicon Inc.	181	86
Nippon Chemifar Company Limited	177	87
Regents of the University of California	175	88
Nikken Chemicals Company Limited	147	89
Pharmacia AB	139	90
Yeda Research & Development	133	91
Alza Corporation	120	92
Chemische Fabriken von Heyden GmbH	117	93
Novo Industries A/S	116	94
National Patent Development Corporation	108	95
Purdue Research Foundation	105	96
Carlo Erba SpA	104	97
Societe Omnium-Chimique SA	91	98
Mundipharma AG	83	99
Laboratoires Clin-Midy SA	81	100

Table 17: Patentees (excluding private inventors) Ranked by Total Number of Patents in database pre-1980 (Continued)

PATENTEE NAME	TOTAL NUMBER PATENTS	RANK
Teikoku Chemical Industries	79	101
Wakamoto Pharmaceutical Company	78	102
Sparamedica AG	71	103
Recherches et Industries Therapeutique SA	70	104=
Chemie Grunenthal GmbH	70	104=
Kommandibolaget Kockums Chemical AB	68	106
Antibiotics Research Institute	67	107
Osaka University	66	108
Bristol-Banyu KK	61	109
Tokyo Tanabe KK	52	110
Institute de Recherches Scientifique	51	111
Laboratoires Merrell-Toraude SA	50	112
Eiken Kagaku KK	48	113
Nelson Research & Development Company	45	114
Zaidan Hojin Sangyo Kagaku KK	44	115
Sigma-Tau SpA	40	116
Pierrel SpA	36	117
Sutures Inc.	33	118
Sanraku-Ocean KK	30	119
A. Gallardo SA	28	120=
Gema SA	28	120=
R & L Molecular Research	28	120=
NIkko Chemical Industries KK	27	123
Alfa Farmaceutici SpA	24	124
Ohta Seiyaku KK	20	125
Toshin Chemical Industries KK	19	126
Caw Industries Inc.	18	127=
Ist. Biochim. Ital. di Loredana Lorenzini	18	127=
Kissei Pharmaceutical Company Limited	18	127=
Labostorios Ferrer & Cia SA	18	127=
Instituto Luso-Farmaco SARL	18	127=
ISF Italseber SpA	17	132=
Nippi Inc.	17	132=
Queens University	15	134
Tobishi Pharmaceutical Company	13	135=
Woodward, R. B., Prof.	13	135=
Purdue Frederick Company	12	137
Fisher Scientific Company	11	138=
Intellectual Property Development Corp.	11	138=
Baylor College of Medicine	10	140=
Connlab Holdings Limited	10	140
Proter SpA	10	140=
Lark SpA	9	143
Cia. International Farmacia Landerlan SA	8	144=
Instytut Przemyslu Faramaceutyczneco	8	144=
Toko Yakuhin Kogypo KK	8	144=
Amstar Corporation	7	147=
Fermion Oy	7	147=
Politechica Gdanska	7	147=
Priorov Traumatolog	7	147=

Table 17: Patentees (excluding private inventors) Ranked by Total Number of Patents in database pre-1980 (Continued)

PATENTEE NAME	TOTAL NUMBER PATENTS	RANK
Forest Laboratories Inc.	6	151=
Pharmaco Inc.	6	151=
Laboratorios Cusi SA	5	153=
Lab. Farmacutico Quimico Lafarquim SA	5	153=
Dobfar SpA	4	155=
Etablissements Viridis	4	155=
Antibioticos SA	3	157=
Biochemie GmbH	3	157=
Instituto de Farmacologica Espanola SA	3	157=
Craf-Sud SpA	2	160=
KRKA-Frmacevtica	2	160=
Lumac International NV	2	160=
Seoul Pharmaceutical Industries KK	2	160=
Toho Pharmaceuticals Laboratories Company	2	160=
Purdue University	1	165=
Stada Arzneimittel GmbH	1	165=
Laboratoires Thekan SA	1	165=

Table 17: Patentees (excluding private inventors) Ranked by Total Number of Patents in database pre-1980 (Concluded)

PATENTEE NAME	NUMBER OF PATENTS	RANK
Merck & Company Inc.	1,648	1
Takeda Chemical Industries	1,422	2
Sandoz Limted	1,397	3
Ciba-Geigy Limited	1,382	4
F. Hoffmann-La Roche Company Ltd.	1,378	5
Upjohn Company	1,257	6
American Home Products Corporation	1,242	7
Sumitomo Chemical Company	1,217	8
Tanabe Pharmaceutical Company	1,192	9
E. R. Squibb & Sons Inc.	966	10
Hoechst AG	924	11
Eli Lilly & Company	921	12
Fujisawa Pharmaceutical Industries KK	896	13
Ajinomoto KK	860	14
Kyowa Hakko Kogyo KK	848	15
American Cyanamid Comapny	809	16
Sankyo Company Limited	785	17
Yoshitomi Pharmaceutical Industries KK	775	18
Bayer AG	771	19
Pfizer Inc.	754	20
Shionogi Limited	682	21
Yamanouchi Pharmaceutical Company	630	22
Smith, Kline & French Laboratories Inc.	621	23
Roussell-Uclaf SA	552	24=
Teijin KK	552	24=
Beecham Group Limited	520	26
Syntex Corp.	502	27
Ashahi Chemical Industries KK	498	28
Warner-Lambert Company	494	29
Boehringer Mannheim GmbH	470	30
Bristol Myers Company	453	31
Abbott Laboratories Inc.	446	32
ICI Limited	440	33
Mitsubishi Chemical Industries KK	434	34
Aries Associates SA	387	35
C.H. Boehringer Sohn GmbH	341	36
Dainippon Pharmaceuticals KK	335	37
Meiji Seika KK	328	38
Otsuka Pharmaceuticals KK	312	39
Ono Pharmaceuticals KK	295	40
E. Merck AG	282	41
Kanebo Pharmaceuticals Limited	275	42
Chugai Pharmacueticals KK	273	43
Sagami Chemical Research Centre	271	44
Rhone-Poulenc SA	267	45
Toyama Chemical Industries KK	261	46
Wellcome Foundation Limited	254	47
Richardson-Merrell Inc.	252	48
E.I. du Pont de Nemours & Company	240	49
Parke Davis & Company	235	50

Table 18: Patentees (excluding private inventors) Ranked by Total Number of Patents in CPI Section B pre-1980

PATENTEE NAME	NUMBER OF PATENTS	RANK
Glaxo Group Limited	233	51
Chinoin Gyogyszer	220	52
Toyobo KK	211	53
Miles Laboratores Inc.	210	54=
Nippon Shinyaku KK	210	54=
Banyu Pharmaceutical Company Limited	202	56
Agence Nationale de Valorisation	191	57
Teikoku Hormone Manufacturing Company	190	58
Farmitalia SpA	174	59=
Kureha Chemical Industries KK	174	59=
Nippon Chemifar Company Limited	166	61
Lepetit SpA	165	62
Toyo Jozo KK	162	63
Procter & Gamble Company	160	64
Research Corporation	157	65
Nippoon Kagaku KK	150	66
Scherico Limited	129	67
Astra Pharmaceutica AB	126	68
Nisshin Flour Milling Company Limited	116	69
Akzo NV	107	70
Alza Corporation	105	71=
Gist-Brocades BV	105	71=
Leo Pharmceutical Products AB	95	73
Dynamit Nobel AG	88	74
Chemische Fabriken von Heyden GmbH	85	75
National Research & Development Corporation	81	76
Toray Industries Inc.	80	77
Unilever BV	79	78
Carlo Erba SpA	73	79
Societe Omnium-Chimique SA	70	80
Pharmacia AB	69	81
Sparamedica AG	62	82
Organon NV	60	83
Nikken Chemicals Company Limited	59	84=
Union Carbide Corporation	59	84=
Wakamoto Pharmaceuticals Company	58	86
Yeda Research & Development	52	87
Chemie Grunenthal GmbH	51	88
Antibiotics Research Institute	49	89=
Mundipharma AG	49	89=
Regents of the University of California	49	89=
Snam-Progetti SpA	49	89=
Mitsubishi Petroleum Company Limited	48	93=
Teikoku Chemical Industries	48	93=
Tokyo Tanabe KK	44	95
Novo Industries AS	43	96
Massachusetts Institute of Technology	42	97=
Nelson Research & Development Company	42	97=
Laboratoires Merrell-Toraude SA	39	99=
Zaidan Hojin Sangyo Kagaku KK	39	99=

Table 18: Patentees (excluding private inventors) Ranked by Total Number of Patents in CPI Section B pre-1980 (continued)

PATENTEE NAME	NUMBER OF PATENTS	RANK
Recherches et Industries Therapeutiques SA	38	101
Dow Chemical Company	37	102=
Eiken Kagaku KK	37	102=
Bristol-Banyu KK	35	104=
Laboratoires Clin-Midy SA	35	104=
National Patent Development Corp.	32	106=
Zaidan Hojin Sangyo Kagaku KK	32	106=
Sigma-Tau SpA	30	108
Osaka University	29	109=
Hodogaya Chemical Industries KK	24	110=
Sanraku-Ocean KK	24	110=
Purdue Research Foundation	23	112=
R & L Molecular Research	23	112=
NASA	22	114
Institute de Recherches Scientifique	21	115
Alfa Farmaceutici SpA	20	116=
Pierrel SpA	20	116=
A. Gallardo SA	18	118=
Laboratorios Ferrer & Cia. SA	18	118=
Instituto Luso-Farmaco SARL	18	118=
Ohta Seiyaku KK	18	118=
Ist. Biochim. Ital. di Loredana Lorenzini SAS	17	122=
ISF Italseber SpA	17	122=
McDonnell Douglas Corporation	17	122=
Kissei Pharmaceutical Company Limited	16	125
Ethicon Inc.	13	126=
Woodward, R. B., Prof.	13	126=
Tobishi Pharmaceutical Company	12	128
Intellectual Property Development Corporation	11	129
Connlab Holdings Limited	10	130=
Proter SpA	10	130=
Purdue Frederick Company	10	130=
Lark SpA	9	133=
Queens University	9	133=
Toshin Chemical Industries KK	9	133=
Cia. International Farmacia Landerlan SA	8	136=
Instytut Przemyslu Farmaceutyczneco	8	136=
Nippi Inc.	8	136=
Toko Yakuhin Kogyo KK	8	136=
Fermion Oy	7	140=
Sutures Inc.	7	140=
Fisher Scientific Company	6	142
Caw Industries Inc.	5	143=
Laboratorios Cusi SA	5	143=
Forest Laboratories Inc.	5	143=
Gema SA	5	143=
Nikko Chemical Industries	5	143=
Pharmaco Inc.	5	143=
Dobfar SpA	4	149=
Politechnica Gdanska	4	149=

Table 18: Patentees (excluding private inventors) Ranked by Total Number of Patents in CPI Section B pre-1980 (continued)

PATENTEE NAME	NUMBER OF PATENTS	RANK
Lab. Farmaceutico Quimico Lafarqium SA	4	149=
Etablissements Viridis	4	149=
Antibioticos SA	3	153=
Biochemie GmbH	3	153=
Instituto de Farmacologia Espanola SA	3	153=
Craf Sud SpA	2	156=
KRKA-Farmacevtica	2	156=
Seoul Pharmaceutical Industries KK	2	156=
Toho Pharmaceutical Laboratories Company	2	156=
Amstar Corporation	1	160=
Baylor College of Medicine	1	160=
Kommanditbolaget Kockums Chemical AB	1	160=
Lumac International NV	1	160=
Priorov Traumatolog	1	160=
Purdue University	1	160=
Stada Arzneimittel GmbH	1	160=
Laboratoires Thekan SA	1	160=

Table 18: Patentees (excluding private inventors) Ranked by Total Number of Patents in CPI Section B pre-1980 (concluded)

PATENTEE NAME	%	RANK
Antibioticos SA	100.00	1=
Biochemie GmbH	100.00	1=
Cia. Internationale Farmacia Landerlan SA	100.00	1=
Connlab Holdings Limited	100.00	1=
Craf Sud SpA	100.00	1=
Laboratorios Cusi SA	100.00	1=
Dobfar SpA	100.00	1=
Instytut Przemyslu Farmaceutyczneco	100.00	1=
Instituto de Farmacologia Espanola SA	100.00	1=
Fermion Oy	100.00	1=
Intellectual Property Development Corporation	100.00	1=
ISF Italseber SpA	100.00	1=
KRKA-Farmacevtica	100.00	1=
Lark SpA	100.00	1=
Laboratorios Ferrer SA	100.00	1=
Instituto Luso-Farmaco SARL	100.00	1=
Proter SpA	100.00	1=
Purdue University	100.00	1=
Seoul Pharmaceutical Industries KK	100.00	1=
Stada Arzneimittel GmbH	100.00	1=
Laboratoires Thekan SA	100.00	1=
Toho Pharmaceutical Laboratories Company	100.00	1=
Toko Yakuhin Kogyo KK	100.00	1=
Etablissements Viridis	100.00	1=
Woodward, R. B., Prof.	100.00	1=
Ist. Biochim. Ital di Loredana Lorenzini SAS	94.44	26
Nippon Chemifar Company Limited	93.79	27
Nelson Research & Development Company	93.33	28
Tobishi Pharmaceutical Company	92.31	29
Ohta Seiyaku KK	90.00	30
Kissei Pharmaceutical Company Limited	88.89	31
Alza Corporatipon	87.50	32
Sparamedica AG	87.32	33
Ono Pharmaceuticals KK	86.01	34
Tokyo Tanabe KK	84.62	35
Alfa Farmaceutici SpA	83.33	36=
Forest Laboratories Inc.	83.33	36=
Pharmaco Inc.	83.33	36=
Purdue Frederick Company	83.33	36=
R & L Molecular Research	82.14	40
Banyu Pharmaceutical Company Limited	81.78	41
Lab. Farmaceutico Quimico Lafarquim SA	80.00	42=
Sanraku-Ocean KK	80.00	42=
Laboratoires Merrell-Toraude SA	78.00	44
Toyo Jozo KK	77.14	45
Eiken Kagaku KK	77.08	46
Societe Omnium-Chimique SA	76.92	47
Yamanouchi Pharmaceutical Company	76.55	48
Sigma-Tau SpA	75.00	49
Wakamoto Pharmaceutical Company	74.36	50

Table 19: Patentees (excluding private inventors) Ranked by Percentage of Total pre-1980 Patents in CPI Section B

PATENTEE NAME	%	RANK
Antibiotics Research Institute	73.13	51
Chemie Grunenthal GmbH	72.86	52
Zaidan Hojin Sangyo Kagaku KK	72.73	53
Chemische Fabriken von Heyden GmbH	72.65	54
Chugai Pharmaceuticals KK	70.36	55
Carlo Erba SpA	70.19	56
Richardson-Merrell Inc.	69.23	57
Nippon Shinyaku KK	69.08	58
Otsuka Pharmaceutical KK	64.33	59
A. Gallardo SA	64.29	60
Beecham Group Limited	62 73	61
Eli Lilly & Company	62.57	62
American Home Products Corporation	62.38	63
Chinoin Gyogyzer	61.28	64
Tanabe Pharmaceutical Company	61.10	65
Yoshitomi Pharmaceutical Industries KK	60.93	66
Teikoku Chemical Industries	60.76	67
Boehringer Mannheim GmbH	60.03	68
Queens University	60.00	69
Glaxo Group Limited	59.59	70
Warner-Lambert Company	59.37	71
Mundipharma AG	58.33	72
Teikoku Hormone Manufacturing Company	57.75	73
Bristo-Banyu KK	57.38	74
Aries Associates SA	57.33	75
Politechnica Gdanska	57.14	76
Gist-Brocades NV	56.45	77
Bristol Myers Company	55.93	78
Pierrel SpA	55.56	79
Lepetit SpA	55.00	80
Smith, Kline & French Laboratories Inc.	54.67	81
Fisher Scientific Company	54.55	82
83cherches et Industries Therapeutique SA	54 29	83
Scherico Limited	54.20	84
Research Corporation	52.68	85
F. Hoffmann-La Roche Limited	52.46	86
Meiji Seika KK	51.57	87
Fujisawa Pharmaceutical Industries KK	51.55	88
Farmitalia SpA	51.18	89
Astra Pharmaceutical AB	50.81	90
Pfizer Inc.	50.77	91
Leo Pharmaceutical Products AB	50.53	92
Abbott Laboratories Inc.	50.51	93
Lumac International NV	50.00	94
Pharmacia AB	49.64	95
Toyama Chemical Industreis KK	49.25	96
Merck & Company Inc.	48.46	97
C.H. Boehringer Sohn GmbH	48.03	98
Toshin Chemical Industries KK	47.37	99
Nippi Inc.	47.06	100

Table 19: Patentees (excluding private inventors) Ranked by Percentage of Total pre-1980 Patents in CPI Section B
Continued

PATENTEE NAME	%	RANK
Wellcome Foundation Limited	45.68	101
Kyowa Hakko Kogyo KK	44.77	102
Osaka University	43.94	103
Upjohn Company	43.46	104
Laboratoires Clin-Midy SA	43.21	105
Sagami Chemical Research Centre	43.15	106
Takeda Chemical Industries	42.38	107
E.R. Squibb & Sons Inc.	41.95	108
Sandoz Limited	41.93	109
Institute de Recherche Scientifiques	41.18	110
Ajinomoto KK	41.17	111
E. Merck AG	40.46	112
Nikken Chemicals Company Limited	40.14	113
Syntex Corporation	39.37	114
Yeda Research & Development	39.10	115
Shionogi Limited	38.88	116
Miles Laboratories Inc,.	38.82	117
Parke Davis & Company	38.79	118
Dainippon Pharmaceuticals KK	37.73	119
Novo Industries A/S	37.07	120
Sankyo Company Limited	33.16	121
Roussel-Uclaf SA	32.94	122
National Patent Development Corporation	29.63	123
Regents of the University of California	28.00	124
Caw Industries Inc.	27.78	125
Organon NV	27.40	126
Purdue Research Foundation	21.90	127
Sutures Inc.	21.21	128
American Cyanamid Company	21.18	129
Nikkon Chemical Industries KK	18.52	130
Nisshin Flour Milling Company Limited	18.15	131
Gema SA	17.86	132
Agence Nationale de Valorisation	17.02	133
Ciba-Geigy Limited	16.27	134
Massachusetts Institute of Technology	15.97	135
Sumitomo Chemical Company	14.92	136
Mitsubishi Chemical Industries KK	14.52	137
Amstar Corporation	14.29	138=
Priorov Traumatolog	14.29	138=
Nippoon Kagaku KK	13.23	140
Hoechst AG	13.00	141
Akzo NV	12.27	142
Rhone-Poulenc SA	11.65	143
Zaidan Hojin Seikan-Kai	11.30	144
Kureha Chemical Industries KK	10.89	145
Kanebo Pharmaceuticals Limited	10.48	146
Baylor College of Medicine	10.00	147
Procter & Gamble Cpmpany	9.99	148
Snam-Progetti SpA	8.24	149
Bayer AG	7.46	150

Table 19: Patentees (excluding private inventors) Ranked by Percentage of Total pre-1980 Patents in CPI Section B
Continued

PATENTEE NAME	%	RANK
Ethicon Inc.	7.18	151
Teijin KK	7.00	152
Mitsubishi Petroleum Company Limited	6.08	153
Asahi Chemical Industries KK	5.59	154
National Research & Development Corporation	5.47	155
ICI Limited	5.40	156
Dynamit Nobel AG	4.79	157
Unilever BV	4.62	158
McDonnell Douglas Corporation	4.04	159
Hodogaya Chemical Industries KK	3.81	160
Toyobo KK	3.72	161
Dow Chemical Comapny	2.96	162
E.I. du Pont de Nemours & Company	2.72	163
NASA	1.74	164
Kommanditbolaget Kockums Chemical AB	1.47	165
Union Carbide Corporation	1.32	166
Toray Industries Inc.	1.08	167

Table 19: Patentees (excluding private inventors) Ranked by Percentage of Total pre-1980 Patents in CPI Section B
Concluded

PATENTEE NAME	%	RANK
Amstar Corporation	100.00	1=
Baylor College of Medicine	100.00	1=
Politechnica Gdanska	100.00	1=
Gema SA	100.00	1=
Kommanditbolaget Kockums Chemical AB	100.00	1=
Lumac International NV	100.00	1=
Priorov Traumatolog	100.00	1=
Purdue University	100.00	1=
Stada Arzneimittel GmbH	100.00	1=
Laboratoires Thekan SA	100.00	1=
Woodward, R. B., Prof.	100.00	1=
Zaidan Hojin Sangyo Kagaku KK	78.13	12
Dobfar SpA	75.00	13
Antibioticos SA	66.67	14
Caw Industries Inc	60.00	15=
Laboratorios Cusi SA	60.00	15=
Queens University	55.56	17
Glaxo Group Limited	50.21	18
Craf Sud SpA	50.00	19=
KRKA-Farmacevtica	50.00	19=
Lab. Farmaceutico Quimico Lafarquim SA	50.00	19=
Seoul Pharmaceutical Industries KK	50.00	19=
Toho Pharmaceutical Laboratories Company	50.00	19=
Etablissements Viridis	50.00	19=
Toshin Chemical Industries KK	44.44	25
Laboratoires Merrell-Toraude SA	43.59	26
Fermion Oy	42.86	27=
Sutures Inc.	42.86	27=
Proter SpA	40.00	29
Chemische Fabriken von Heyden GmbH	35.29	30
Biochemie GmbH	33.33	31=
Instituto de Farmacologia Espanola SA	33.33	31=
Fisher Scientific Company	33.33	31=
Hodogaya Chemical Industries KK	33.33	31=
Yeda Research & Development	32.69	35
Fujisawa Pharmaceutical Industries KK	32.25	36
R & L Molecular Research	30.43	37
Connlab Holdings Limited	30.00	38
Eli Lilly & Company	27.80	39
Alfa Farmaceutici SpA	25.00	40=
Kissei Pharmaceutical Company Limited	25.00	40=
Bristol Myers Company	22.30	42
National Research & Development Corporation	20.99	43
Forest Laboratories Inc.	20.00	44=
Gist-Brocades NV	20.00	44=
Nikko Chemical Industries KK	20.00	44=
Pharmaco Inc.	20.00	44=
Novo Industries A/S	18.60	48
Ist. Biochim. Ital. di Lorendana Lorenzini SAS	17.65	49
Toyama Chemical Industries KK	17.62	50

Table 20: Patentees (excluding private inventors) Ranked by Percentage of Total CPI Section B Patents which are for Cephalosporins

PATENTEE NAME	%	RANK
Toyo Jozo KK	17.28	51
Osaka University	17.24	52
Bristol-Banyu KK	17.14	53
A. Gallardo SA	16.67	54=
Tobishi Pharmaceutical Company	16.67	54=
Recherches et Industries Therapeutiques SA	15.79	56
Pierrel SpA	15.00	57
Massachusetts Institute of Technology	14.29	58
Meiji Seika KK	14.02	59
Smith, Kline & French Laboratories Inc.	13.85	60
E.R. Squibb & Sons Inc.	13.56	61
Cia Internationale Farmacia Landerlan SA	12.50	62=
Instytut Przemyslu Farmaceutyczneco	12.50	62=
Nippi Inc.	12.50	62=
Toko Yakuhin Kogyo KK	12.50	62=
Banyu Pharmaceutical Company Limited	12.38	66
ISF Italseber SpA	11.76	67=
McDonnell Douglas Corporation	11.76	67=
Leo Pharmaceutical Products AB	11.58	69
Yamanouchi Pharmaceutical Company	11.27	70
Beecham Group Limited	11.15	71
Lark SpA	11.11	72=
Instituto Luso-Farmaco SARL	11.11	72=
Takeda Chemical Industries	10.06	74
Purdue Frederick Company	10.00	75
Intellectual Property Development Corporation	9.09	76
Purdue Research Foundation	8.70	77
Nippon Kagaku KK	8.67	78
Sankyo Company Limited	8.66	79
Nikken Chemicals Company Limited	8.47	80
Teikoku Chemical Industries	8.33	81
Carlo Erba SpA	8.22	82
Dow Chemical Company	8.11	83
Farmitalia SpA	8.05	84
Aries Associates SA	8.01	85
Chemie Grunenthal GmbH	7.84	86
Asahi Chemical Industries KK	7.83	87
Ethicon Inc.	7.69	88
Teijin KK	7.61	89
Toyobo KK	7.58	90
Ciba-Geigy Limited	7.53	91
Astra Pharmaceutica AB	7.14	92=
Nelson Research & Development Company	7.14	92=
Snam-Progetti SpA	6.12	94
Shionogi Limited	6.01	95
Laboratoires Clin-Midy SA	5.71	96
Merck & Company Inc.	5.64	97
Laboratorios Ferrer & Cia SA	5.56	98=
Ohta Seiyaku KK	5.56	98=
Kanebo Pharmaceutical Limited	5.45	100

Table 20: Patentees (excluding private inventors) Ranked by Percentage of Total CPI Section B Patents which are for Cephalosporins, continued

PATENTEE NAME	%	RANK
Rhone-Poulenc SA	5.24	101
Institute de Recherches Scientifique	4.76	102
NASA	4.55	103
E. Merck AG	4.26	104
Mitsubishi Petroleum Company Limited	4.17	105=
Sanraku-Ocean LKK	4.17	105=
Regents of the University of California	4.08	107
Bayer AG	3.89	108
American Home Products Corporation	3.62	109
Parke Davis & Company	3.40	110
Sigma-Tau SpA	3.33	111
Hoechst AG	3.25	112
National Patent Development Corp.	3.13	113
Pfizer Inc.	2.79	114
Richardson-Merrell Inc.	2.78	115
Eiken Kagaku KK	2.70	116
Zaidan Hojin Seikan-Kai	2.56	117
Toray Industries Inc,	2.50	118
Dainippon Pharmaceuticals KK	2.39	119
Sumitomo Chemical Company	2.30	120
Tokyo Tanabe KK	2.27	121
Antibiotics Research Institute	2.04	122=
Mundipharma AG	2.04	122=
Nippon Chemifar Company Limited	1.81	124
Wakamoto Pharmaceutical Company	1.72	125
Union Carbide Corp.	1.69	126
E. I. du Pont de Nemours & Company	1.67	127=
Organon NV	1.67	127=
Sparamedica AG	1.61	129
Chugai Pharmaceuticals KK	1.47	130
Pharmacia AB	1.45	131
Societe Omnium-Chimique SA	1.43	132
Research Corporation	1.27	133=
Unilever NV	1.27	133=
Procter & Gamble Company	1.25	135
American Cyanamid Company	1.24	136
Lepetit SpA	1.21	137
Syntex Corporation	1.20	138
Dynamit Nobel AG	1.14	139
Alza Corporation	0.95	140
F. Hoffmann-La Roche Company Limited	0.94	141=
Kyowa Hakko Kogyo KK	0.94	141=
Akzo NV	0.93	143
Nisshin Flour Milling Company Limited	0.86	144
Scherico Limited	0.78	145
Sagami Chemical Research Centre	0.74	146
Ajinomoto KK	0.70	147
Mitusbishi Chemical Industries KK	0.69	148
Ono Pharmaceuticals	0.68	149
Kureha Chemical Industries KK	0.57	150

Table 20: Patentees (excluding private inventors) Ranked by Percentage of Total CPI Section B Patents which are for Cephalosporins, continued

PATENTEE NAME	%	RANK
Teikoku Hormone Manufacturing Company	0.53	151
Agence Nationale de Valorisation	0.52	152
Miles Laboratories Inc.	0.48	153=
Nippon Shinyaku KK	0.48	153=
Abbott Laboratories Inc.	0.45	155=
Chinoin Gyogyszer	0.45	155=
Boehringer Mannheim GmbH	0.43	157
Wellcome Foundation Limited	0.39	158
Otsuka Pharmaceuticals KK	0.32	159
C.H. Boehringer Sohn GmbH	0.29	160
Tanabe Pharmaceutical Company	0.25	161
ICI Limited	0.23	162
Warner-Lambert Company	0.20	163
Upjohn Company	0.16	164
Sandoz Limited	0.14	165
Yoshitomi Pharmaceutical Industries KK	0.13	166

Table 20: Patentees (excluding private inventors) Ranked by Percentage of Total CPI Section B Patents which are for Cephalosporins, concluded

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
Abbott Laboratories Inc.	2	2	-	-	-	-	-
Ajinomoto KK	6	4	-	1	-	1	-
Alfa Farmaceutici SpA	5	5	-	-	-	-	-
Akzo NV	1	1	-	-	-	-	-
Alza Corporation	1	-	-	-	-	1	-
American Cyanamid Company	10	9	-	-	-	-	1
American Home Products Corporation	45	37	4	-	-	3	1
Amstar Corporation	1	-	-	1	-	-	-
Ansberg, S. E.	1	-	-	-	-	-	1
Antibiotics Research Institute	1	-	-	1	-	-	-
Antibioticos SA	2	1	1	-	-	-	-
Agence National de Valorisation	1	-	-	-	-	-	1
Aries Associates SA	31	29	-	1	-	1	-
Asahi Chemical Industries KK	39	35	1	3	-	-	-
Astra Pharmaceutica AB	9	6	2	-	-	1	-
Banker, G. S.	2	-	-	-	-	2	-
Banyu Pharmaceutical Company Limited	25	6	-	16	2	1	-
Baylor College of Medicine	1	-	-	-	-	-	1
Beecham Group Limited	58	29	9	-	1	18	1
Biochemie GmbH	1	-	1	-	-	-	-
Bocher, D.	1	-	-	-	-	1	-
Boehringer Mannheim GmbH	2	1	-	-	-	1	-
C.H. Boehringer Sohn GmbH	1	-	1	-	-	-	-
Bristol Myers Company	101	83	8	3	3	4	-
Bristol-Banyu KK	6	6	-	-	-	-	-
Caw Industries Inc.	3	-	-	-	-	3	-
Charm, S. E.	1	-	-	-	-	-	1
Chemische Fabriken von Heyden GmbH	30	30	-	-	-	-	-
Chemie Grunenthal GmbH	4	4	-	-	-	-	-

Table 21: Classification of Cephalosporin Patents into Types of Invention

S = Synthesis I = Intermediates B = Biological Synthesis
P = Isolation/Purification C = Composition O = Other

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
Chinoin Gyogyszer es Vegyeszeti Termekek Gyara	1	1	-	-	-	-	-
Chigai Pharmaceuticals KK	4	2	-	2	-	-	-
Ciba-Geigy Limited	104	83	10	4	3	4	-
Laboratoires Clin-Midy SA	2	2	-	-	-	-	-
Cia. Internationale Farmacia Landerlan SA	1	1	-	-	-	-	-
Connlab Holdings Limited	3	-	3	-	-	-	-
Craf Sud SpA	1	1	-	-	-	-	-
Crast, L. B.	1	1	-	-	-	-	-
Laboratorios Cusi SA	3	3	-	-	-	-	-
Dainippon Pharmaceuticals KK	8	7	1	-	-	-	-
Pereira da Luz, A.	1	1	-	-	-	-	-
Dobfar SpA	3	3	-	-	-	-	-
Dow Chemical Company	3	3	-	-	-	-	-
E. I. du Pont de Nemours & Company	4	1	3	-	-	-	-
Dynamit Nobel AG	1	-	1	-	-	-	-
Eiken Kagaku KK	1	-	-	-	-	-	1
Eli Lilly & Company	256	160	52	8	22	11	3
Carlo Erba SpA	6	5	1	-	-	-	-
Ethicon Corporation	1	-	-	-	-	1	-
Bayer AG	30	25	1	2	1	1	-
Hoechst AG	30	22	7	-	1	-	-
Farmitalia SSpA	14	11	3	-	-	-	-
Instytut Przemyslu Farmaceutyczneco	1	1	-	-	-	-	-
Instituto de Farmacologia Espanola SA	1	-	-	-	-	1	-
Fermion Oy	3	2	1	-	-	-	-
Fisher Sceintific COmpany	2	-	-	-	-	-	2
Forest Laboratories Inc.	1	-	-	-	-	1	-
Fujisawa Pharmaceutical Industries KK	289	277	5	3	3	3	1
A. Gallardo SA	3	2	-	-	-	1	-
Politechnika Gdanska	4	4	-	-	-	-	-
Gema SA	5	3	2	-	-	-	-
Glaxo Group Limited	117	89	19	3	7	1	-

Table 21: Classification of Cephalosporin Patents into Types of Invention, continued

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
Gregor, H. P.	1	-	-	1	-	-	-
Higashikawa, T.	1	1	-	-	-	-	-
Hodogaya Chemical Industries KK	8	6	2	-	-	-	-
F. Hoffmann-La Roche Company Limited	13	5	-	-	-	8	-
ICI Limited	1	-	-	1	-	-	-
Institute de Recherches Scientifique	1	-	-	-	-	1	-
Intellectual Property Development Corporation	1	-	-	-	-	1	-
Istituto Biochimico Italiano di Loredana Lorenzini SA	3	2	-	1	-	-	-
ISF Italseber SpA	2	2	-	-	-	-	-
Jackson, B. G.	1	1	-	-	-	-	-
Kanebo Pharmaceuticals Limited	15	10	-	2	3	-	-
Keck, J. M.	1	1	-	-	-	-	-
Kissei Pharmaceutical Company Limited	4	3	1	-	-	-	-
Kommanditbolaget Kockums Chemical AB	1	-	-	-	-	1	-
Gist-Brocades NV	21	18	2	-	-	-	1
KRKA-Farmacevtica	1	1	-	-	-	-	-
Kureha Chemical Industries KK	1	-	-	-	-	1	-
Kyowa Hakko Kogyo KK	8	3	1	4	-	-	-
Laboratorio Farmaceutico Quimico Lafarquim SA	2	1	-	-	-	1	-
Lark SpA	1	1	-	-	-	-	-
Lepetit SpA	2	1	-	-	1	-	-
Laboratorios Ferrer & Cia SA	1	1	-	-	-	-	-
Leo Pharmaceutical Products AB	11	11	-	-	-	-	-
Laboratoires Merrell-Toraude SA	17	2	15	-	-	-	-
Lumac International NV	1	-	-	-	-	-	1
Instituto LUso-Farmaco SARL	2	2	-	-	-	-	-
Marx, R.	1	-	-	-	-	1	-
Massachusetts Institute of Technology	6	6	-	-	-	-	-
Masuda, G.	1	-	-	-	-	-	1
McDonnell Douglas Corporation	2	-	-	-	-	-	2
MacLaren, S. A.	1	-	-	-	-	1	-
Meiji Seika KK	46	26	3	7	9	1	-

Table 21: Classification of Cephalosporin Patents into Types of Invention

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
E.Merck AG	12	10	-	-	-	2	-
Merck & Company Inc.	93	60	15	10	5	2	1
Metcalf, B. W.	1	1	-	-	-	-	-
Miles Laboratories Inc.	1	-	-	-	-	-	1
Mitsubishi Petrochemical Company Limited	2	2	-	-	-	-	-
Mitsubishi Chemical Industries KK	3	3	-	-	-	-	-
Mundipharma AG	1	-	-	-	-	1	-
National Research & Development Corporation	17	11	-	1	4	1	-
Nelson Research & Development Company	3	-	-	-	-	3	-
Nippon Chemifar Company Limited	3	3	-	-	-	-	-
Nikken Chemicals Company Limited	5	5	-	-	-	-	-
Nippon Kagaku KK	13	11	-	-	1	1	-
Nippi Inc.	1	-	-	-	-	1	-
Nisshin Flour Milling Company Limited	1	-	-	-	1	-	-
Nikko Chemical Industries KK	1	1	-	-	-	-	-
Nippon Shinyaku KK	1	1	-	-	-	-	-
Novo Industries AS	8	2	3	-	3	-	-
National Patent Development Corporation	1	-	-	-	-	1	-
Ogura, H.	1	1	-	-	-	-	-
Ohta Seiyaku KK	1	-	-	-	-	1	-
Ono Pharmaceuticals KK	2	2	-	-	-	-	-
Organon NV	1	-	1	-	-	-	-
Osaka University	5	5	-	-	-	-	-
Parke Davis & Company	8	7	1	-	-	-	-
Petrizilka, T.	1	1	-	-	-	-	-
Pfizer Inc.	21	13	4	-	2	2	-
Pharmacia AB	1	-	-	-	-	-	1
Pharmaco Inc.	1	-	-	-	-	1	-
Pierrel SpA	3	2	1	-	-	-	-
Priorov Traumatolog	1	-	-	-	-	1	-
Procter & Gamble Company	2	-	-	-	-	2	-
Proter SpA	4	2	1	-	1	-	-

Table 21: Classification of Cephalosporin Patents into Types of Invention

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
Prugnaud, R. L.	1	-	-	-	-	1	-
Purdue Research FOundation	2	-	-	-	-	2	-
Purdue University	1	-	-	-	-	1	-
Purdue Frederick Company	1	-	-	-	-	1	-
Recherches et Industries Therapeutiques SA	6	6	-	-	-	-	-
Regents of the University of California	2	-	2	-	-	-	-
Research Corporation	2	1	-	-	-	1	-
Rhone-Poulenc SA	14	7	7	-	-	-	-
Richardson-Merrell Inc.	7	7	-	-	-	-	-
R & L Molecular Research	7	7	-	-	-	-	-
Roussell-Uclaf SA	37	27	8	-	2	-	-
Sagami Chemical Research Centre	2	1	1	-	-	-	-
Otsuka Pharmaceuticals KK	1	1	-	-	-	-	-
Sakakida, T.	3	3	-	-	-	-	-
Zaidan Hojin Sangyo Kagaku KK	25	18	4	1	1	1	-
Sandoz Limited	2	2	-	-	-	-	-
Sankyo Company Limited	68	54	10	2	1	1	-
Sanraku-Ocean KK	1	-	-	1	-	-	-
Scherico Limited	1	-	-	-	-	1	-
Zaidan Hojin Seiken-Kai	1	1	-	-	-	-	-
Shionogi Limtied	41	29	8	2	-	2	-
Sigma-Tau SpA	1	1	-	-	-	-	-
Smith, Kline & French Laboratories Inc.	86	74	8	-	2	2	-
Snam Progetti SpA	3	-	-	3	-	-	-
Societe Omnium-Chimique SA	1	1	-	-	-	-	-
Seoul Pharmaceutical Industries KK	1	1	-	-	-	-	-
Sparamedica AG	1	1	-	-	-	-	-
E.R. Squibb & Sons Inc.	131	114	12	2	1	2	-
Stada Arzneimittel AG	1	-	-	-	-	1	-
Stapley, E. O.	1	-	-	1	-	-	-
Sumitomo Chemical Company	28	23	2	2	-	1	-
Sutures Inc.	3	-	-	-	-	3	-

Table 21: Classification of Cephalosporin Patents into Types of Invention

PATENTEE NAME	NO. OF PATENTS	S	I	B	P	C	X
Syntex Corporation	6	6	-	-	-	-	-
Takeda Chemical Industries	143	101	18	14	5	5	-
Takino, H.	1	1	-	-	-	-	-
Tanabe Pharmaceutical Company	3	3	-	-	-	-	-
Tokyo Tanabe KK	1	1	-	-	-	-	-
Teijin KK	42	23	16	1	1	-	1
Teikoku Hormone Manufacturing Company	1	1	-	-	-	-	-
Laboratoires Thekan SA	1	-	-	-	-	1	-
Tobishi Pharmaceutical Company	2	2	-	-	-	-	-
Toho Pharmaceutical Laboratories Company	1	1	-	-	-	-	-
Toko Yakuhin Kogyo KK	1	-	-	-	-	1	-
Queens University	5	4	1	-	-	-	-
Toray Industries Inc.	2	2	-	-	-	-	-
Toshin Chemical Industries	4	4	-	-	-	-	-
Toyo Jozo KK	28	6	2	14	3	2	1
Toyama Chemical Industries KK	46	39	1	-	2	4	-
Toyobo KK	16	6	1	8	-	1	-
Treuner, U. D.	1	1	-	-	-	-	-
Teikoku Chemical Industries	4	4	-	-	-	-	-
Union Carbide Corporation	1	1	-	-	-	-	-
Unilever BV	1	-	-	-	-	1	-
Upjohn Company	2	-	-	-	-	2	-
NASA	1	-	-	-	-	-	1
Etablissements Viridis	2	2	-	-	-	-	-
Wakamoto Pharmaceutical Company KK	1	1	-	-	-	-	-
Warner-Lambert Company	1	1	-	-	-	-	-
Wellcome Foundation Limited	1	-	-	-	-	-	1
Woodward, R. B., Prof.	13	13	-	-	-	-	-
Yamanouchi Pharmaceutical Company	71	57	4	8	-	2	-
Yamada, S.	2	2	-	-	-	-	-
Yeda Research & Development	17	17	-	-	-	-	-
Yoshitomi Pharmaceutical Industries KK	1	-	-	-	1	-	-

Table 21: Classification of Cephalosporin Patents into Types of Invention

RETRIEVAL OF ADDITIONAL DATA SETS

For the further studies, described below, an additional nine sets of patents data for different technologies were retrieved from the WPI online database. In each case, the retrieved citations were printed offline sorted by (a) patentee, and (b) priority. These additional data sets, and the strategies used to retreive them, are described in Appendices II to X. Table 22 gives details of all the data sets used in the subsequent studies.

Data Set	Total No. Patents	Total No. Patentees
Cephalosporins - original data set	2599	192
Cephalosporins - updated data set	2944	216
Air cushion vehicles	460	233
Cyclopropane derivative insecticides	1106	168
Videodiscs	548	162
Genetic engineering	1308	665
Pressure sensitive adhesives	1126	427
Production of terephthalic acid	722	159
Pharmacologically active pyrazolones	243	130
Olivanic acid	118	13
Clavulanic acid	133	16

Table 22: Patents Data Sets used in Bibliometric Studies

BRADFORD-ZIPF LAW BIBLIOGRAPHS

Bradford's Law offers the possibility of estimating the number of sources and the number of items that one can expect to find for any bibliographic data set. This estimate is based only on knowledge of a small but sufficient number of the most productive sources. Unfortunately, Bradford formulated his "law of scatter" in two versions which Wilkinson[155] has shown to be formally different although closely similar and concluded that, of the two Bradford formulations, the graphical one is in closer accord with existing data. Both formulations lend themselves to methods of estimating the size of a comprehensive bibliography if the subject and the range in time are first well-defined.

In its original form Bradford's Law said nothing about comprehensiveness. But a bibliography must be finite and the number of items produced by the least productive sources cannot be less than one. When this consideration is expressed in one of the two formulations of

Bradford's Law, a simple graphical technique for estimating the size of the complete bibliography can be devised[149]. It requires the drawing of the "bibliograph".

The "bibliograph", Figure 15, is a plot of the cumulative number of articles (vertical axis) versus the logarithm of the cumulative number of journals in which the articles appear (horizontal axis). The plot has an S-shape with a central straight section following Bradford's log-linear law. The upward curving bottom of the curve represents the small nuclear zone of the most relevant journals. The upper end of the curve, usually termed the Groos Droop, represents the peripheral zone where relevant references are widely scattered amongst a great number of journals.

In constructing the bibliograph, the most productive sources are first ranked in decreasing order of productivity. The cumulative sums of items found are then plotted on a graph as shown in Figure 16. The most convenient graph paper for this purpose is semi-logarithmic; the linear scale is applied to the cumulative sums and the logarithmic scale is used to indicate the ranks of the sources. So, on the graph (Figure xx) point A indicates the number of items yielded by the most productive source, point B indicates the number of items yielded by the

Figure 15: The Bibliograph

two most productve sources together, etc., etc. The first few points are found to lie on a rising curve which, sooner or later, should run into a straight line. As soon as the straight line is definite enough, an estimate of the end point of the line can be made.

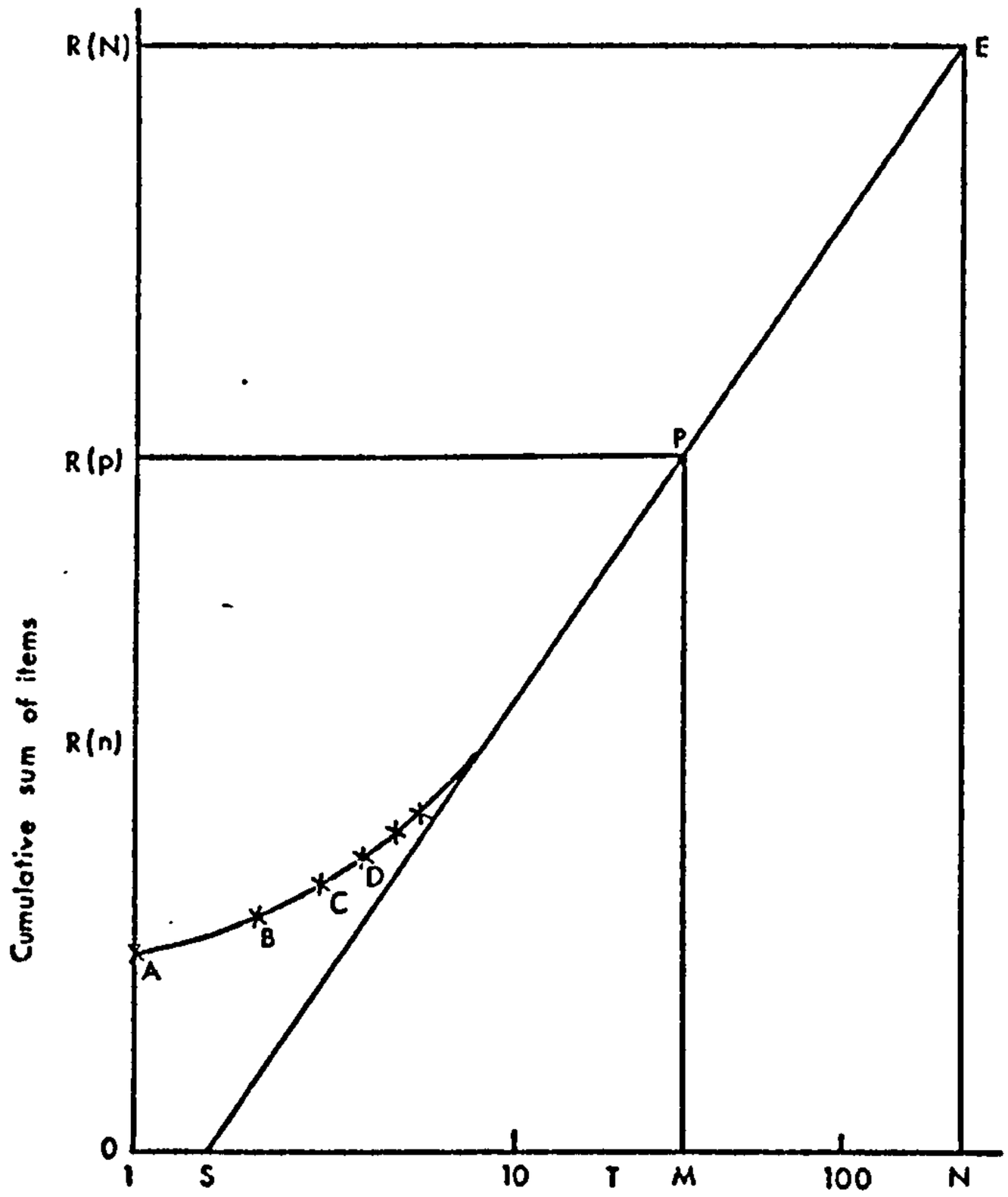


Figure 16: Plotting and Interpreting the Bibliograph

When the technique is applied to manually produced bibliographies the real and estimated end-points can differ appreciably. A common occurence is illustrated in Figure 17. Here, if the plotting of the graph is continued beyond the points required to determine the straight line, the plotted points may fail to maintain the linear climb and fall away in a droop to end at some point such as G. In such cases it is plausible to argue that the bibliography is not complete in the sense in which the technique requires. For example, the bibliographer may quite reasonably state that he has been selective. He may say that he has noted only those references which are "of professional interest" or that he has omitted exact translations of some items in to other languages. According to Brookes[149], whenever a droop has been observed, it has always been possible to indicate either some selectivity or some omissions.

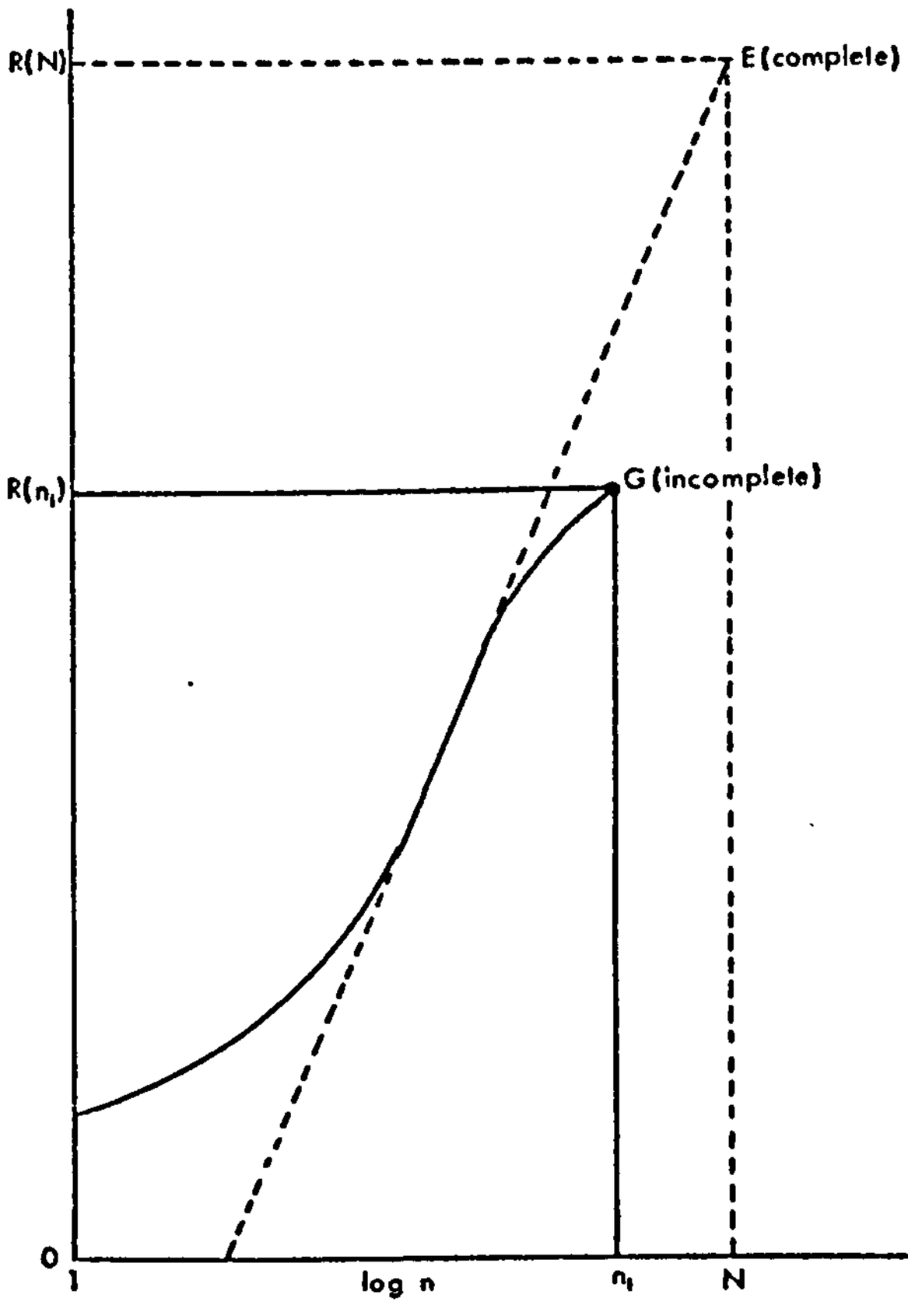


Figure 17: The "Droop": an indication of Incompleteness

It has been noted, however, that the point E as calculated slightly overestimates the total number of items, though not the total number of sources. This fault arises because, as the graph nears the end-point, the sources end with a number which provides three items, a larger number which provides two items and a still larger number of sources which provide only one item each. When the corresponding cumulative sums are plotted on a logarithmic scale they do not lie exactly on a straight line, but form a series of lengthening arcs which intersect on the straight line (Figure 18). The last one, however, is open at the end-point. When the complete data are carefully plotted, the graph ends in an open hook which ends just below the estimated end-point E. The "hook", however, is clearly distinguishable from the "droop": the hook is concave upwards whereas the drop is concave downwards.

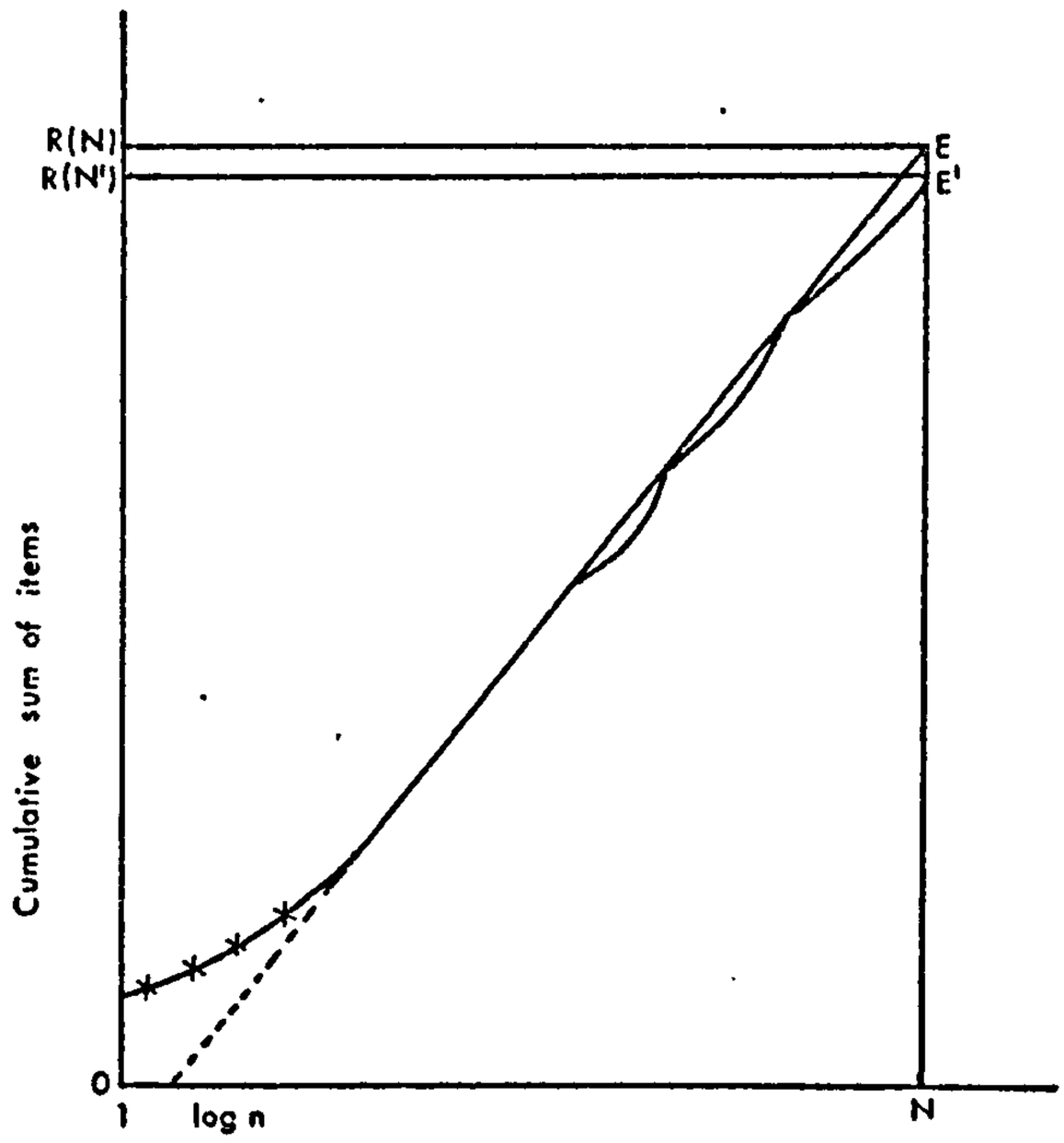


Figure 18: The Arcs near the end of the Bibliograph

The straight line is extended to meet the axis of log n (at S in Figure 18) and some convenient point P is marked on the straight line. Brooks showed[149] that the total number of sources, N, expected to contribute to the bibliography is given by:-

$$N = \frac{R(p).OT}{3SM}$$

where R(p) is the number of items corresponding to the point P and where the lengths OT and SM are measured as accurately as possible in millimetres.

Brookes does not explain in his paper that T is the point where N=20. Furthermore, the "3" in the denominator of the equation for calculating N should really be ln 20 which is 2.9957. Thus, $\frac{OT}{3}$ is simply a factor for the scale of the graph paper used in constructing the bibliograph, whilst $\frac{R(p)}{SM}$ is a measure of the slope of the straight line portion.

Having calculated N, it is then possible to estimate the total number of items to be expected. It may be possible to mark the point N on the graph and so to mark the corresponding point E on the continuation of straight line SP. The required value of R(N) can then be read from the scale of R(n) on the left hand side. Alternatively, and more precisely, R(N) can be calculated from the formula:

$$R(N) = N \ln (N/S)$$

where S is the number corresponding to S on the log n scale.

It is not possible to <u>prove</u> that E <u>must</u> be the end point of the line because there is no logical reason why a comprehensive bibliography should conform so precisely to a mathematical law. However, the technique has now been tested many times, especially against computer-produced bibliographies derived from retrospective searches of large databases and seems to be realistic. The advantage of using computer-produced bibliographs is that the items found must all conform to the search question as formulated for the computer search program. The relevance to the subject specified by the question is therefore uniformly controlled and it does not matter (for the purpose of testing the technique) whether the search question is correctly formulated or not.

Using the technique described above, bibliographs have been drawn for eight of the eleven patents data sets; these are shown in Figures 19 to 26. Using these graphs, calculations for total numbers of patentees and patents, i.e., N and R(N), have been calculated and are given in Table 23.

Vector Graph Analysis

The Vector Analysis technique described in Chapter 7, as used by the Japanese Patent Office and OTAF, was considered to be a possible suitable method of technology assessment; therefore, such Vector Analysis Graphs were constructed for each of the patents data sets. Data for plotting the graphs was taken from the online print outs sorted by priority, except for the cephalosporins where the data was taken from the computer generated lists, supplemented by the updating data, as described in Appendix I. The Vector Analysis Graphs obtained are shown in Figures 27 to 37.

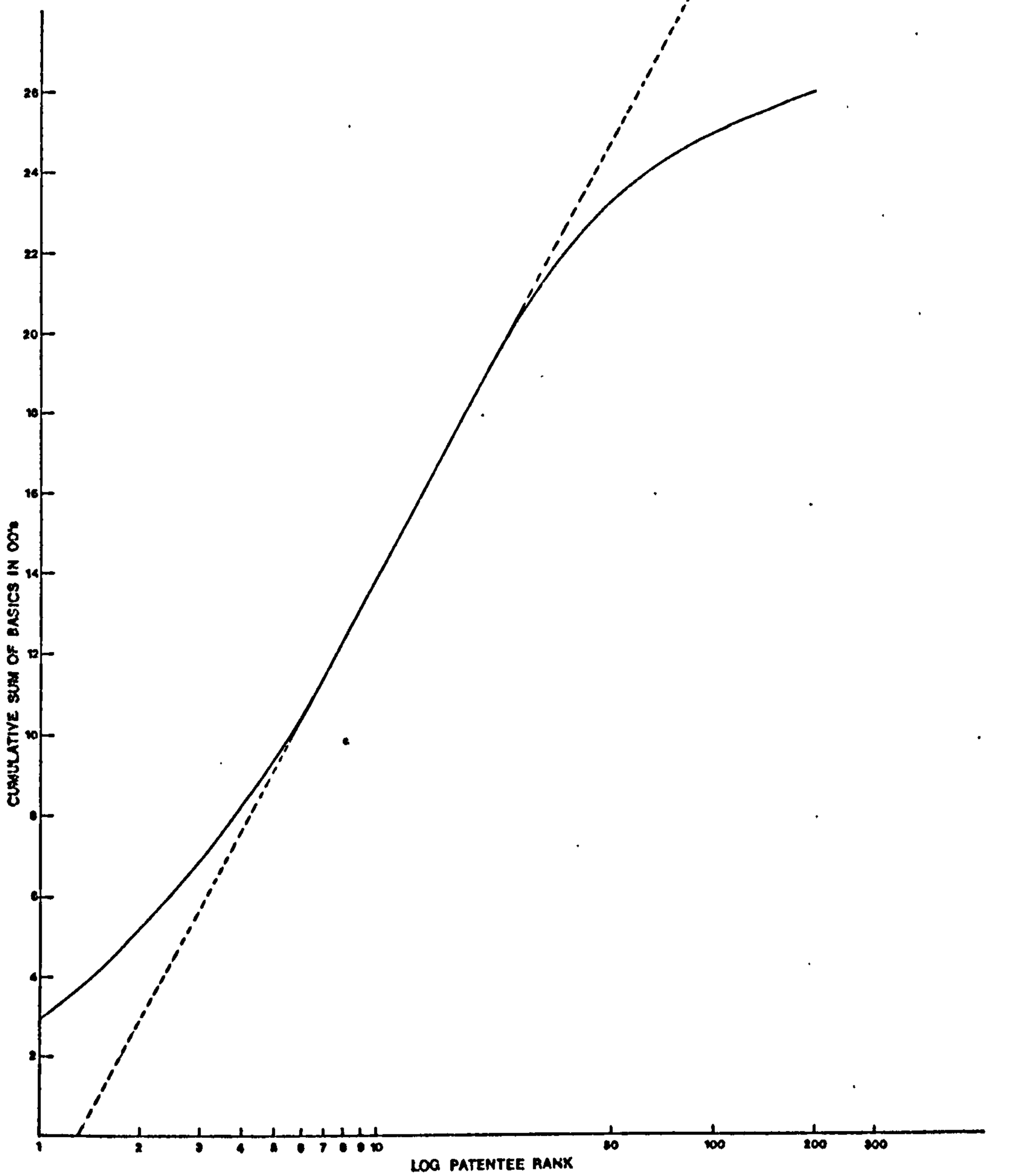


Figure 19: Bradford-Zipf Plot for Original Cephalosporins Patents Data Set

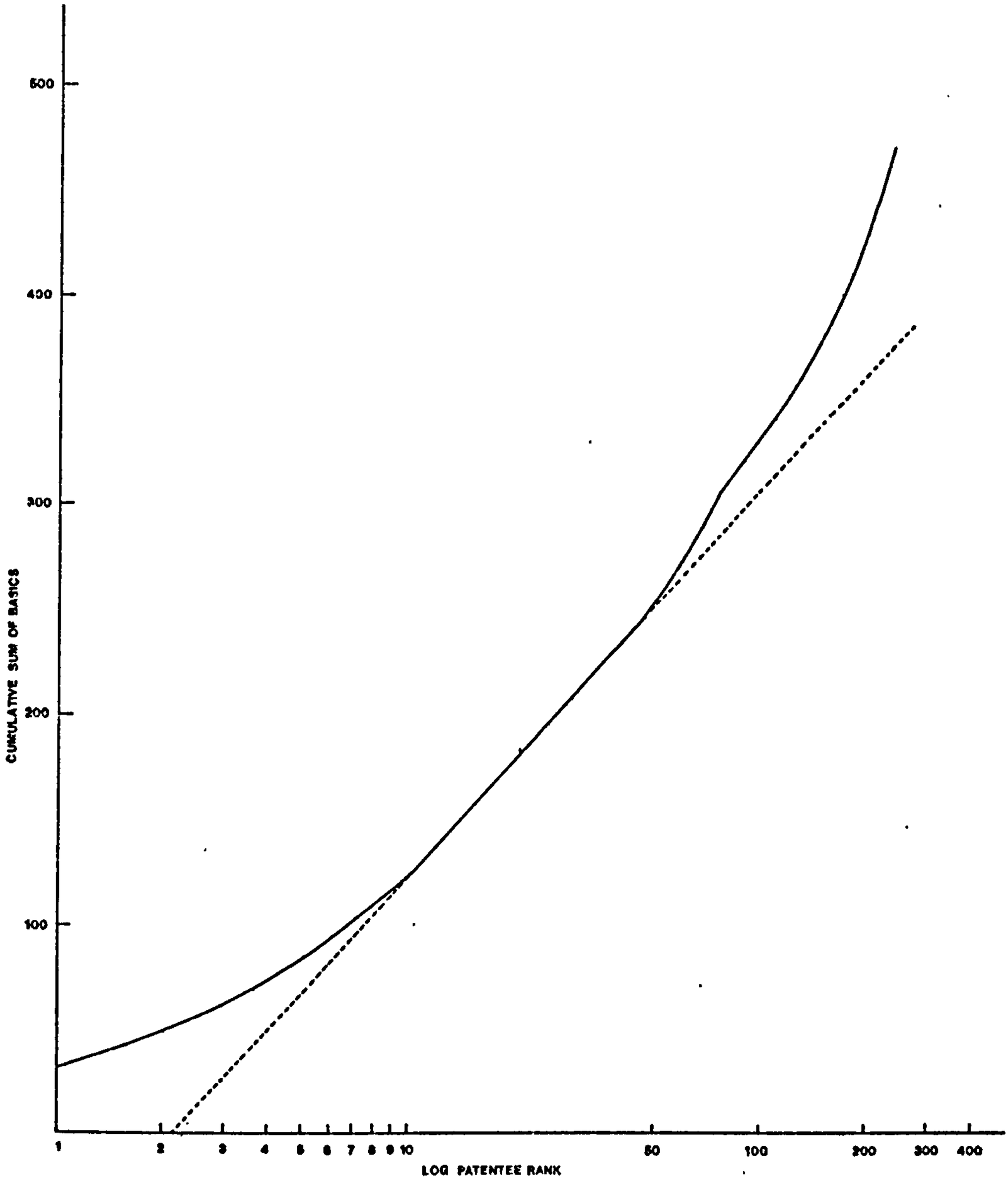


Figure 20: Bradford-Zipf Plot for Air Cushion Vehicles Patents

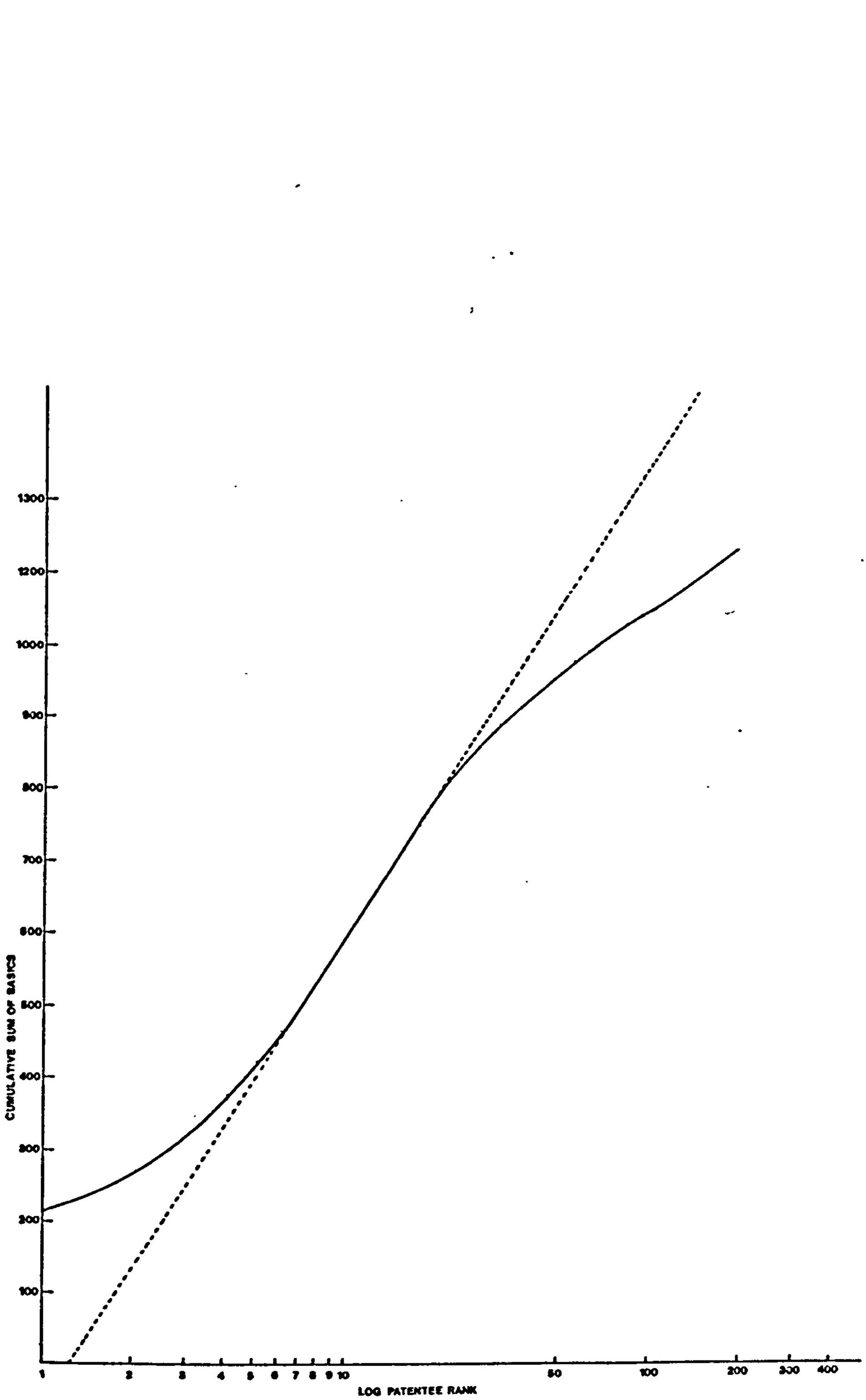


Figure 21: Bradford-Zipf Plot for Cyclopropane Derivative Insecticide Patents

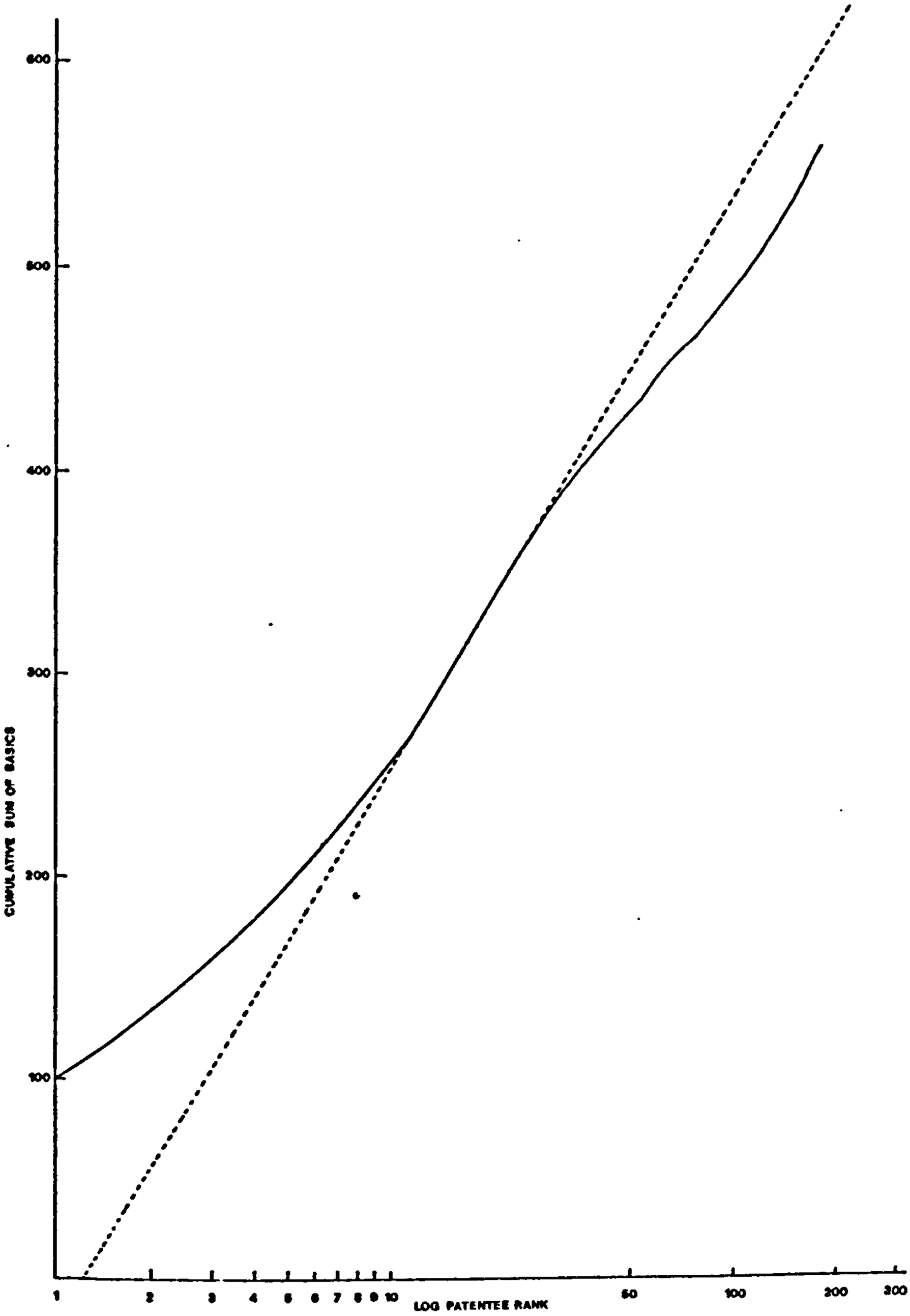


Figure 22: Bradford-Zipf Plot for Videodisc Patents

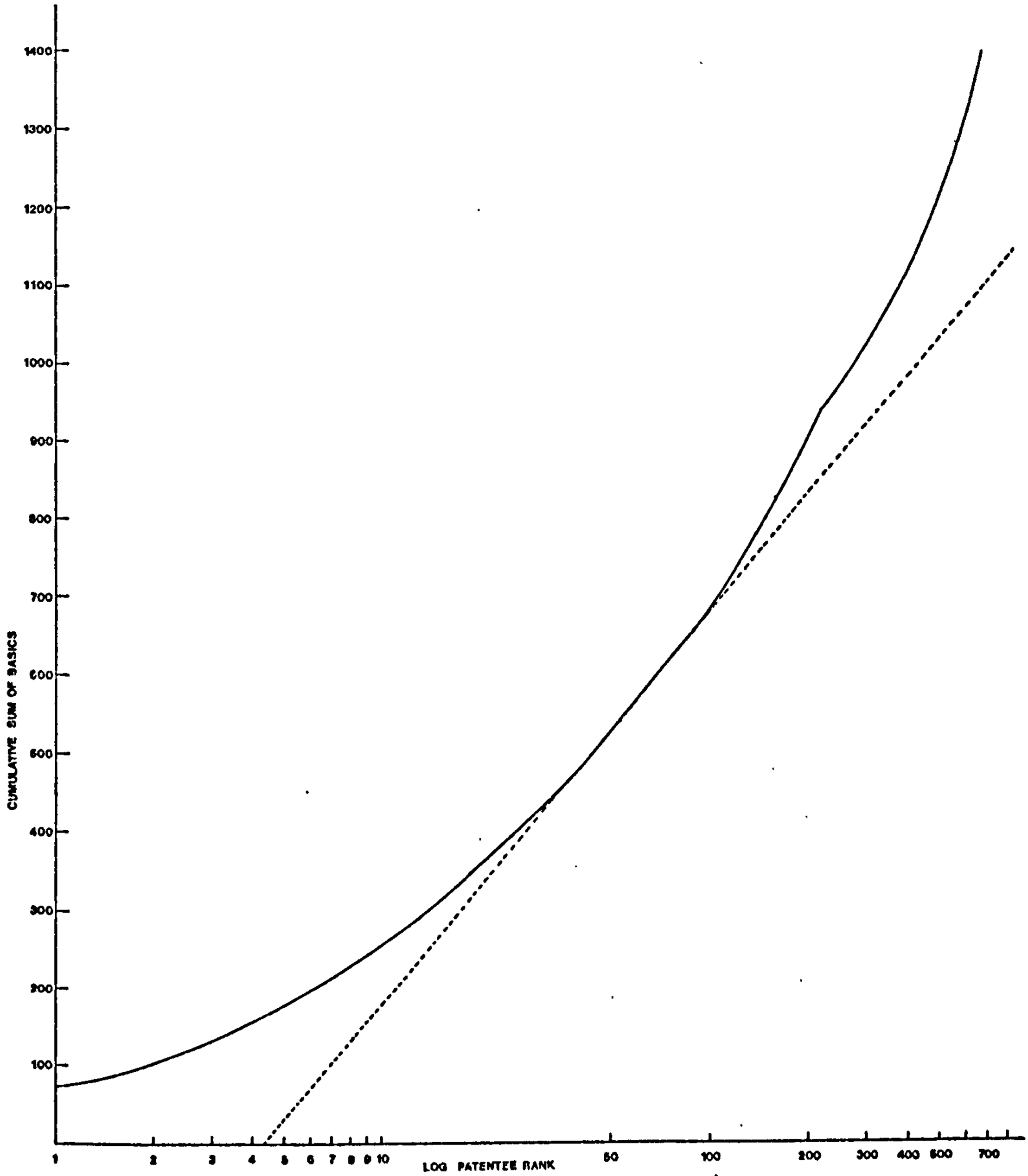


Figure 23: Bradford-Zipf Plot for Genetic Engineernig Patents

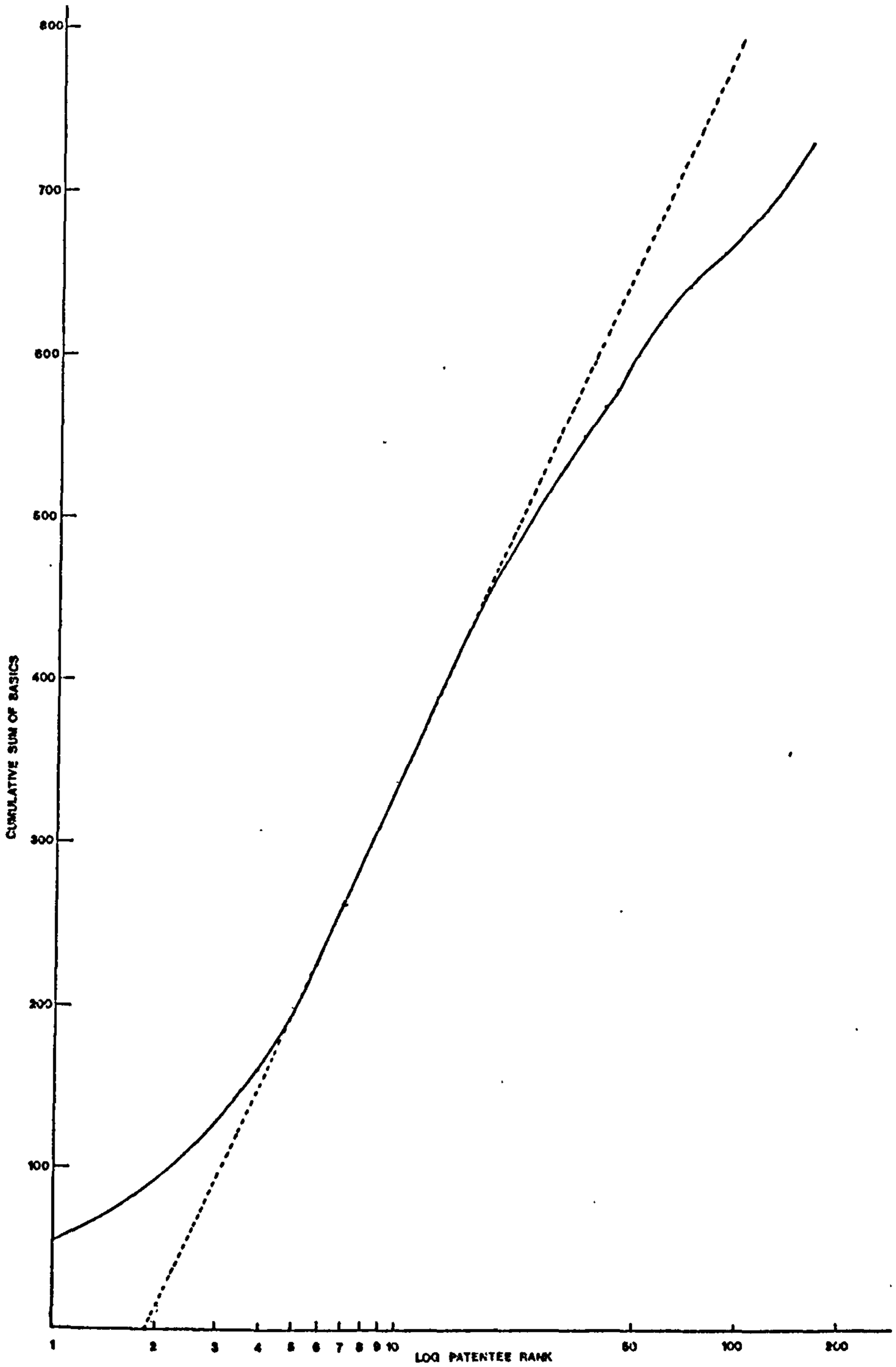


Figure 24: Bradford-Zipf Plot for Terephthalic Acid Production Patents

Figure 25: Bradford-Zipf Plot for Pressure Sensitive Adhesive Patents

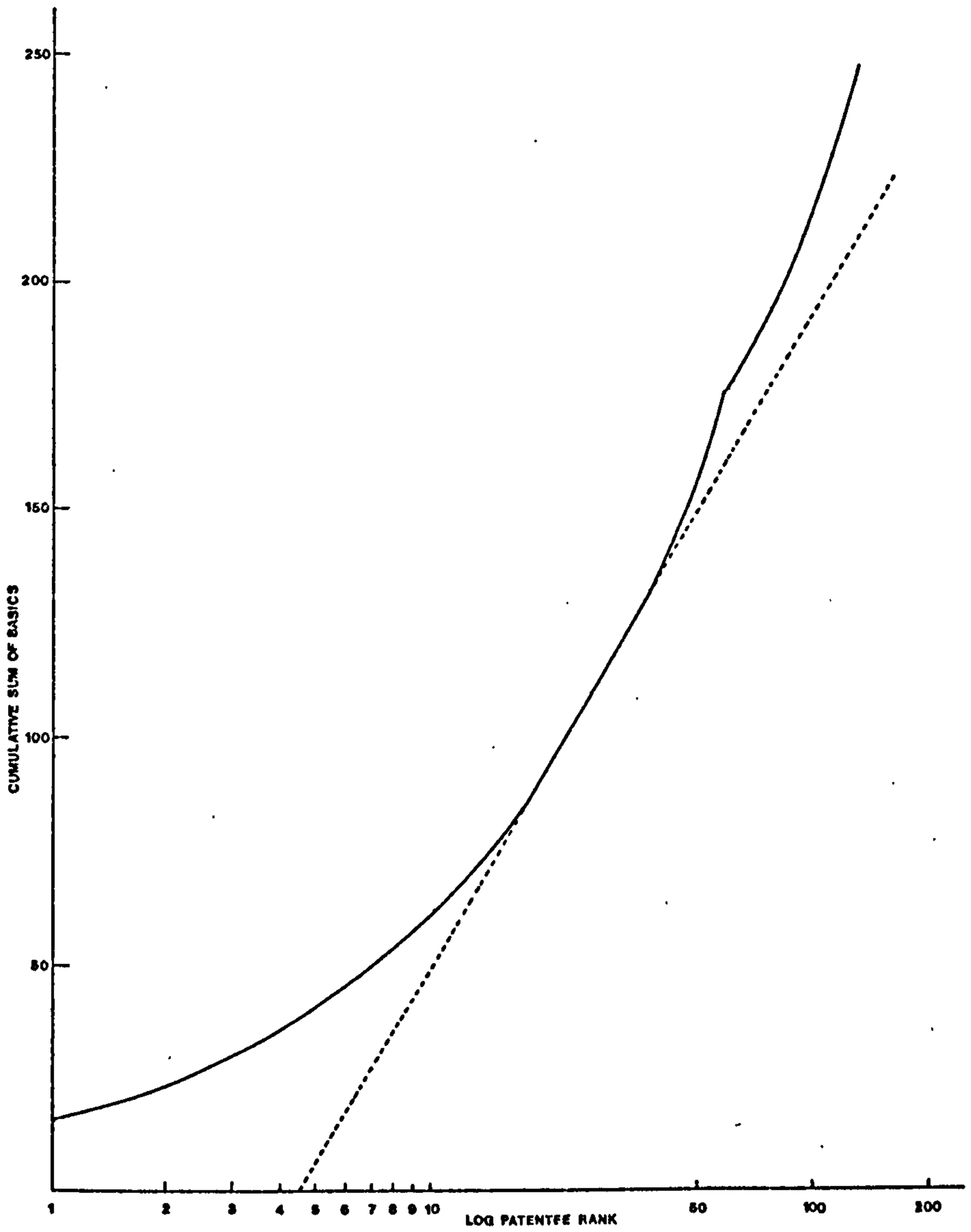


Figure 26: Bradford-Zipf Plot for Pharmacologically Active Pyrazolone Patents

DATA SET	MEASURED FROM GRAPH				CALCULATED		OBSERVED	
	R(p)	OT	SM	S	N	R(N)	N	R(N)
Cephalosporins (Original)	2040	108.7	107.9	1.30	685.04	4293.21	192	2589
Air Cushion Vehicles	180	108.7	82.4	2.15	79.15	285.41	233	460
Cyclopropane Insecticides	650	108.7	82.3	1.24	286.17	1557.19	168	1106
Videodiscs	336	108.7	100.3	1.26	121.38	554.44	162	548
Genetic Engineering	600	108.7	101.0	4.35	215.25	839.82	665	1308
Terephthalic Acid Production	350	108.7	64.3	1.87	197.23	918.78	159	722
Pressure Sensitive Adhesives	550	108.7	120.5	1.07	165.38	833.61	427	1126
Pharmacological Pyrazolones	140	108.7	70.1	4.45	71.75	199.49	130	243

Table 23: Summary of Calculations from Bradford-Zipf Bibliographs

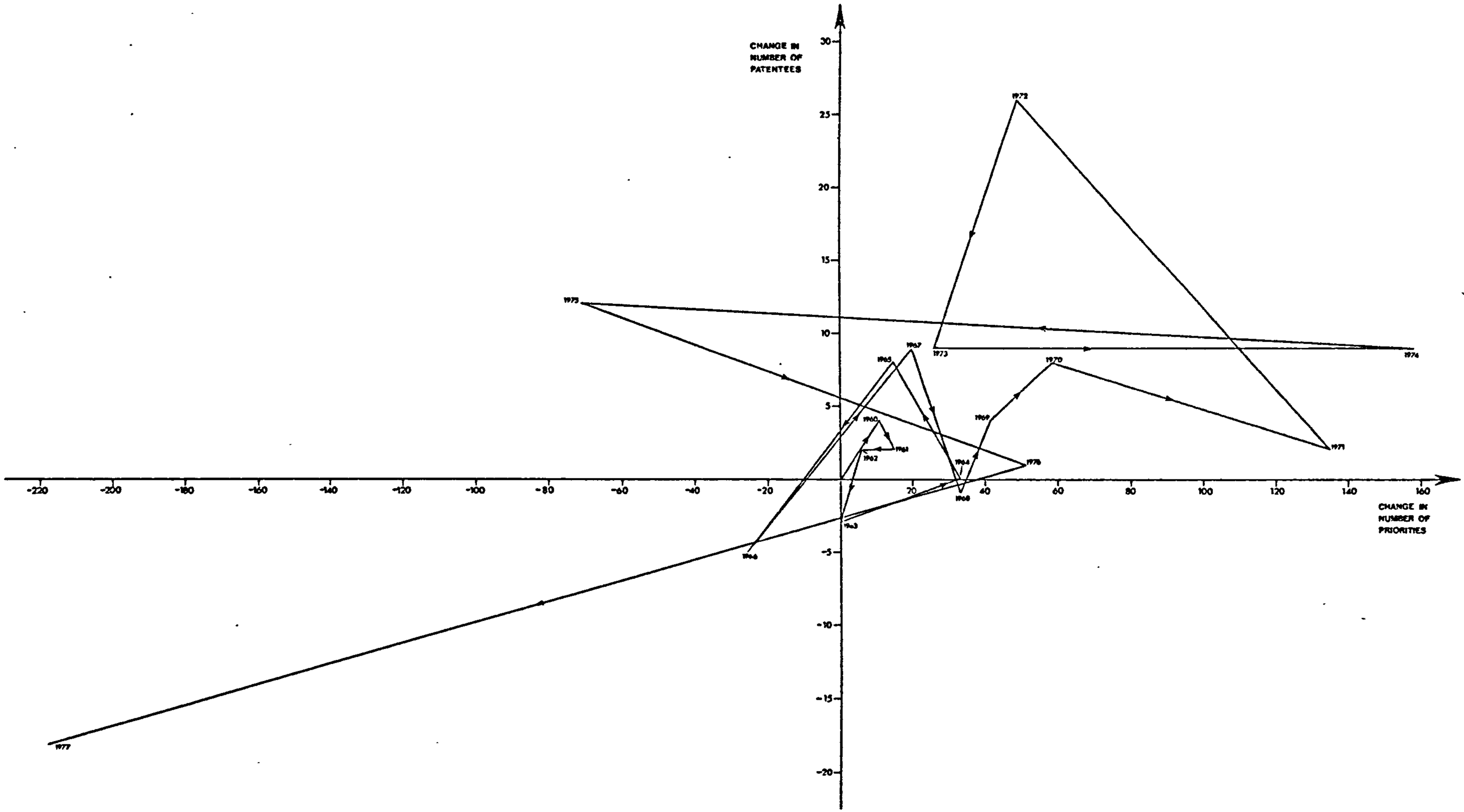


Figure 27: Vector Analysis Graph for Original Cephalosporins Patents Data Set

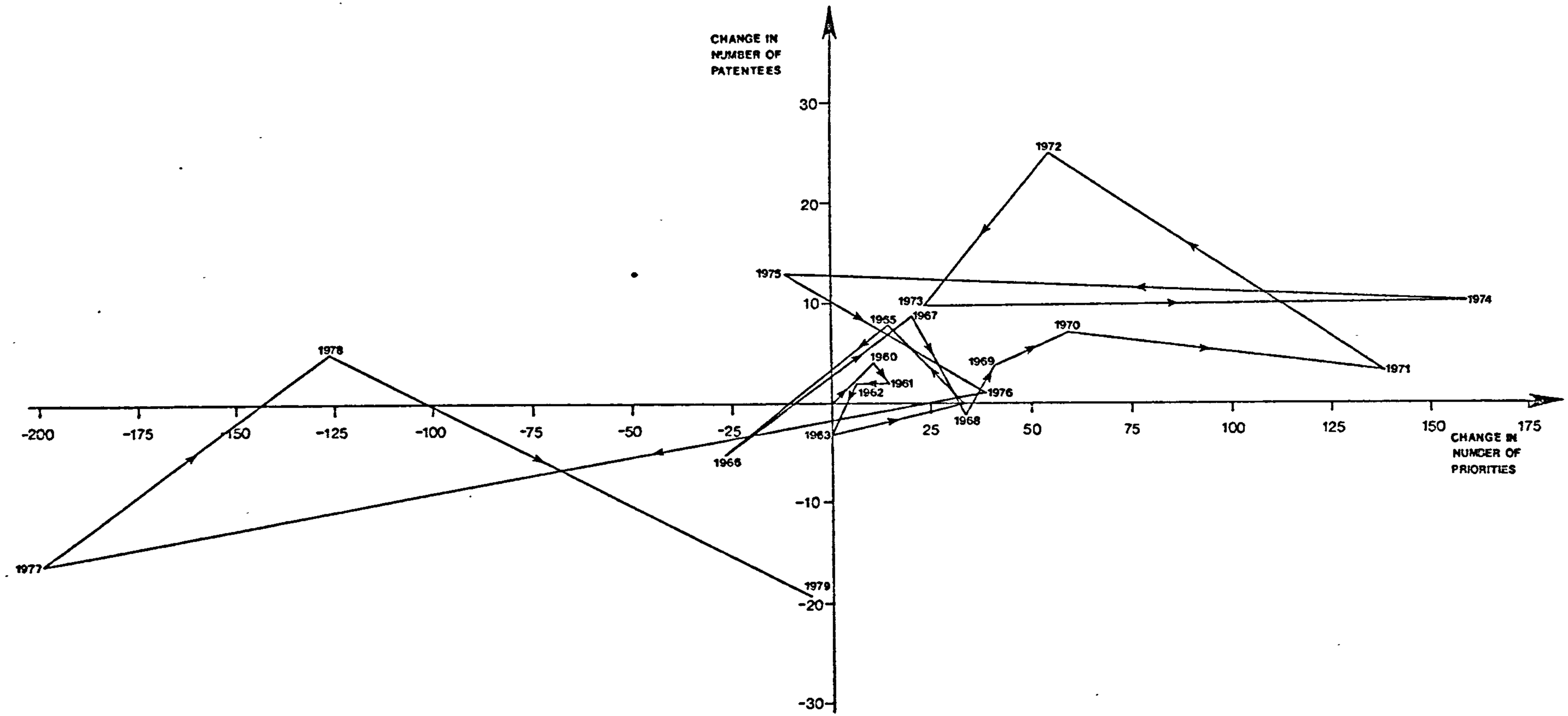


Figure 28: Vector Analysis Graph for Updated Cephalosporins Patents Data Set

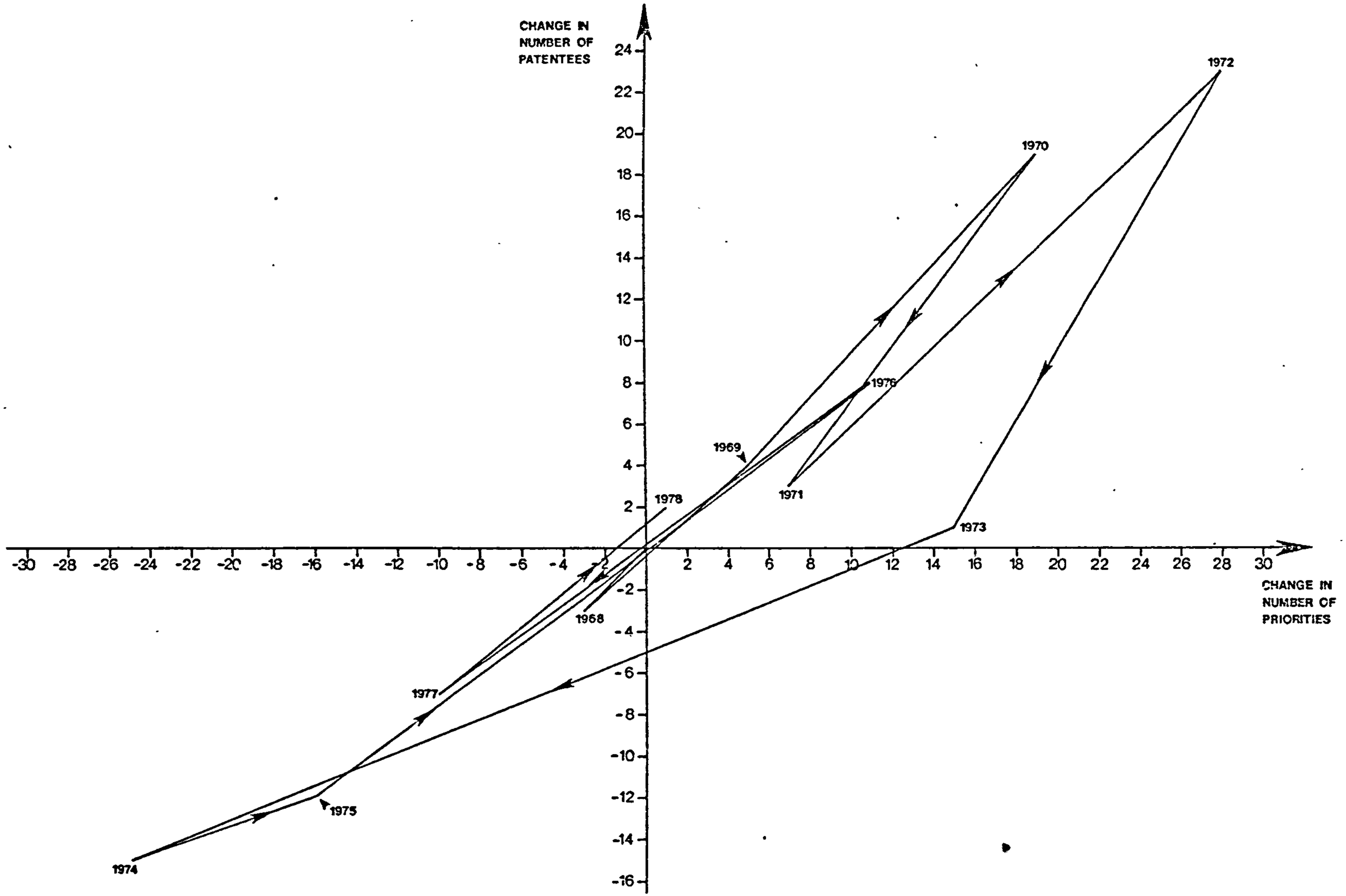


Figure 29: Vector Analysis Graph for Air Cushion Vehicles Patents

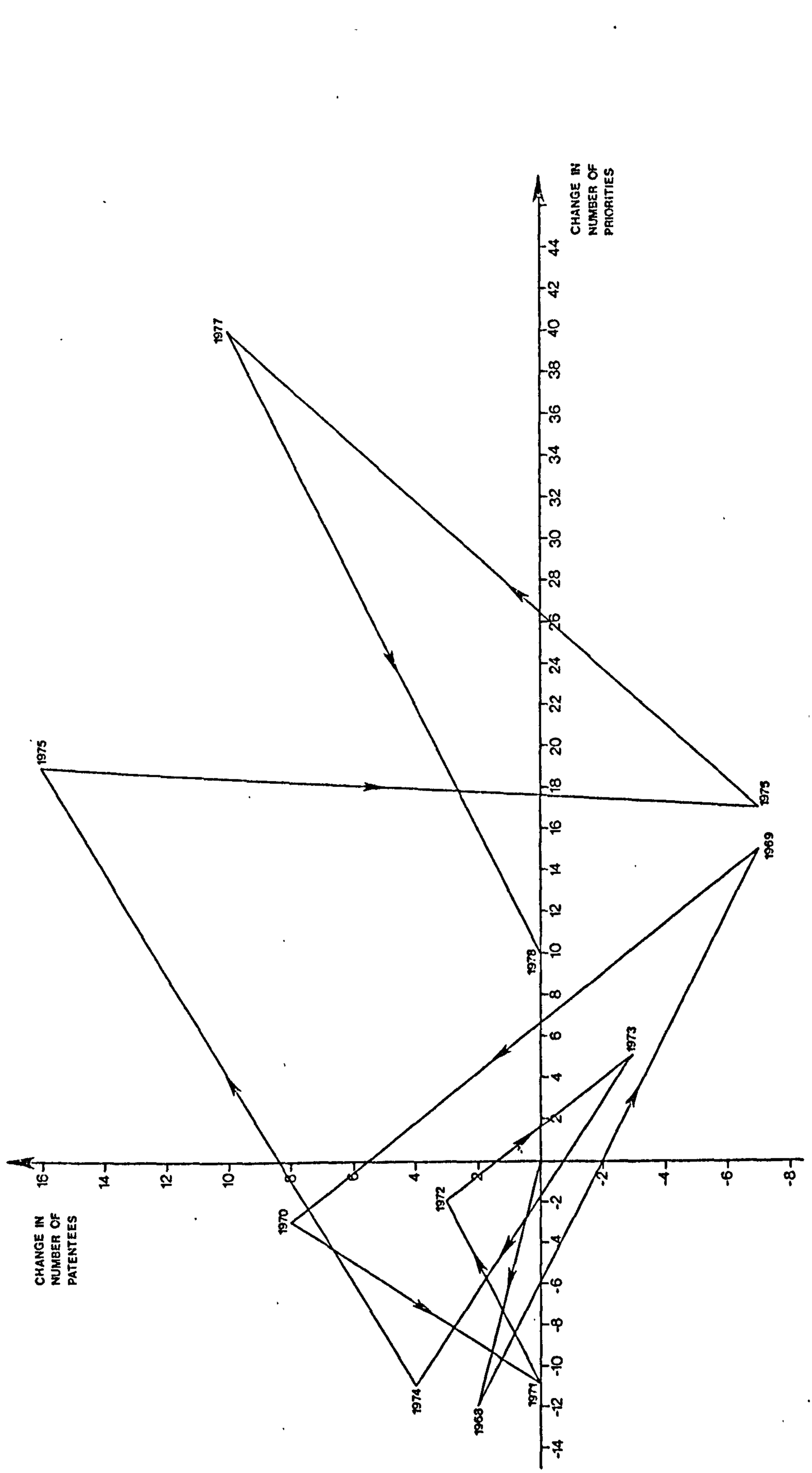


Figure 30: Vector Analysis Graph for Air Cyclopropane Derivatives Insecticides Patents

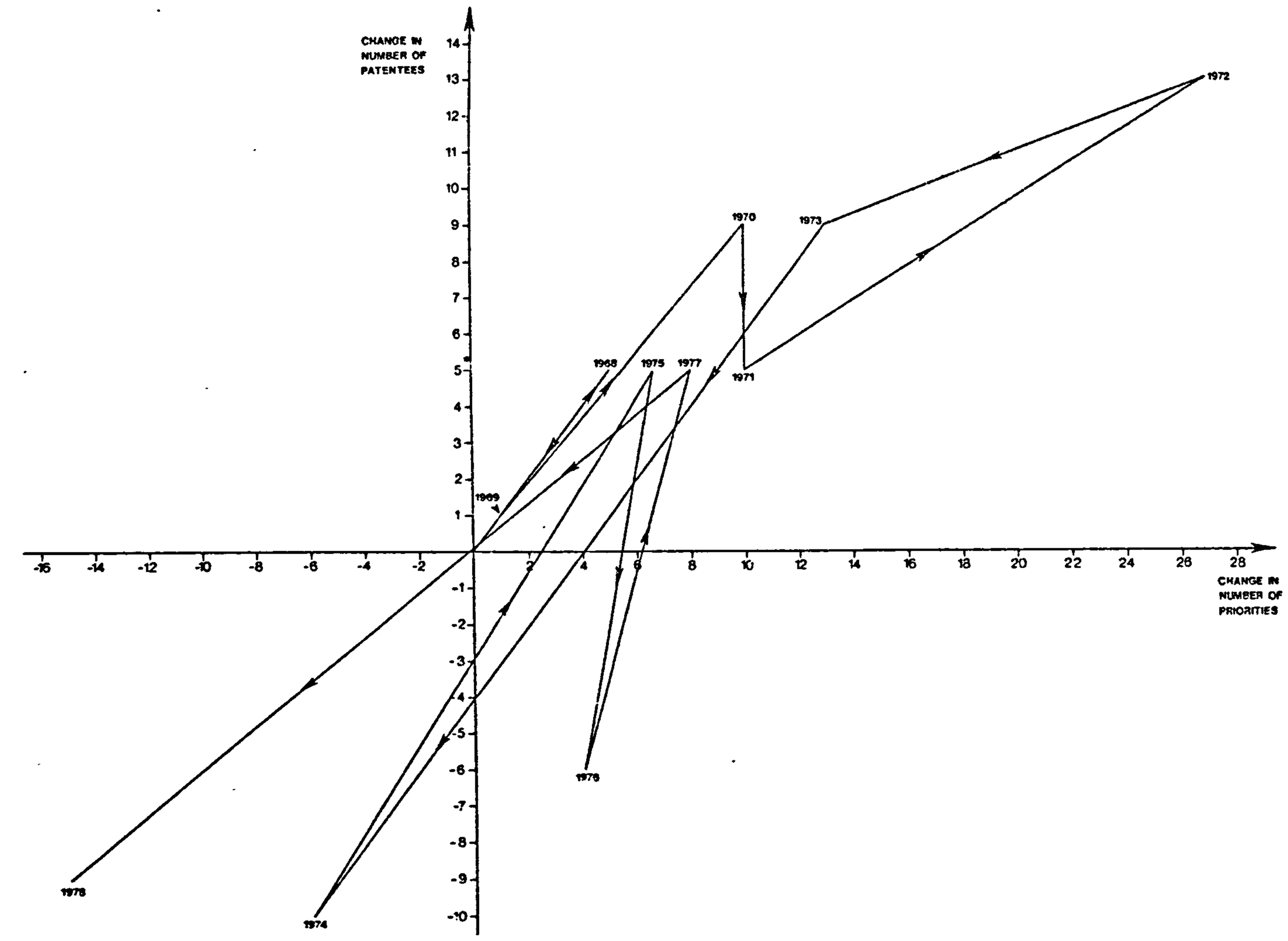


Figure 31: Vector Analysis Graph for Videodisc Patents

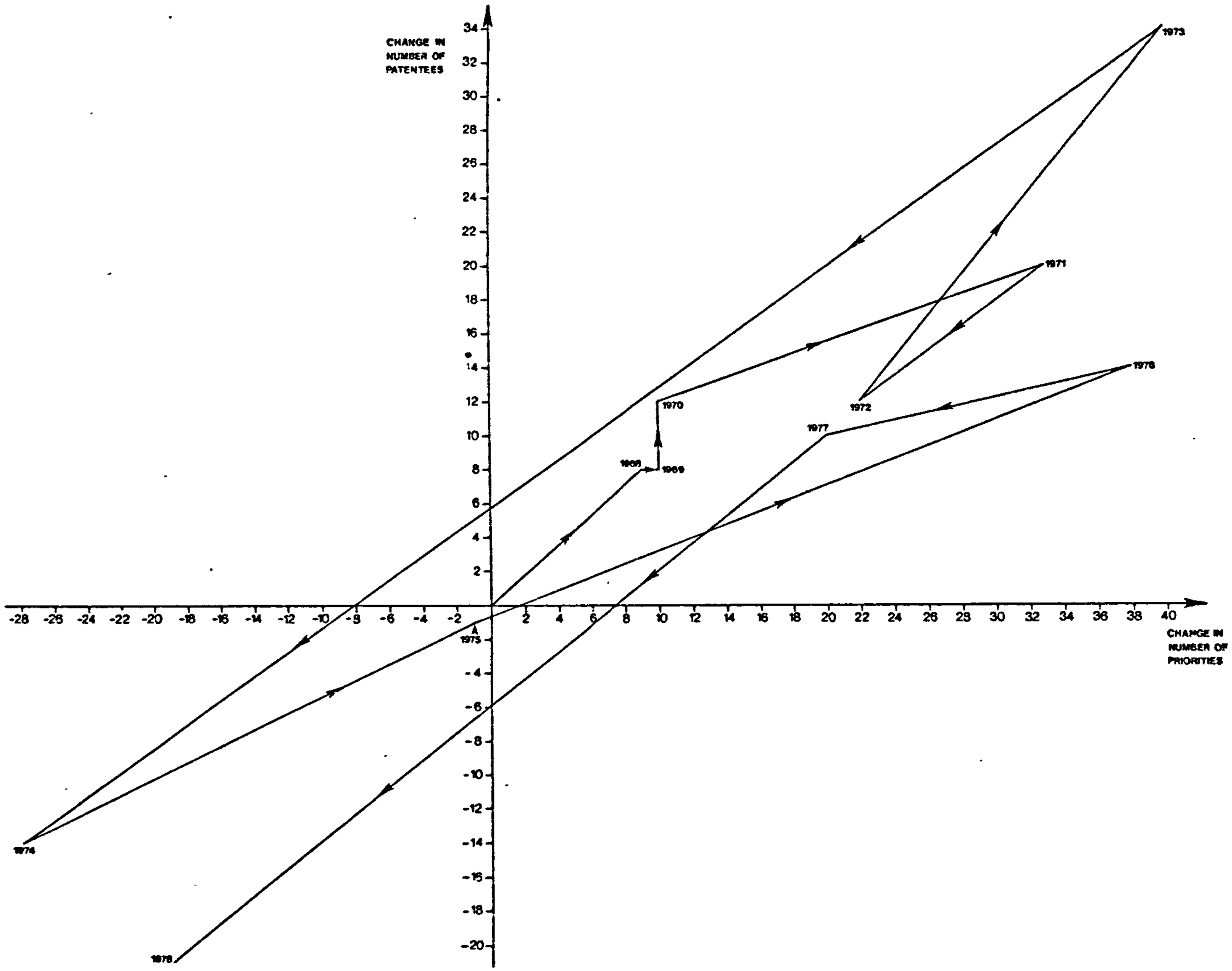


Figure 32: Vector Analysis Graph for Genetic Engineering Patents

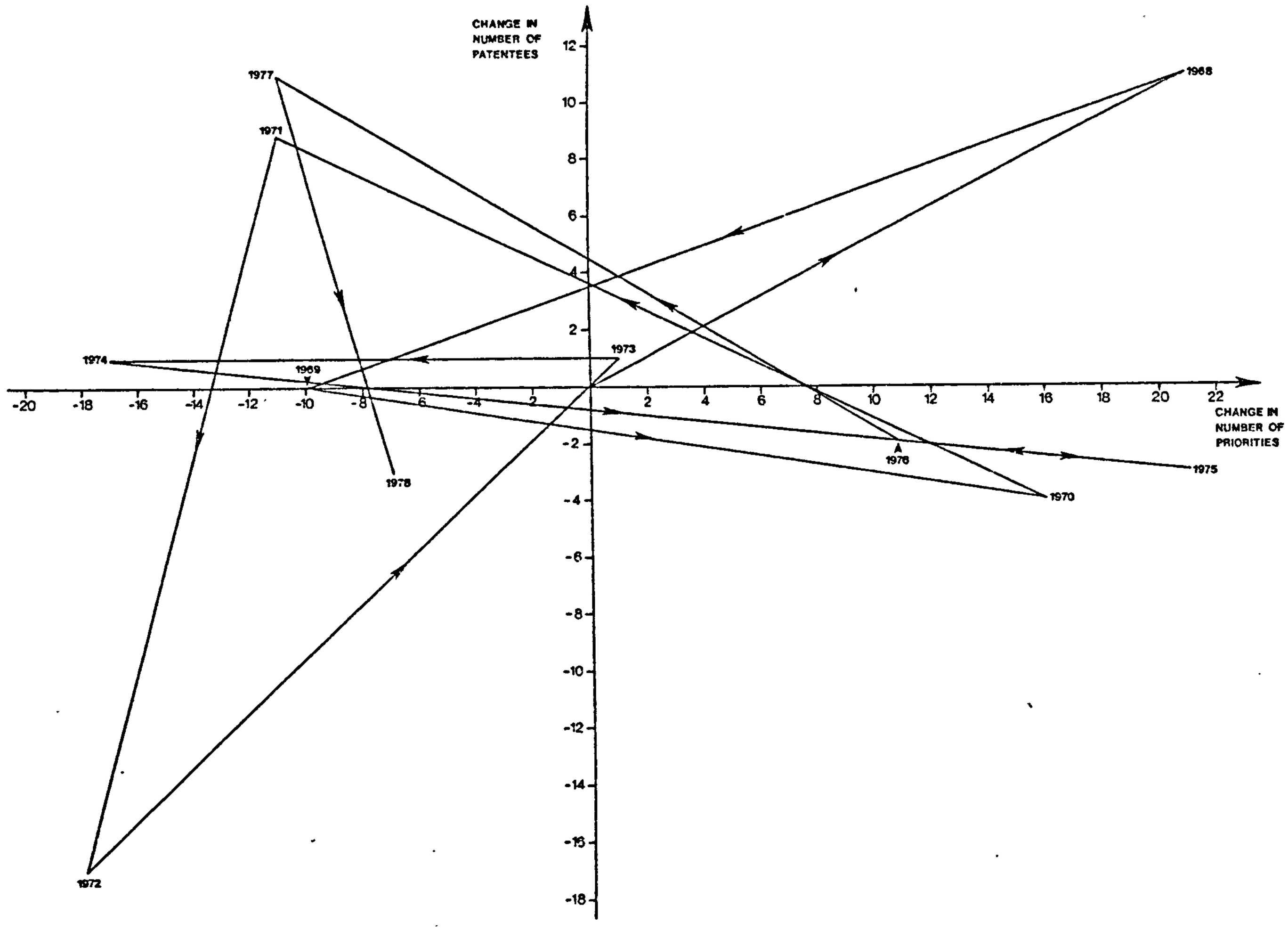


Figure 33: Vector Analysis Graph for Terephthalic Acid Production Patents

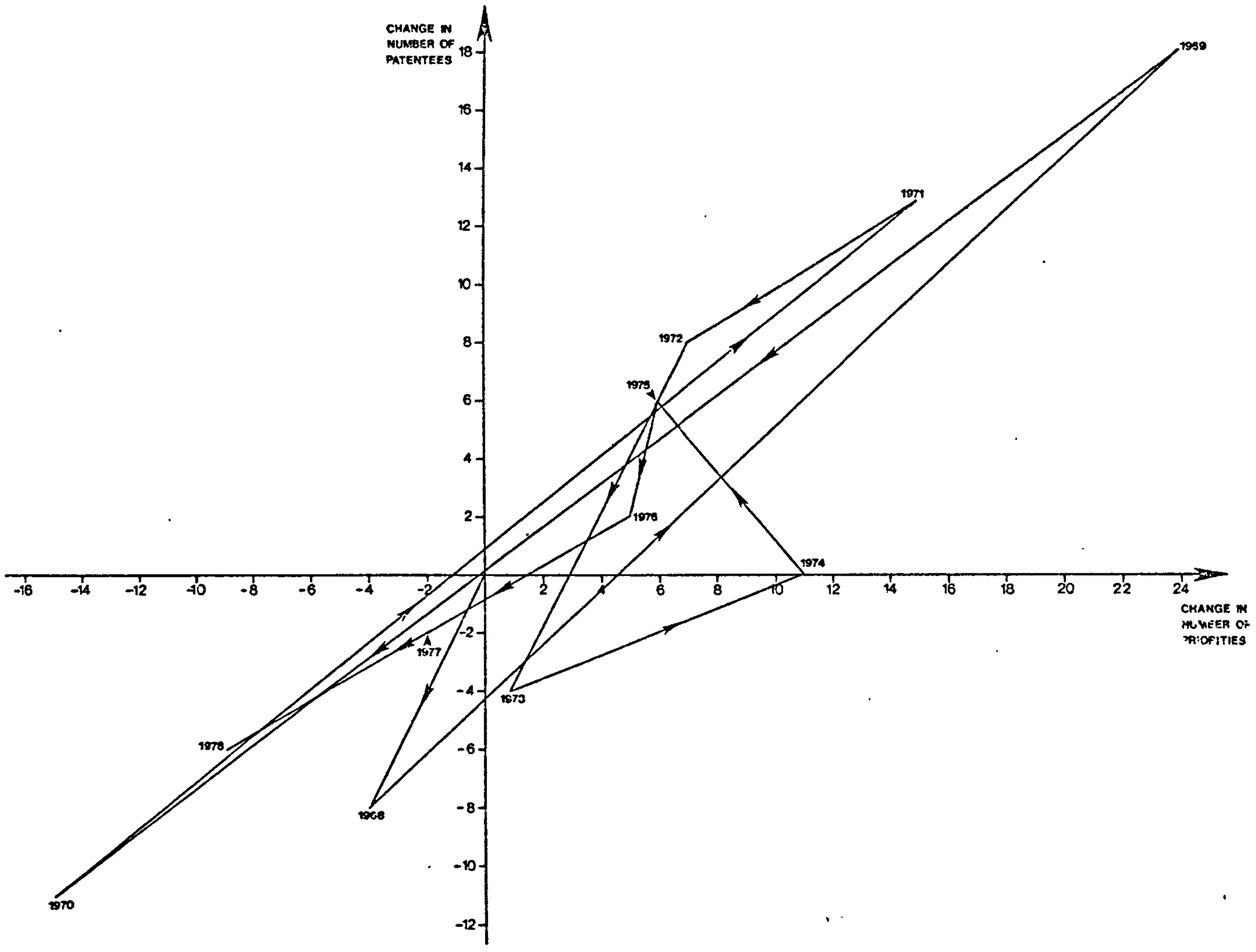


Figure 34: Vector Analysis Graph for Pressure Sensitive Adhesives Patents

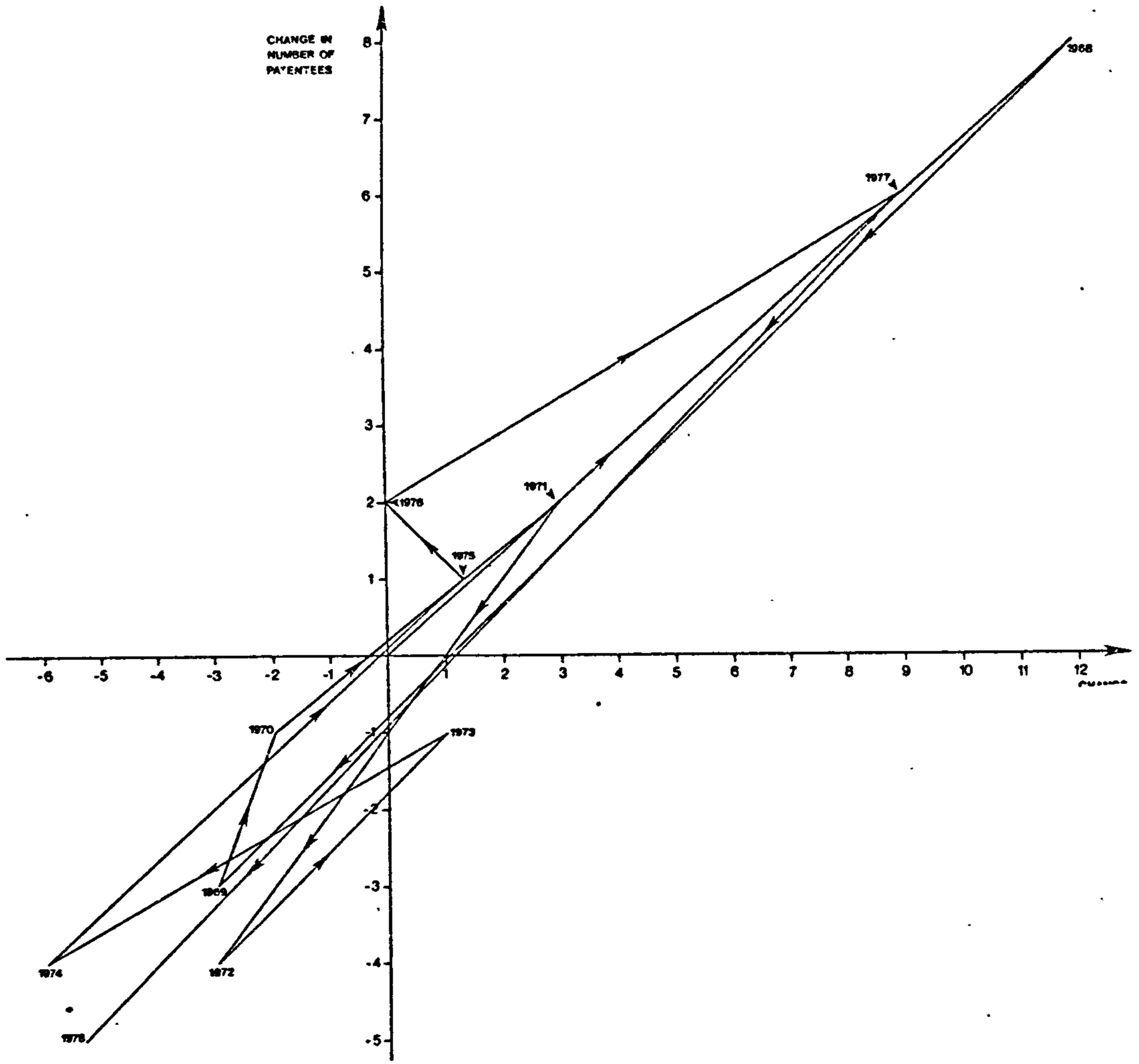


Figure 35: Vector Analysis Graph for Pharmacologically Active Pyrazolone Patents

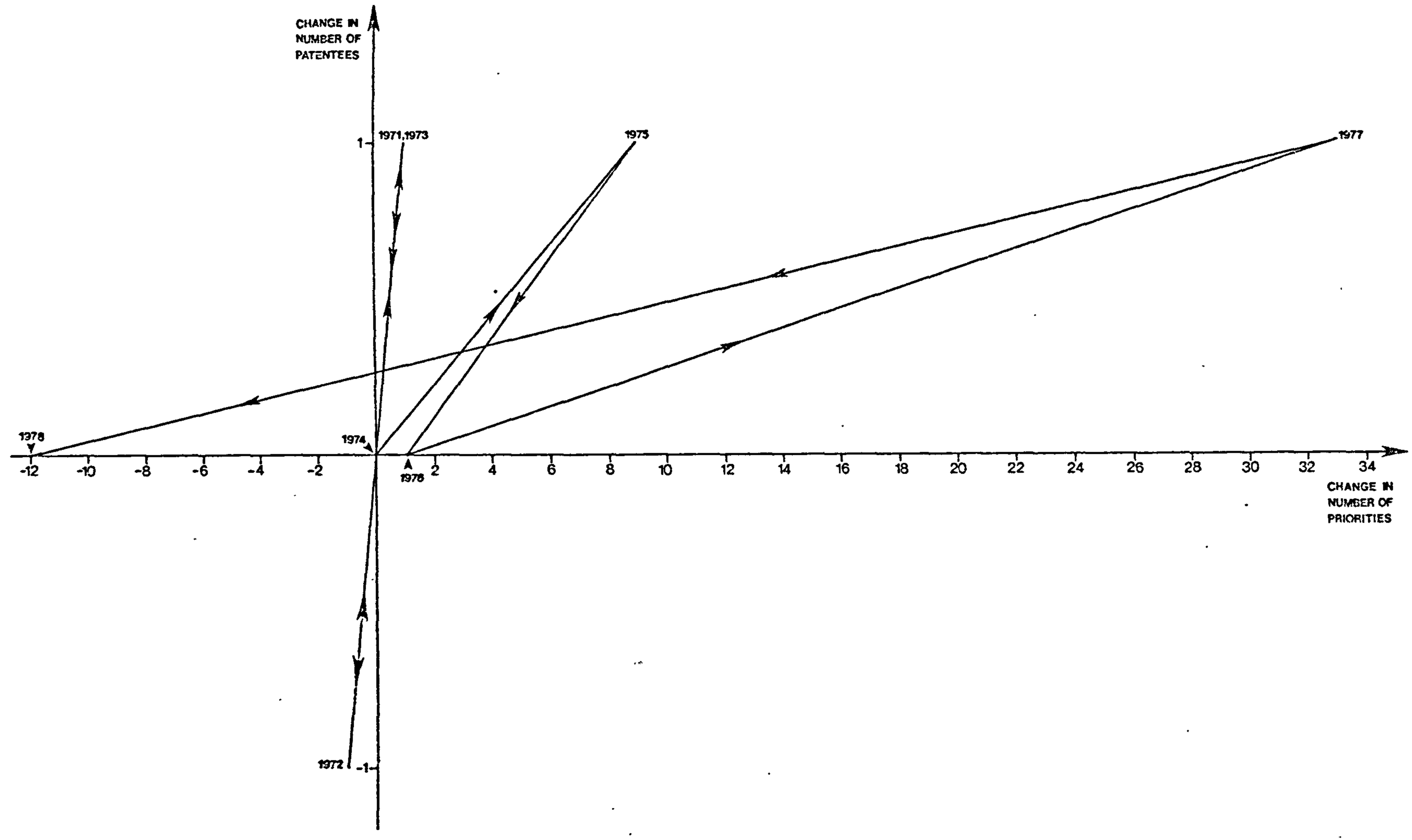


Figure 36: Vector Analysis Graph for Olivanic Acid Patents

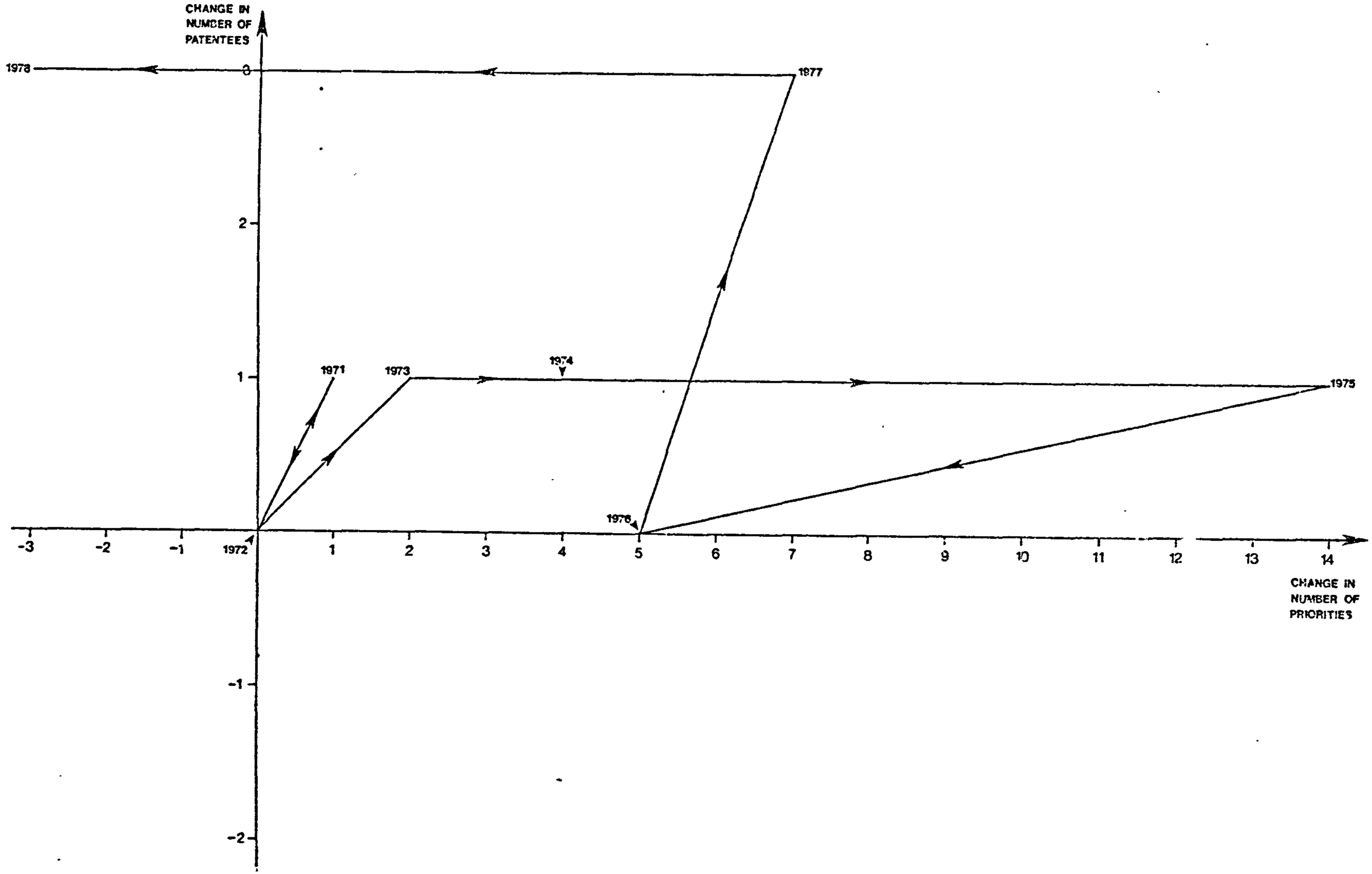


Figure 37: Vector Analysis Graph for Clavulanic Acid Patents

FREQUENCY DISTRIBUTIONS AND PATENTS DATA SETS

None of the investigations of frequency distributions and scientific productivity identified in the literature of bibliometrics has been concerned with patents. It was thus considered appropriate to test sets of patents data in different technologies with various functions. The distributions chosen for investigation, and those which have been tested in bibliometric studies by Coile[171] and Rao[172] are shown in Table 24.

Theoretical Frequency Distribution	Coile	Rao	Present Study
Lotka	Yes	No	Yes
Simon-Yule	Yes	No	Yes
Price's Pareto-type	Yes	No	Yes
Williams' Geometric	Yes	Yes	Yes
Fisher's Logarithmic	Yes	Yes	Yes
Shockley's Lognormal	Yes	Yes	Yes
Poisson	Yes	Yes	No
Singh-Maddala	Yes	No	No
Weibull	Yes	No	No
Borel-Tanner	No	Yes	Yes
Negative Binomial	No	Yes	Yes
Cumulative	No	Yes	No
Truncated Negative Binomial	No	Yes	No
Truncated Poisson	No	Yes	No
Zeta	No	Yes	No
Sinh Transformation	No	Yes	No

Table 24: Theoretical Frequency Distributions used by Coile[136], Rao[137] and in the present study

Of the frequency distributions tested against patents data, and which are listed in Table 24, the Simon-Yule function was selected following Coile's[171] demonstration of its applicability whilst the Negative Binomial and Borel-Tanner were selected because of Rao's successes with them[172]. These, together with the other seven functions, and the method of determining the theoretical distributions, are described in Appendices XI to XVIII.

"Goodness-of-fit" was ascertained by using the Kolmogorov-Smirnov one-sample test. This was used in preference to the χ^2 test and, as discussed by Coile[171], is based on observed and theoretical cumulative distributions; the Kolmogorov-Smirnov test is distribution free, and its use requires data at least in an ordinal scale and assumes that the data are continuously distributed. Robertson[253] has expressed the opinion that in testing for goodness-of-fit with frequency distribution

functions the Kolmogorov-Smirnov test is more suitable than the X^2 test. The Kolmogorov-Smirnov test is discussed in Appendix XIX.

An Eaca EG3003 (Video Genie) microcomputer was used to carry out the calculations for determining theoretical distributions and applying Kolmogorov-Smirnov tests. This machine uses BASIC programming language. The EG3003 has 16K of random access memory, and 3.5K of read only memory. The particular machine available was not equipped with a printer, but with only a video display unit; for this reason the programs written for this study, and those adapted from other sources, e.g., Coile, were mostly written to display output such that manual recording of results could be achieved before the next output data item was displayed. Generally, for clarity, double width characters were displayed. Program listings and sample runs on hard copy were, however, obtained using a machine equipped with a printer. The programs and sample runs are given in the appropriate Appendices. Programs developed for this study were checked for validity by running them with data for which the theoretical distributions were known from either Coile or Rao.

In the program listings exponentiation is shown by the symbol [(left hand square parenthesis), the character used on the EG3003, rather than the more usual ↑(upwards arrow).

The observed and theoretical frequency distributions for each of the patents data sets are given in Tables 25 to 35; Table 36 summarises the results of the Kolmogorov-Smirnov Tests for each data set. Additionally, Lotka's Law plots were constructed for the patents data set; these are given in Figures 38 to 47.

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	83	49.0994	99.6820	102.1789	14.1839	46.9769	51.4497	77.2208	96.8125
2	24	21.4025	32.3667	33.5616	13.1361	23.0639	21.5795	25.2320	33.4252
3	16	13.1680	15.8669	16.4709	12.1657	15.0980	12.0945	15.5200	17.3105
4	8	9.3294	9.3707	9.6749	11.2669	11.1188	7.7439	10.4857	10.6250
5	5	7.1411	6.1652	6.3036	10.4346	8.7343	5.3674	7.5246	7.1648
6	6	5.7400	4.3541	4.3951	9.6638	7.1470	3.9239	5.5894	5.1294
7	2	4.7721	3.2333	3.2158	8.9498	6.0153	2.9814	4.2457	3.8278
8	5	4.0667	2.4927	2.4388	8.2887	5.1683	2.3334	3.2760	2.9447
9	1	3.5316	1.9784	1.9021	7.6764	4.5110	1.8693	2.5572	2.3187
10	1	3.1128	1.6070	1.5174	7.1093	3.9865	1.5258	2.0141	1.8597
11	1	2.7769	1.3303	1.2330	6.5841	3.5586	1.2655	1.5975	1.5140
12	1	2.5021	1.1188	1.0174	6.0977	3.2031	1.0631	1.2745	1.2478
13	3	2.2733	0.9535	0.8508	5.6472	2.9032	0.9037	1.0216	1.0392
14	2	2.0802	0.8220	0.7194	5.2300	2.6471	0.7755	0.8222	0.8731
15	1	1.9152	0.7157	0.6144	4.8437	2.4260	0.6716	0.6640	0.7391
16	1	1.7727	0.6286	0.5295	4.4859	2.2333	0.5860	0.5379	0.6299
17	3	1.6485	0.5563	0.4596	4.1545	2.0639	0.5148	0.4368	0.5399
18	0	1.5394	0.4956	0.4020	3.8476	1.9140	0.4548	0.3555	0.4652
19	0	1.4429	0.4443	0.3535	3.5633	1.7805	0.4042	0.2900	0.4027
20	0	1.3569	0.4005	0.3130	3.3001	1.6609	0.3610	0.2369	0.3500
⩾ 21	29	51.3283	7.4174	3.8483	41.3707	35.7894	74.1310	30.0977	2.7808

Table 25: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Original Cephalosporins data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	89	87.6003	112.1130	114.9098	15.8478	52.7420	60.5478	86.9049	107.6310
2	29	31.1279	36.4100	37.7495	14.6851	25.8985	26.4648	29.4699	37.3581
3	22	16.9939	17.8516	18.5298	13.6076	16.9564	14.9826	17.5551	19.4502
4	10	11.0610	10.5440	10.8864	12.6093	12.4895	9.6144	11.9590	12.0019
5	6	7.9274	6.9378	7.0943	11.6841	9.8126	6.6578	8.6582	8.1364
6	6	6.0386	4.9001	4.9477	10.8269	8.0307	4.8559	6.4906	5.8560
7	2	4.7974	3.6391	3.6206	10.0325	6.7601	3.6774	4.9767	4.3933
8	4	3.9304	2.8057	2.7464	9.2964	5.8091	2.8676	3.8767	3.3977
9	2	3.2967	2.2269	2.1425	8.6144	5.0712	2.2885	3.0554	2.6897
10	3	2.8169	1.8090	1.7092	7.9823	4.4823	1.8608	2.4299	2.1688
11	1	2.4434	1.4976	1.3893	7.3967	4.0018	1.5368	1.9463	1.7750
12	1	2.1458	1.2596	1.1463	6.8540	3.6026	1.2858	1.5680	1.4707
13	2	1.9041	1.0736	0.9588	6.3511	3.2659	1.0891	1.2693	1.2313
14	1	1.7047	0.9255	0.8111	5.8851	2.9783	0.9307	1.0317	1.0400
15	2	1.5379	0.8058	0.6927	5.4533	2.7299	0.8029	0.8415	0.8851
16	1	1.3966	0.7077	0.5968	5.0532	2.5135	0.6979	0.6884	0.7583
17	1	1.2758	0.6264	0.5184	4.6825	2.3232	0.6108	0.5646	0.6535
18	3	1.1715	0.5581	0.4532	4.3389	2.1549	0.5376	0.4642	0.5661
19	0	1.0806	0.5003	0.3990	4.0206	2.0049	0.4761	0.3824	0.4926
20	1	1.0010	0.4510	0.3529	3.7256	1.8705	0.4236	0.3156	0.4304
≥21	30	24.7481	8.3572	4.3453	46.4226	40.5021	73.7911	31.5517	3.6139

Table 26 Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Updated Cephalosporins data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	156	102.9060	156.0120	145.8137	118.0200	133.8000	78.5112	165.2470	146.8370
2	44	34.7058	38.7469	40.7470	58.2401	47.4409	29.0206	27.5913	42.7257
3	10	18.3771	15.4172	17.4398	28.7402	22.4278	14.2081	13.4137	18.6482
4	5	11.7048	7.6748	9.1264	14.1827	11.9282	8.0660	7.9483	9.6465
5	5	8.2490	4.3691	5.3888	6.9988	6.7669	5.0228	5.1326	5.4822
6	3	6.1978	2.7217	3.4526	3.4538	3.9989	3.3345	3.4782	3.3077
7	2	4.8670	1.8092	2.3468	1.7044	2.4306	2.3209	2.4311	2.0803
8	1	3.9475	1.2631	1.6685	0.8411	1.5082	1.6760	1.7361	1.3487
9	3	3.2818	0.9164	1.2288	0.4150	0.9507	1.2454	1.2596	0.8951
10	0	2.7821	0.6858	0.9318	0.2048	0.6067	0.9483	0.9251	0.6050
11	0	2.3958	0.5265	0.7230	0.1011	0.3911	0.7370	0.6860	0.4151
12	0	2.0903	0.4129	0.5727	0.0499	0.2543	0.5820	0.5126	0.2883
13	1	1.8437	0.3297	0.4613	0.0246	0.1664	0.4667	0.3856	0.2024
14	0	1.6414	0.2674	0.3770	0.0121	0.1096	0.3789	0.2916	0.1433
15	1	1.4731	0.2199	0.3120	0.0060	0.0725	0.3113	0.2215	0.1022
16	0	1.3313	0.1830	0.2612	0.0030	0.0482	0.2586	0.1690	0.0734
17	1	1.2106	0.1539	0.2211	0.0015	0.0322	0.2162	0.1293	0.0530
18	0	1.1068	0.1307	0.1885	0.0007	0.0216	0.1824	0.0993	0.0385
19	0	1.0169	0.1118	0.1619	0.0004	0.0145	0.1547	0.0765	0.0281
20	0	0.9383	0.0965	0.1405	0.0002	0.0098	0.1328	0.0590	0.0206
≥ 21	1	20.9329	0.9515	1.4366	0.0004	0.0209	85.2796	1.2063	0.0587

Table 27: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Air Cushion Vehicles data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	89	16.1939	90.9041	93.7863	25.5190	52.5096	40.1046	86.2444	87.9738
2	23	9.2570	28.5943	29.9006	21.6427	25.0083	15.4962	22.1115	29.8024
3	10	6.6741	13.6844	14.2185	18.3552	15.8807	8.4746	12.3432	15.1440
4	9	5.2917	7.9267	8.0974	15.5671	11.3450	5.3757	8.1322	9.1204
5	5	4.4198	5.1313	5.1228	13.2024	8.6451	3.7140	5.7670	6.0345
6	3	3.8152	3.5738	3.4754	11.1970	6.8622	2.7157	4.2637	4.2390
7	3	3.3690	2.6216	2.4788	9.4962	5.6027	2.0674	3.2381	3.1038
8	0	3.0249	1.9993	1.8362	8.0537	4.6696	1.6230	2.5058	2.3429
9	1	2.7507	1.5713	1.4013	6.8304	3.9537	1.3049	1.9661	1.8101
10	1	2.5265	1.2650	1.0957	5.7929	3.3894	1.0697	1.5591	1.4245
11	2	2.3395	1.0387	0.8738	4.9129	2.9350	0.8907	1.2468	1.1379
12	3	2.1809	0.8669	0.7088	4.1667	2.5626	0.7521	1.0039	0.9202
13	2	2.0445	0.7337	0.5831	3.5338	2.2532	0.6419	0.8129	0.7519
14	1	1.9258	0.6284	0.4860	2.9970	1.9929	0.5541	0.6614	0.6198
15	0	1.8216	0.5437	0.4092	2.5418	1.7718	0.4817	0.5404	0.5149
16	0	1.7291	0.4748	0.3481	2.1557	1.5822	0.4224	0.4430	0.4305
17	1	1.6466	0.4178	0.2985	1.8282	1.4184	0.3728	0.3643	0.3621
18	0	1.5724	0.3704	0.2582	1.5505	1.2760	0.3310	0.3004	0.3061
19	0	1.5053	0.3304	0.2248	1.3150	1.1515	0.2952	0.2483	0.2600
20	2	1.4443	0.2964	0.1967	1.1153	1.0419	0.2651	0.2057	0.2217
≥21	13	92.4672	5.0270	2.1998	6.2265	12.1482	81.0472	14.0419	1.4795

Table 28: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Cycloprorane Derivative Insecticides data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	104	23.7562	95.0493	96.0482	47.8905	67.9980	33.8894	97.4230	90.1666
2	20	12.2035	27.7947	28.8725	33.7331	29.7803	12.3050	21.7739	29.4054
3	10	8.2653	12.5777	13.0368	23.7609	17.3900	6.5966	11.6007	14.3847
4	5	6.2689	6.9622	7.1029	16.7367	11.4242	4.1472	7.3766	8.3399
5	1	5.0590	4.3380	4.3278	11.7890	8.0053	2.8540	5.0708	5.3122
6	2	4.2459	2.9233	2.8429	8.3039	5.8433	2.0833	3.6426	3.5923
7	4	3.6613	2.0832	1.9720	5.8491	4.3871	1.5861	2.6918	2.5322
8	2	3.2203	1.5481	1.4259	4.1200	3.3724	1.2476	2.0288	1.8400
9	1	2.8757	1.1886	1.0511	2.9020	2.6179	1.0029	1.5515	1.3686
10	4	2.5988	0.9367	0.8176	2.0441	2.0638	0.8238	1.1998	1.0369
11	2	2.3713	0.7542	0.6414	1.4399	1.6434	0.6875	0.9361	0.7973
12	1	2.1811	0.6182	0.5126	1.0142	1.3195	0.5817	0.7356	0.6207
13	0	2.0196	0.5145	0.4163	0.7144	1.0669	0.4980	0.5815	0.4883
14	1	1.8808	0.4338	0.3426	0.5032	0.8677	0.4304	0.4620	0.3875
15	1	1.7601	0.3698	0.2854	0.3544	0.7094	0.3752	0.3686	0.3099
16	0	1.6543	0.3185	0.2404	0.2497	0.5825	0.3300	0.2952	0.2494
17	1	1.5607	0.2766	0.2043	0.1759	0.4802	0.2916	0.2372	0.2020
18	0	1.4772	0.2422	0.1751	0.1239	0.3973	0.2598	0.1911	0.1644
19	0	1.4024	0.2135	0.1513	0.0873	0.3297	0.2326	0.1543	0.1344
20	0	1.3350	0.1894	0.1317	0.0165	0.2743	0.2091	0.1249	0.1103
⩾ 21	3	72.2026	2.6675	1.4012	0.1463	1.4565	91.5682	3.5541	0.5570

Table 29: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Videodiscs data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	445	305.6100	445.8330	416.3179	388.0930	382.8230	235.6015	465.3660	423.4420
2	110	100.3330	110.5130	116.2726	116.2030	135.3900	87.8339	83.4845	121.7030
3	46	52.2982	43.9047	49.9249	81.7038	63.8427	42.3957	40.1287	52.4683
4	17	32.4900	21.8279	26.0248	40.1648	33.8680	23.6547	23.3188	26.8090
5	13	23.0144	12.4124	15.3642	19.7446	19.1645	14.4777	14.7214	15.0493
6	7	17.1698	7.7247	9.8420	9.7063	11.2962	9.4503	9.7373	8.9691
7	4	13.4026	5.1303	6.6886	4.7715	6.8486	6.4751	6.6362	5.5717
8	5	10.8144	3.5790	4.7554	2.3456	4.2387	4.6051	4.6180	3.5682
9	3	8.9496	2.5948	3.5019	1.1531	2.6650	3.3735	3.2632	2.3389
10	2	7.5558	1.9406	2.6547	0.5668	1.6965	2.5350	2.3332	1.5617
11	2	6.4828	1.4888	2.0608	0.2787	1.0909	1.9438	1.6838	1.0583
12	2	5.6369	1.1670	1.6312	0.1370	0.7073	1.5162	1.2244	0.7261
13	0	4.9566	0.9314	1.3140	0.0673	0.4618	1.2017	0.8960	0.5034
14	1	4.4002	0.7552	1.0740	0.0331	0.3033	0.9649	0.6591	0.3521
15	2	3.9384	0.6207	0.8891	0.0163	0.2002	0.7847	0.4870	0.2481
16	0	3.5504	0.5162	0.7441	0.0080	0.1328	0.6437	0.3612	0.1760
17	0	3.2209	0.4339	0.6298	0.0039	0.0884	0.5333	0.2689	0.1256
18	0	2.9382	0.3682	0.5367	0.0019	0.0590	0.4456	0.2007	0.0901
19	0	2.6937	0.3151	0.4622	0.0010	0.0396	0.3751	0.1502	0.0649
20	1	2.4806	0.2717	0.3997	0.0005	0.0266	0.3185	0.1127	0.0470
⩾ 21	5	53.0635	2.6714	3.9114	49.9998	0.0569	55.8700	5.3481	0.1275

Table 30: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Genetic Engineering data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	289	102.7930	263.4530	259.5426	161.9260	205.0560	128.4920	294.3200	263.1480
2	55	45.7220	72.9611	75.6238	100.5210	83.8566	47.0972	50.7713	78.5016
3	25	28.4651	31.6474	33.3359	62.4015	45.7237	23.7621	25.0974	35.1276
4	20	20.3370	16.9211	17.8273	38.7377	28.0477	13.9612	15.0985	18.6296
5	11	15.6683	10.2384	10.7023	24.0477	18.3519	8.9935	9.8930	10.8546
6	6	12.6612	6.7261	6.9469	14.9283	12.5082	6.1672	6.8006	6.7145
7	3	10.5737	4.6867	4.7713	9.2672	8.7689	4.4246	4.8207	4.3294
8	1	9.0458	3.4135	3.4220	5.7529	6.2755	3.2883	3.4911	2.8778
9	2	7.8825	2.5736	2.5385	3.5713	4.5624	2.5125	2.5684	1.9580
10	2	6.9692	1.9949	1.9364	2.2170	3.3584	1.9625	1.9125	1.3569
11	1	6.2345	1.5819	1.5112	1.3763	2.4971	1.5624	1.4378	0.9545
12	2	5.6317	1.2785	1.2020	0.8544	1.8721	1.2635	1.0893	0.6797
13	0	5.1287	1.0500	0.9723	0.5304	1.4134	1.0363	0.8306	0.4891
14	0	4.7032	0.8744	0.7972	0.3292	1.0734	0.8600	0.6368	0.3550
15	1	4.3388	0.7370	0.6623	0.2044	0.8194	0.7208	0.4904	0.2597
16	1	4.0236	0.6277	0.5560	0.1269	0.6283	0.6098	0.3792	0.1912
17	0	3.7483	0.5396	0.4714	0.0788	0.4837	0.5201	0.2942	0.1416
18	0	3.5061	0.4678	0.4031	0.0489	0.3736	0.4471	0.2290	0.1054
19	2	3.2914	0.4085	0.3476	0.0304	0.2895	0.3869	0.1787	0.0789
20	0	3.0999	0.3592	0.3015	0.0188	0.2249	0.3369	0.1398	0.0592
⩾ 21	6	123.1760	4.4596	3.1284	0.0309	0.8153	178.5951	6.5208	0.1880

Table 31: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Pressure Sensitive Adhesives data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	89	23.7166	89.3370	91.6543	35.0152	87.9859	39.0564	81.0633	85.2953
2	16	12.1308	27.2168	28.4025	27.3041	26.6645	15.0443	23.3195	28.4965
3	15	8.1954	12.7110	13.1555	21.2912	16.3486	8.1726	12.9823	14.2807
4	6	6.2048	7.2188	7.3199	16.6024	11.2767	5.1502	8.3917	8.4819
5	4	5.0003	4.5962	4.5380	12.9462	8.2969	3.5365	5.8007	5.5346
6	4	4.1919	3.1557	3.0245	10.0952	6.3588	2.5713	4.1657	3.8342
7	1	3.6112	2.2861	2.1241	7.8720	5.0126	1.9473	3.0663	2.7687
8	2	3.1737	1.7240	2.0292	6.1384	4.0338	1.5212	2.2963	2.0611
9	3	2.8320	1.3413	1.1702	4.7866	3.2976	1.2175	1.7418	1.5705
10	1	2.5576	1.0700	0.9053	3.7325	2.7295	0.9934	1.3341	1.2189
11	4	2.3324	0.8711	0.7150	2.9105	2.2821	0.8241	1.0299	0.9602
12	1	2.1441	0.7214	0.5749	2.2696	1.9239	0.6931	0.8001	0.7658
13	1	1.9844	0.6061	0.4695	1.7698	1.6333	0.5896	0.6248	0.6171
14	0	1.8471	0.5156	0.3883	1.3800	1.3948	0.5067	0.4901	0.5017
15	1	1.7279	0.4433	0.3252	1.0761	1.1973	0.4393	0.3858	0.4110
16	0	1.6233	0.3848	0.2748	0.8391	1.0323	0.3840	0.3048	0.3389
17	1	1.5309	0.3368	0.2345	0.6543	0.8935	0.3377	0.2414	0.2811
18	0	1.4485	0.2969	0.2016	0.5102	0.7761	0.2988	0.1917	0.2344
19	0	1.3747	0.2635	0.1747	0.3979	0.6762	0.2662	0.1526	0.1963
20	0	1.3082	0.2352	0.1523	0.3102	0.5908	0.2380	0.1217	0.1651
≥ 21	10	70.0642	3.6684	1.1657	1.0985	4.5948	75.2118	10.4954	0.9860

Table 32: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Terephthalic Acid Production data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	72	75.8302	88.7359	81.7993	69.5473	77.4609	56.9036	81.3923	81.3001
2	33	20.1608	21.3799	22.6663	32.3409	26.3844	25.1714	22.5450	23.8655
3	15	9.2888	8.3022	9.6465	15.0392	11.9826	11.4979	10.8653	10.5085
4	5	5.3601	4.0495	5.0279	6.9935	6.1222	5.8126	5.9786	5.4840
5	0	3.4991	2.2653	2.9601	3.2521	3.3365	3.1898	3.4939	3.1442
6	2	2.4696	1.3897	1.8920	1.5123	1.8941	1.8663	2.1135	1.9139
7	1	1.8394	0.9112	1.2836	0.7033	1.1060	1.1484	1.3073	1.2143
8	1	1.4251	0.6284	0.9113	0.3270	0.6593	0.7367	0.8214	0.7942
9	0	1.1378	0.4509	0.6704	0.1521	0.3992	0.4885	0.5221	0.5317
10	0	0.9303	0.3340	0.5078	0.0707	0.2448	0.3338	0.3349	0.3626
11	0	0.7754	0.2540	0.3936	0.0329	0.1516	0.2334	0.2163	0.2510
12	0	0.6566	0.1974	0.3116	0.0153	0.0947	0.1669	0.1405	0.1759
13	0	0.5634	0.1564	0.2506	0.0071	0.0595	0.1217	0.0917	0.1245
14	0	0.4890	0.1259	0.2049	0.0033	0.0377	0.0898	0.0601	0.0890
15	1	0.4286	0.1027	0.1694	0.0015	0.0239	0.0676	0.0395	0.0640
⩾ 16	0	5.1458	0.7166	1.3047	0.0015	0.0426	22.1716	0.0775	0.1766

Table 33: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Pharmacologically Active Pyrazolones data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	8	0.4350	6.8789	7.0868	1.4322	3.6155	0.4855	5.0720	6.0511
2	0	0.3159	2.2021	2.2975	1.2744	1.7524	0.1666	1.7363	2.1539
3	0	0.2620	1.0680	1.1113	1.1340	1.1325	0.0922	1.0739	1.1500
4	0	0.2295	0.6253	0.6432	1.0091	0.8233	0.0606	0.7631	0.7277
5	1	0.2070	0.4084	0.4131	0.8979	0.6385	0.0438	0.5773	0.5059
6	0	0.1903	0.2867	0.2841	0.7990	0.5158	0.0335	0.4527	0.3734
7	1	0.1772	0.2117	0.2052	0.7110	0.4285	0.0267	0.3634	0.2873
8	0	0.1666	0.1624	0.1537	0.6326	0.3635	0.0219	0.2964	0.2279
9	0	0.1578	0.1284	0.1185	0.5629	0.3132	0.0184	0.2447	0.1850
10	0	0.1503	0.1039	0.0935	0.5009	0.2732	0.0157	0.2039	0.1530
11	0	0.1439	0.0857	0.0752	0.4457	0.2408	0.0136	0.1712	0.1284
12	1	0.1382	0.0718	0.0615	0.3966	0.2140	0.0119	0.1446	0.1091
13	0	0.1332	0.0610	0.0510	0.3529	0.1914	0.0106	0.1227	0.0937
14	0	0.1287	0.0524	0.0428	0.3141	0.1723	0.0094	0.1045	0.0811
15	0	0.1247	0.0455	0.0362	0.2795	0.1559	0.0085	0.0894	0.0708
16	0	0.1210	0.0399	0.0310	0.2487	0.1417	0.0077	0.0767	0.0622
17	0	0.1177	0.0352	0.0267	0.2213	0.1293	0.0070	0.0660	0.0550
18	0	0.1146	0.0313	0.0232	0.1969	0.1183	0.0064	0.0569	0.0488
19	1	0.1118	0.0280	0.0203	0.1752	0.1087	0.0059	0.0491	0.0436
20	0	0.1092	0.0252	0.0179	0.1559	0.1001	0.0055	0.0425	0.0391
⩾ 21	1	9.4654	0.4482	0.2073	1.2492	1.5711	11.9486	1.2925	0.4530

Table 34: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Olivanic Acid data set

PATENTS PER PATENTEE	OBSERVED FREQUENCY	EXPECTED FREQUENCIES							
		LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
1	7	0.2850	8.5120	8.7758	1.9248	4.5882	4.2011	5.2741	7.6580
2	2	0.2420	2.7136	2.8338	1.6933	2.2150	1.8888	2.6237	2.7007
3	0	0.2199	1.3120	1.3650	1.4896	1.4257	1.1010	1.7313	1.4287
4	1	0.2055	0.7662	0.7869	1.3104	1.0324	0.7250	1.2363	0.8957
5	1	0.1949	0.4994	0.5034	1.1527	0.7974	0.5137	0.9162	0.6170
6	2	0.1867	0.3499	0.3450	1.0141	0.6416	0.3824	0.6939	0.4512
7	0	0.1800	0.2580	0.2483	0.8921	0.5310	0.2952	0.5330	0.3439
8	0	0.1745	0.1977	0.1855	0.7847	0.4486	0.2341	0.4136	0.2703
9	0	0.1697	0.1560	0.1426	0.6903	0.3850	0.1898	0.3233	0.2174
10	1	0.1655	0.1261	0.1123	0.6073	0.3345	0.1567	0.2542	0.1781
11	0	0.1618	0.1039	0.0901	0.5342	0.2936	0.1312	0.2008	0.1481
12	0	0.1585	0.0870	0.0735	0.4670	0.2599	0.1113	0.1592	0.1247
13	0	0.1556	0.0738	0.0608	0.4134	0.2316	0.0954	0.1266	0.1061
14	0	0.1529	0.0634	0.0509	0.3637	0.2076	0.0825	0.1009	0.0910
15	1	0.1504	0.0550	0.0431	0.3199	0.1871	0.0719	0.0807	0.0787
16	0	0.1481	0.0482	0.0372	0.2815	0.1694	0.0632	0.0646	0.0685
17	0	0.1460	0.0425	0.0312	0.2476	0.1539	0.0559	0.0518	0.0600
18	0	0.1441	0.0377	0.0275	0.2178	0.1403	0.0497	0.0416	0.0528
19	0	0.1422	0.0337	0.0240	0.1916	0.1284	0.0444	0.0335	0.0467
20	0	0.1405	0.0303	0.0211	0.1686	0.1177	0.0399	0.0269	0.0415
≥ 21	1	12.4762	0.5336	0.2420	1.2354	1.7111	5.5668	1.1138	0.4209

Table 35: Observed and Theoretical Frequency Distributions for Number of Patents per Patentee for Clavulanic Acid data set

DATA SET	NUMBER OF PATENTEES (N)	SIGNI-FICANCE LEVEL	CRITICAL VALUE OF D	D_{max}							
				LOTKA	SIMON-YULE	PRICE'S PARETO-TYPE	WILLIAMS' GEOMETRIC	FISHER'S LOGARITHMIC	SHOCKLEY'S LOGNORMAL	NEGATIVE BINOMIAL	BOREL-TANNER
Cephalosporins [Original]	192	0.10 0.05 0.01	0.0880 0.0981 0.1176	0.2348	0.1430	0.1656	0.4349	0.1972	0.2413	0.0301***	0.1624
Cephalopsorins [Updated]	216	0.10 0.05 0.01	0.0830 0.0925 0.1109	0.0277	0.1413	0.1605	0.4438	0.2056	0.2029	0.0281***	0.1450
Air Cushion Vehicles	233	0.10 0.05 0.01	0.0799 0.0891 0.1068	0.2676	0.0224***	0.0576***	0.1630	0.0953*	0.3967	0.0397***	0.0448***
Cyclopropane Insecticides	168	0.10 0.05 0.01	0.0941 0.1049 0.1258	0.5606	0.0788***	0.1034**	0.3860	0.2172	0.4053	0.0246***	0.1012**
Videodiscs	162	0.10 0.05 0.01	0.0959 0.1069 0.1281	0.5543	0.0553***	0.0630***	0.3464	0.2223	0.5511	0.0406***	0.0854***
Genetic Engineering	665	0.10 0.05 0.01	0.0473 0.0527 0.0632	0.2241	0.0247***	0.0432***	0.1608	0.0935	0.3536	0.0306***	0.0324***
Pressure Sensitive Adhesives	427	0.10 0.05 0.01	0.0590 0.0658 0.0789	0.4578	0.0598**	0.0690*	0.2976	0.1966	0.4161	0.0125***	0.0865***
Terephthalic Acid Production	159	0.10 0.05 0.01	0.0968 0.1079 0.1293	0.4776	0.0728***	0.0958***	0.3395	0.1950	0.4153	0.0499***	0.0605***
Pharmacolcgical Pyrazolones	130	0.10 0.05 0.01	0.1070 0.1193 0.1430	0.1131	0.1288*	0.0754***	0.0238***	0.0421***	0.2033	0.0722***	0.0715***
Olivanic Acid	13	0.10 0.05 0.01	0.3250 0.3610 0.4330	0.6595	0.2134***	0.2414***	0.5052	0.3373**	0.8425	0.2252***	0.1602***
Clavulanic Acid	16	0.10 0.05 0.01	0.2950 0.3280 0.3920	0.7624	0.2211***	0.2484***	0.3364*	0.1507***	0.3012**	0.1079***	0.1742***

Critical Values D from Tables; rest calculated: 0.10 $D_{CR} = 1.22/\sqrt{N}$; 0.05 $D_{CR} = 1.36/\sqrt{N}$; 0.01 $D_{CR} = 1.63/\sqrt{N}$

* = Accepted at 0.10 level of significance; ** = Accepted at 0.05 level of significance; *** = Accepted at 0.01 level of significance

Table 36: Summary of Kolmogorov-Smirnov One Sample Test Critical and Calculated Parameter Values for Observed and Theoretical Distributions of Patents per Patentee

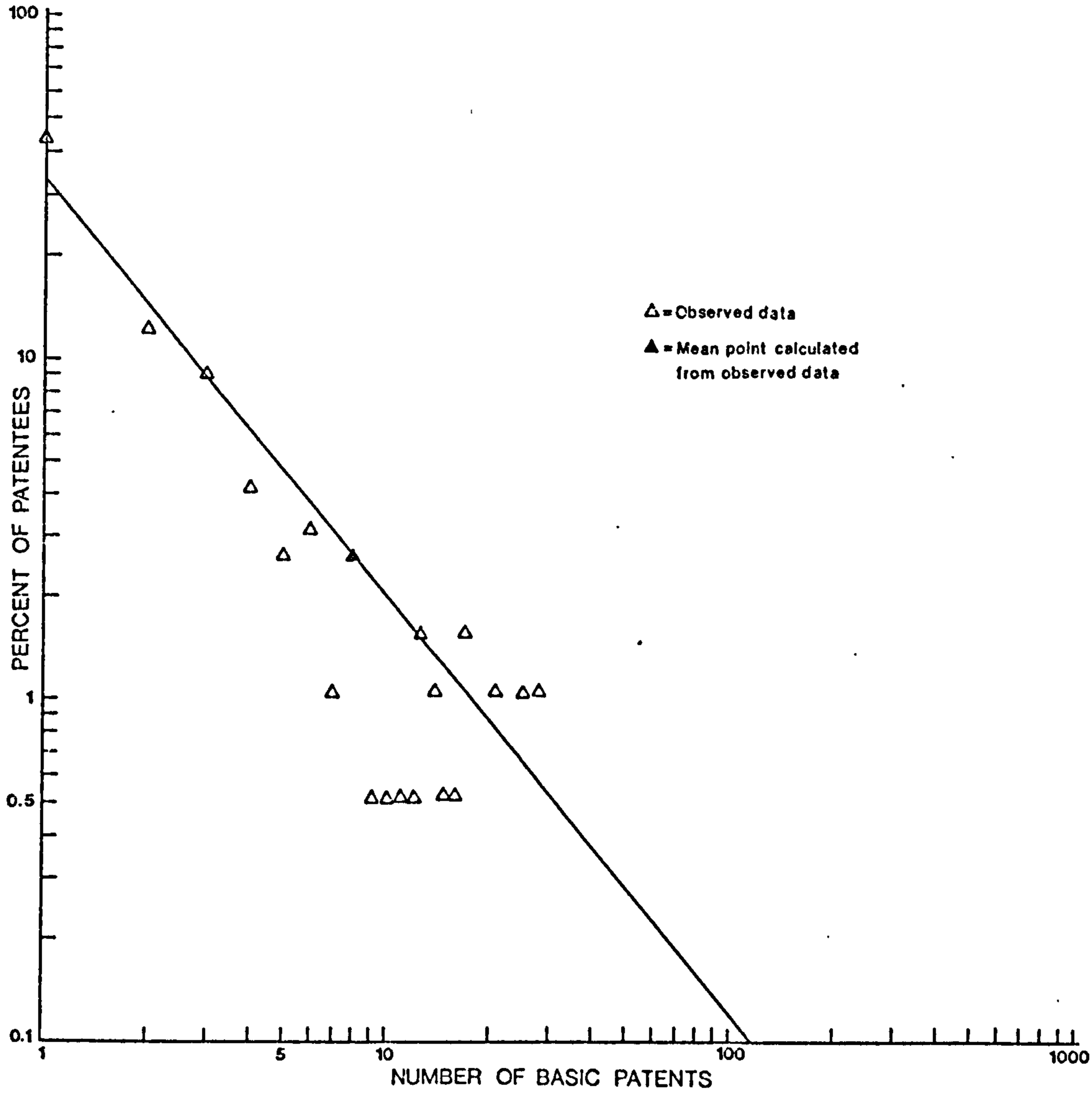


Figure 38: Lotka's Law Graph for Original Cephalosporins Patents Data Set [Exponent = 1.98]

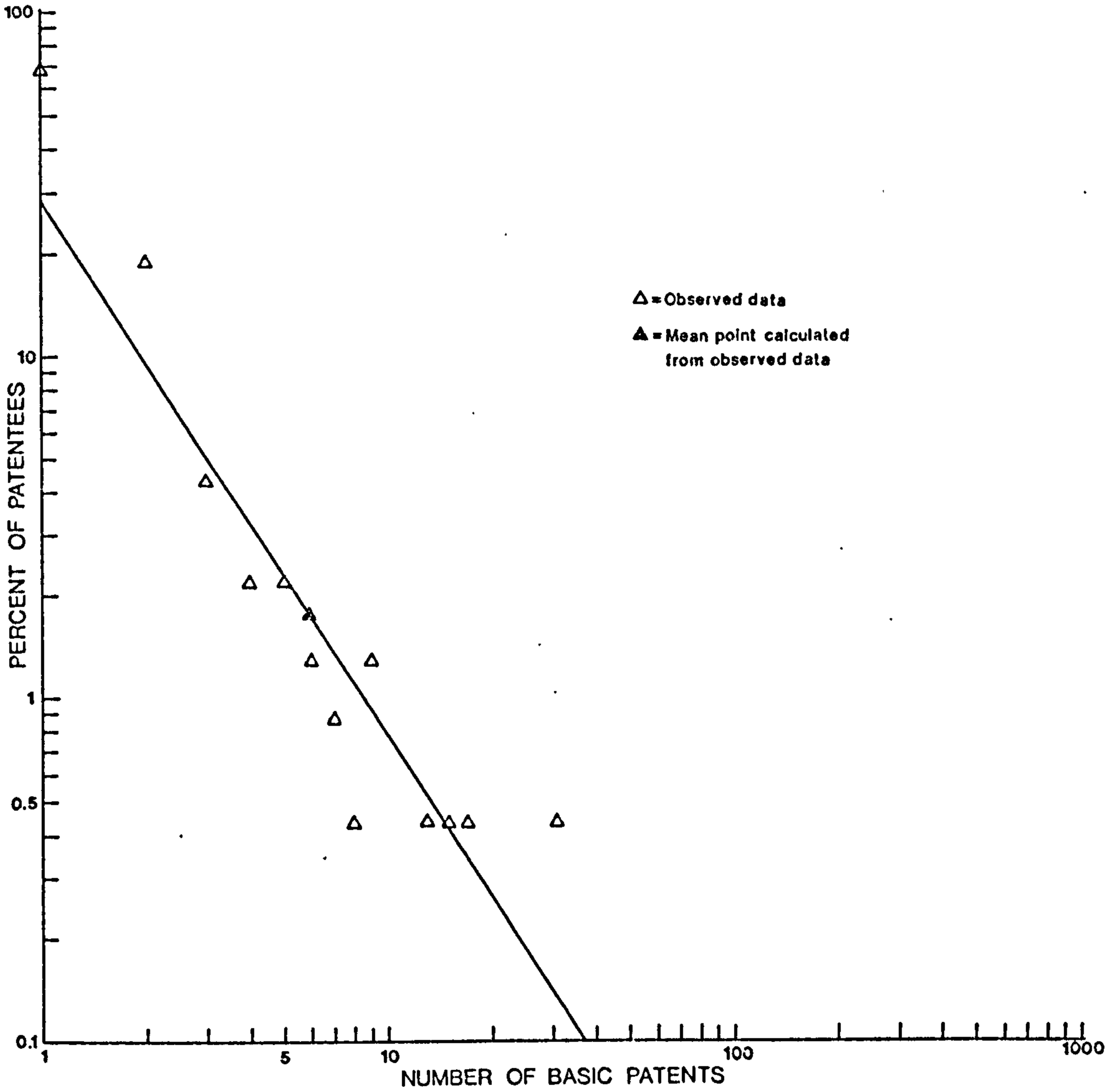


Figure 39: Lotka's Law Graph for Air Cushion Vehicles Patents

[Exponent = 1.568]

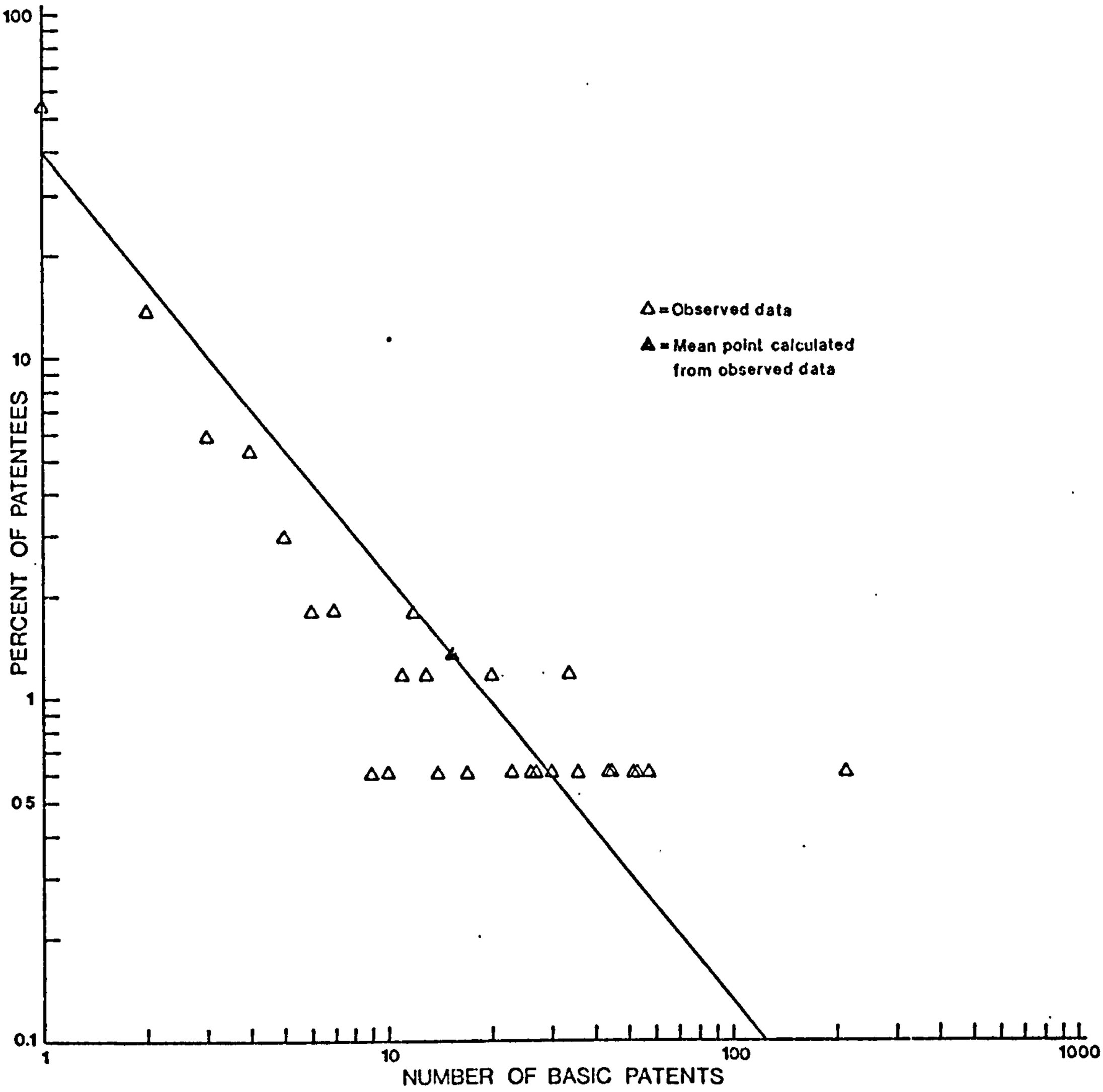


Figure 40: Lotka's Law Graph for Cyclopropane Derivative Insecticide Patents [Exponent = 0.807]

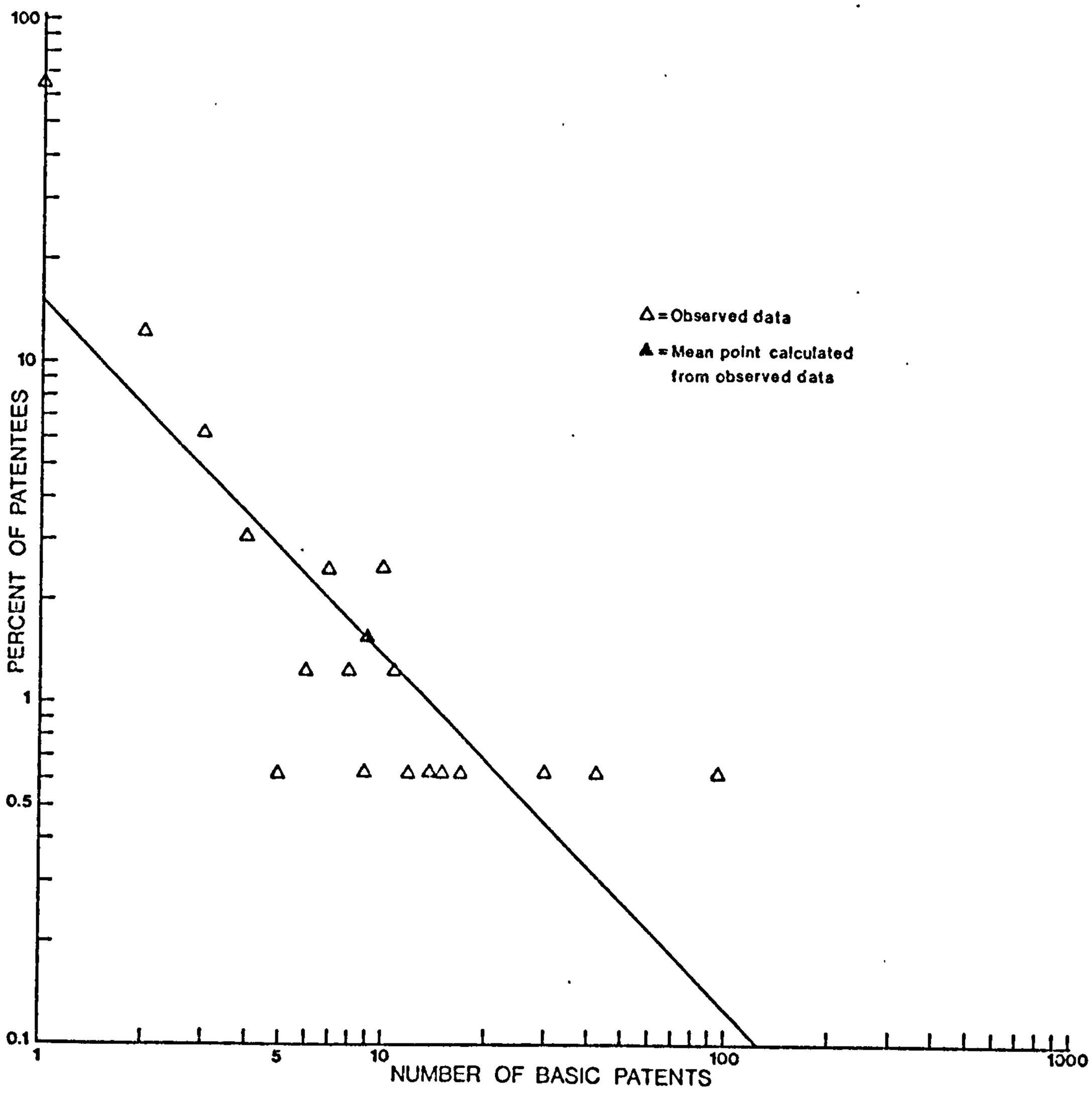


Figure 41: Lotka's Law Graph for Videodisc Patents

[Exponent = 0.961]

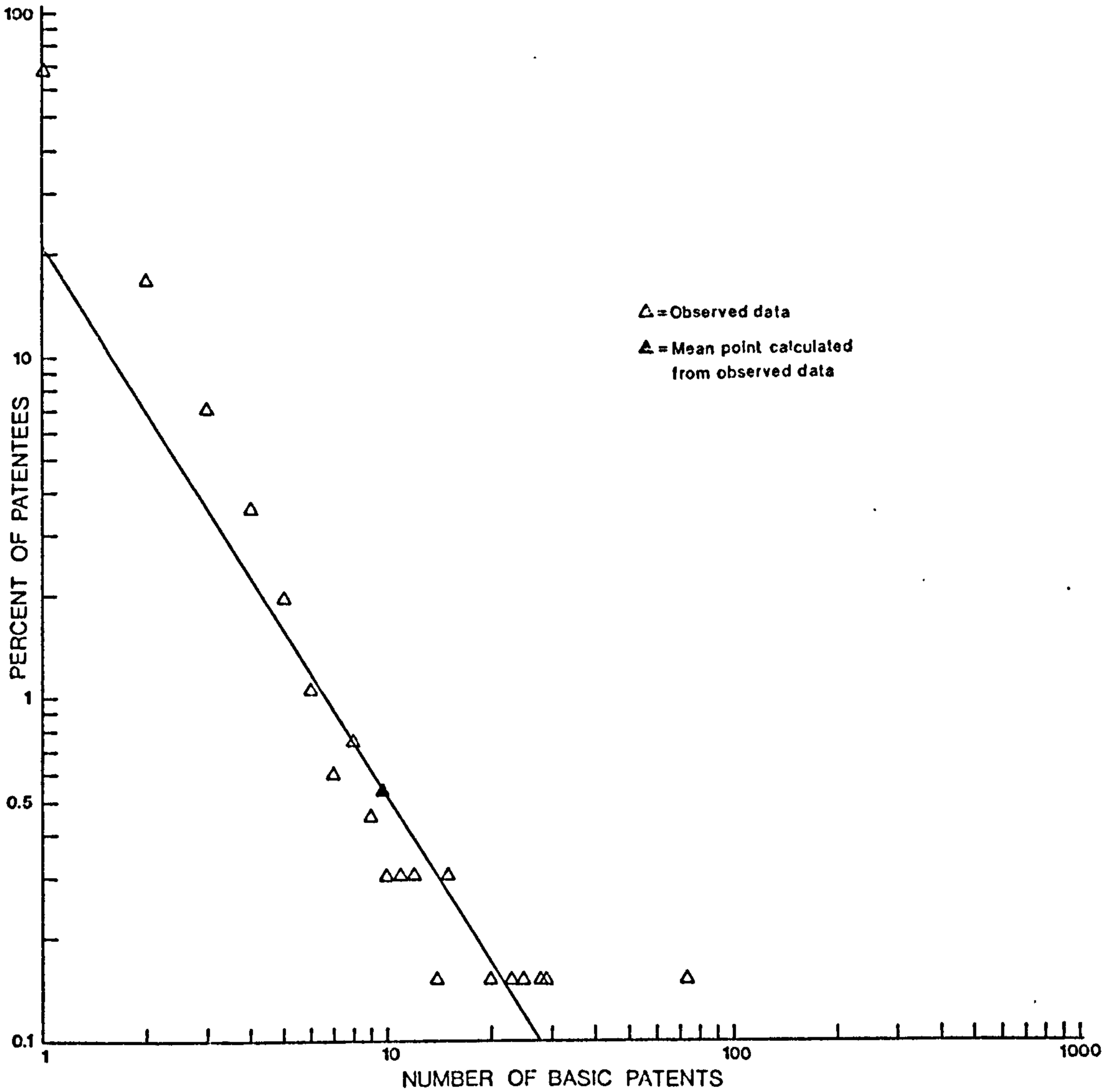


Figure 42: Lotka's Law Graph for Genetic Engineering Patents

[Exponent = 1.607]

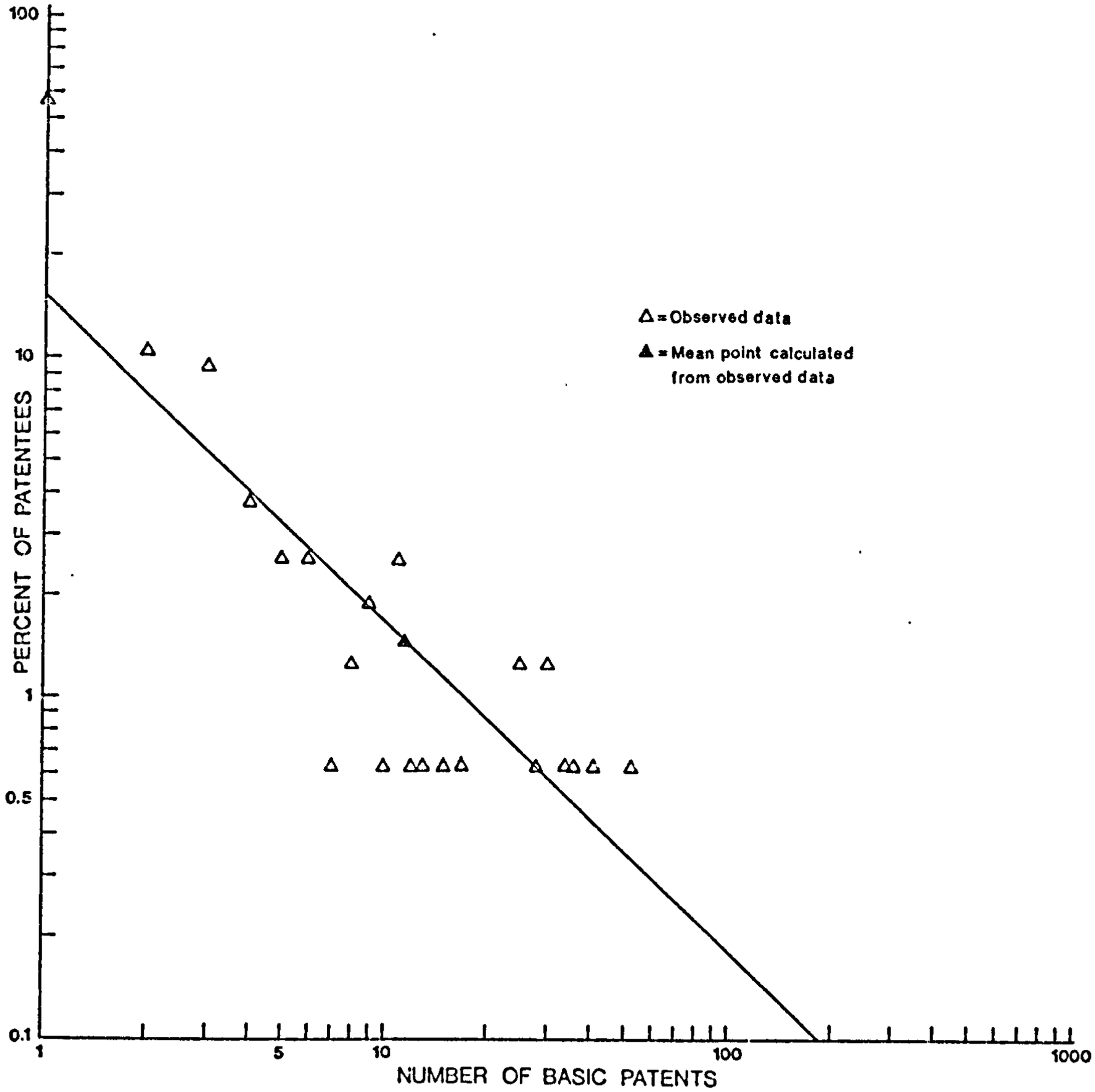


Figure 43: Lotka's Law Graph for Terephthalic Acid Production Patents [Exponent = 0.967]

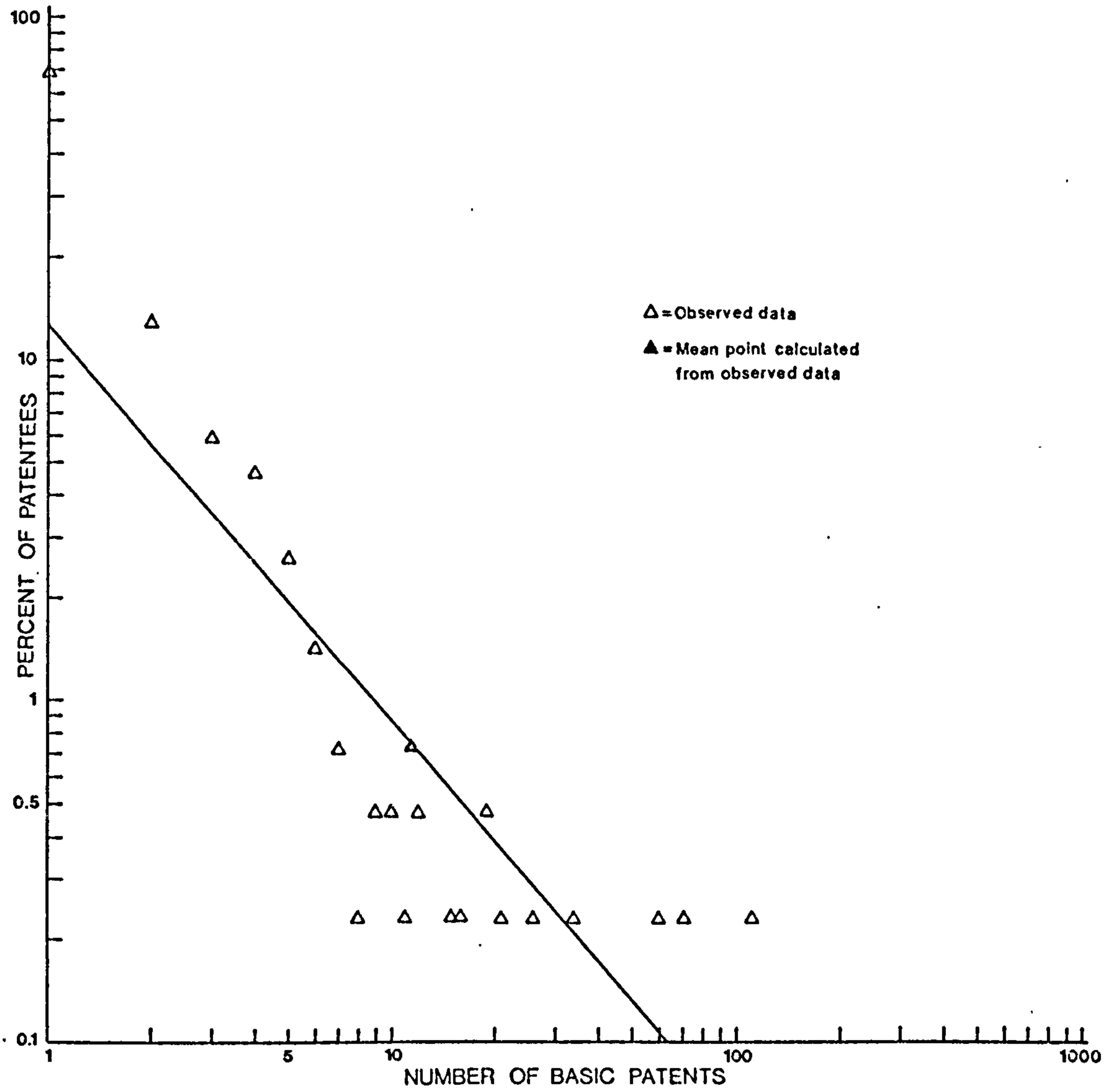


Figure 44: Lotka's Law Graph for Pressure Sensitive Adhesives Patents [Exponent = 1.169]

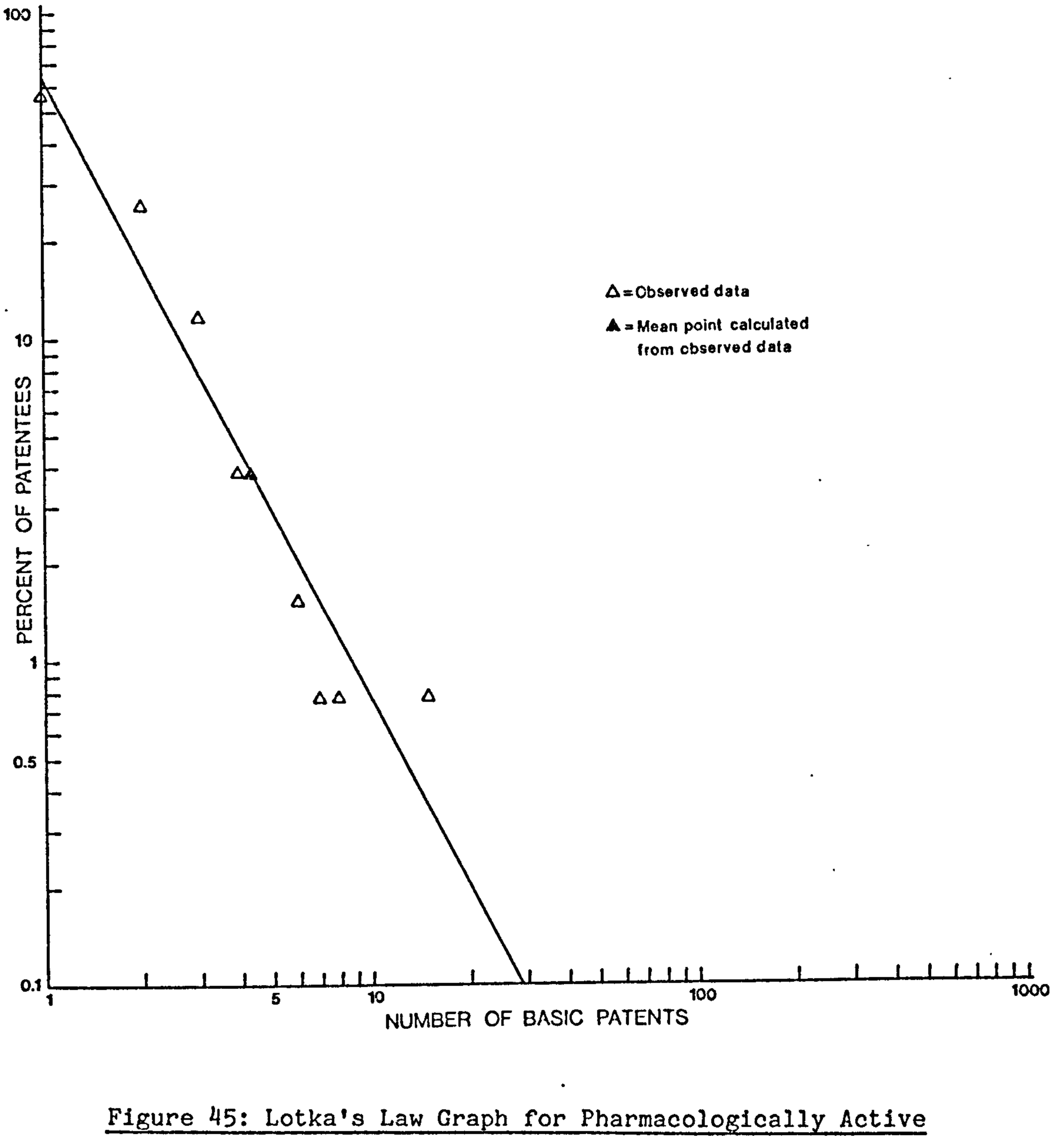


Figure 45: Lotka's Law Graph for Pharmacologically Active Pyrazolone Patents [Exponent = 1.911]

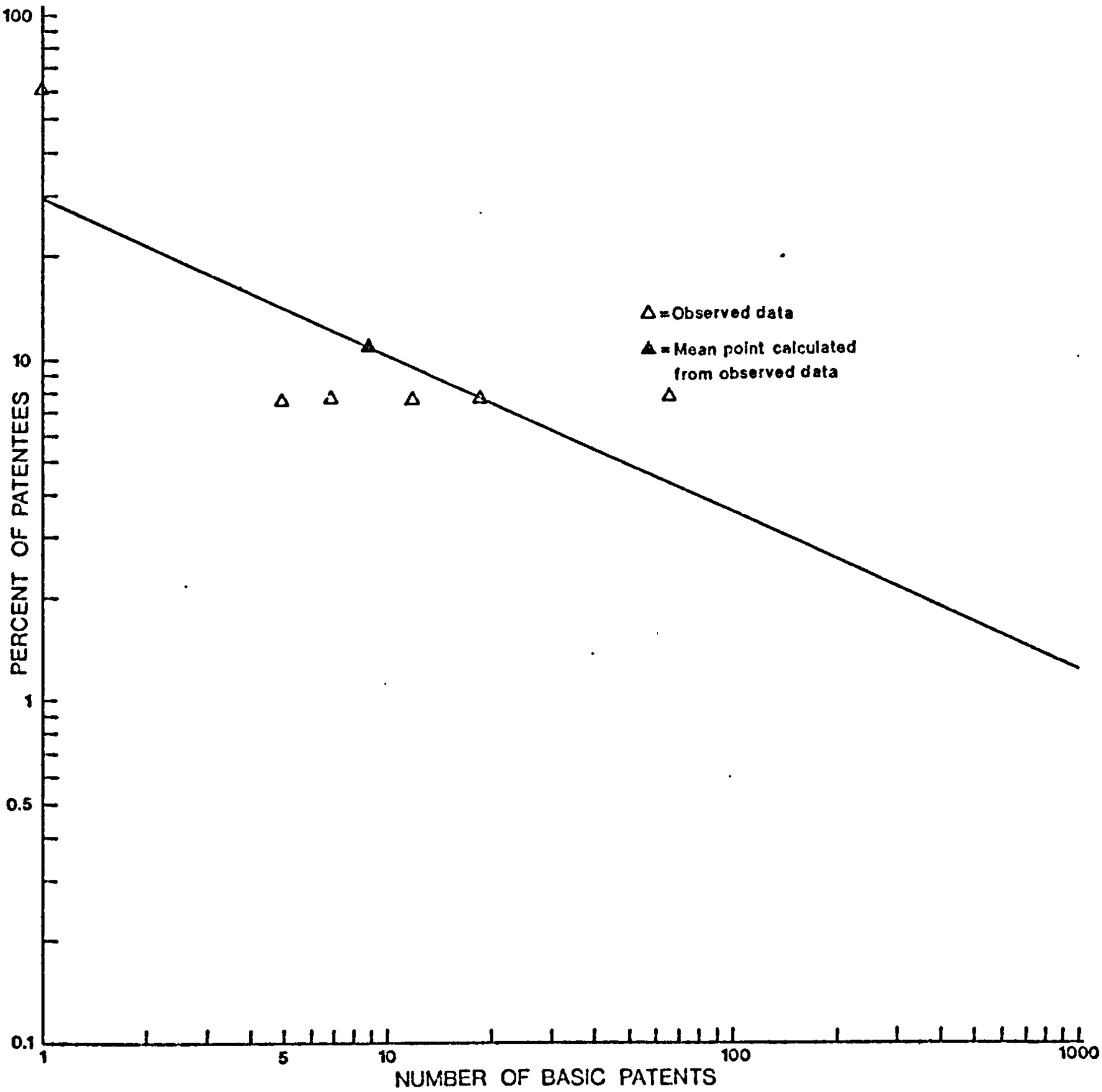


Figure 46: Lotka's Law Graph for Olivanic Acid Patents

[Exponent = 0.461]

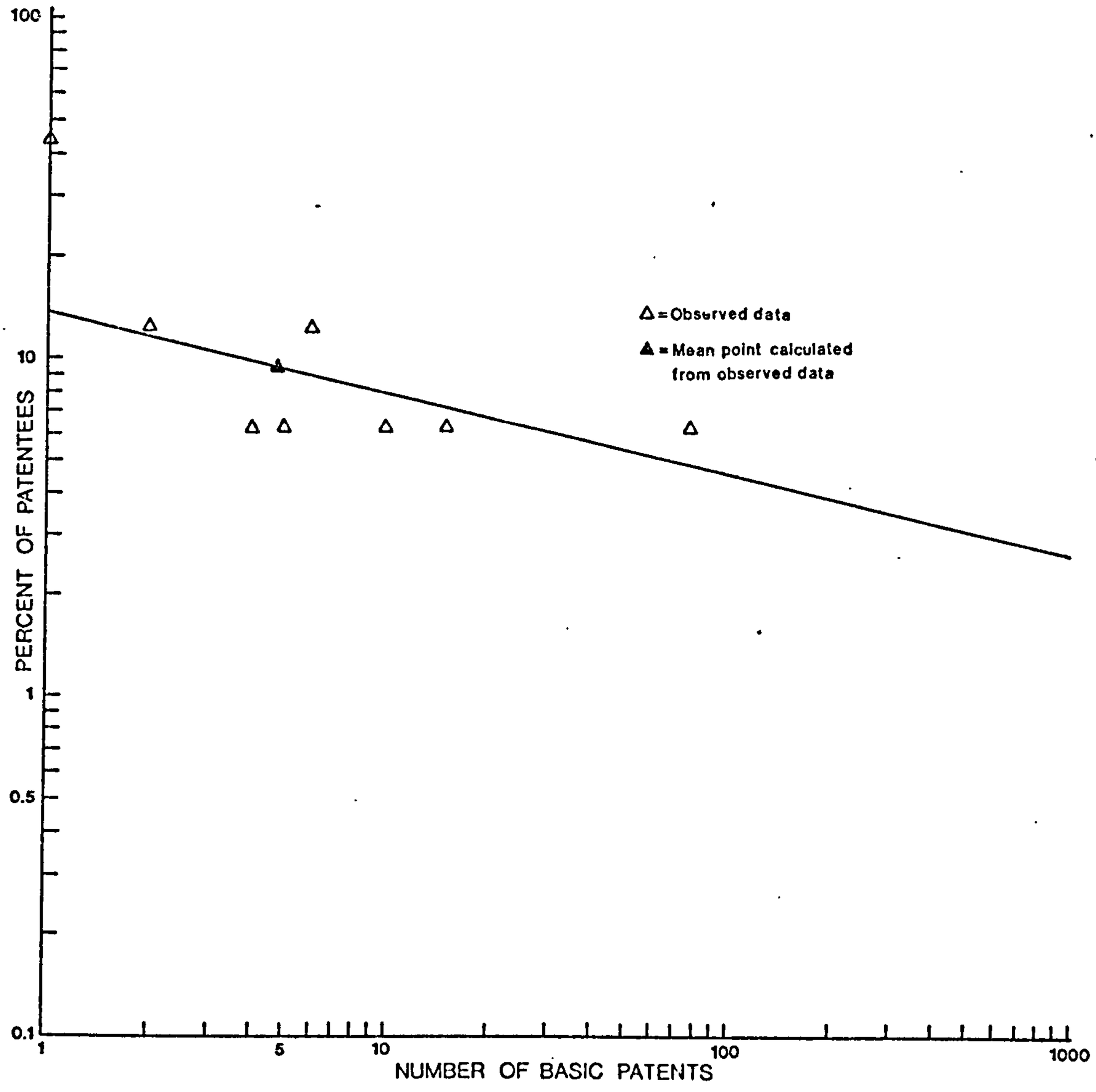


Figure 47: Lotka's Law Graph for Clavulanic Acid Patents

[Exponent = 0.236]

FREQUENCY DISTRIBUTIONS AND PATENT CITATIONS

The patent citation studies of Oppenheim[202], Carpenter, Narin and Woolf[215], and Ellis Hepburn and Oppenheim[212], discussed in Chapter 9, give data for the number of citations received per patent for several patents data sets. Following the observations of applying frequency distributions to patents described above, it was thought appropriate to see whether the theoretical distributions which most closely fitted the observed results, i.e., the Simon-Yule, Borel-Tanner and Negative Binomial, would also fit the citation data reported in the three studies referred to. This was accomplished by using the same computer programs as used previously; the results are given in Tables 37 to 47 for eleven sets of citation data taken. Goodness-of-fit between observed and theoretical distribtion was again tested using the Kolmogorov-Smirnov Test; a summary of the results obtained is given in Table 48.

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	23	42.8058	36.7459	23.7444
2	17	12.1668	12.5261	16.1506
3	12	5.3856	6.4049	10.7214
4	6	2.9279	3.8815	7.0589
5	5	1.7967	2.5843	4.6283
6	3	1.1949	1.8267	3.0271
7	1	0.8417	1.3459	1.9765
8	0	0.6190	1.0223	1.2890
9	0	0.4708	0.7948	0.8399
10	3	0.3679	0.6294	0.5469
11	1	0.2939	0.5059	0.3559
⩾12	0	2.1290	2.7323	0.6611

Table 37: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for "Industrial Research IR100 Award" Patents from Carpenter, Narin and Woolf[215]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	96	105.5290	96.6982	94.6041
2	29	25.7961	28.6667	28.5793
3	12	10.1342	12.7476	13.8972
4	6	4.9915	6.7184	7.6109
5	4	2.8157	3.8900	4.4018
6	4	1.7400	2.3913	2.6269
7	2	1.1484	1.5322	1.5999
8	2	0.7967	1.0121	0.9885
9	0	0.5746	0.6843	0.6172
10	0	0.4277	0.4713	0.3885
11	1	0.3267	0.3294	0.2462
⩾12	0	1.7194	0.8585	0.4395

Table 38: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Hovercraft Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	25	22.9189	21.5313	25.3899
2	4	5.0663	5.7403	2.7078
3	0	1.8343	2.2956	1.2783
4	2	0.8435	1.0880	0.7591
5	0	0.4485	0.5665	0.4971
6	0	0.2631	0.3132	0.3436
7	0	0.1657	0.1805	0.2459
8	0	0.1102	0.1072	0.1803
9	0	0.0765	0.0652	0.1345
10	0	0.0550	0.0404	0.1017
11	0	0.0407	0.0254	0.0778
12	1	0.0308	0.0162	0.0600
⩾13	0	0.1465	0.0302	0.2240

Table 39: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Magnetic Bubble Memory from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	19	19.0256	17.4704	20.8609
2	6	4.6179	5.1417	2.7282
3	0	1.8039	2.2699	1.3427
4	2	0.8842	1.1877	0.8225
5	0	0.4968	0.6827	0.5534
6	0	0.3059	0.4166	0.3924
7	0	0.2012	0.2650	0.2876
8	0	0.1392	0.1738	0.2158
9	0	0.1001	0.1167	0.1647
10	0	0.0744	0.0798	0.1274
11	0	0.0567	0.0554	0.0995
12	0	0.0442	0.0389	0.0784
13	0	0.0350	0.0276	0.0622
14	1	0.0283	0.0198	0.0496
⩾15	0	0.1866	0.0540	0.2147

Table 40: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Magnetic Bubble Memory Patents from Dansey as quoted by Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	65	67.1910	65.7919	69.5854
2	20	17.5645	19.0580	14.8018
3	7	7.2800	8.2808	7.1114
4	6	3.7491	4.2644	4.0514
5	2	2.1971	2.4126	2.4888
6	1	1.4039	1.4492	1.5956
7	0	0.9544	0.9073	1.0514
8	0	0.6800	0.5456	0.7062
9	1	0.5025	0.3869	0.4811
10	0	0.3824	0.2603	0.3314
11	0	0.2892	0.1778	0.2302
12	0	0.2372	0.1230	0.1610
13	0	0.1920	0.0859	0.1133
14	0	0.1877	0.0606	0.0801
15	1	0.1313	0.0430	0.0569
⩾16	1	1.0787	0.1127	1.1440

Table 41: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Fibre Optic Devices for Visible Light Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	33	41.0870	36.9587	31.1826
2	14	10.6031	11.5636	14.4383
3	4	4.3500	5.4270	7.6370
4	5	2.2313	3.0186	4.2073
5	4	1.2924	1.8447	2.3641
6	0	0.8206	1.1968	1.3439
7	2	0.5547	0.8093	0.7699
8	1	0.3932	0.5643	0.4435
⩾ 9	0	1.6777	1.6171	0.6134

Table 42: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Cardiac Pacemakers and Defribillator Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	9	11.7111	10.8222	10.9780
2	7	2.7789	3.1114	2.8462
3	0	1.0659	1.3418	1.3440
4	0	0.5146	0.6858	0.7301
5	0	0.2853	0.3851	0.4225
6	0	0.1737	0.2296	0.2535
7	0	0.1131	0.1427	0.1557
8	1	0.0775	0.0914	0.0972
⩾ 9	0	0.2799	0.1900	0.1728

Table 43 Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Underwater Holography Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	41	44.6420	41.4818	38.6674
2	10	10.3671	11.6588	13.4962
3	6	3.9076	4.9152	6.0271
4	3	1.8590	2.4559	2.8875
5	3	1.0179	1.3481	1.4308
6	0	0.6127	0.7857	0.7225
7	1	0.3950	0.4773	0.3696
⩾ 8	0	1.1988	0.8772	0.3994

Table 44: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Ring Pull Cans from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	13	14.1842	12.6800	10.9185
2	3	3.7182	4.0270	4.7691
3	1	1.5445	1.9184	2.5774
4	1	0.7968	1.0831	1.4820
5	2	0.4677	0.6718	0.8777
6	1	0.2992	0.4424	0.5290
7	2	0.2037	0.3037	0.3224
⩾ 8	0	0.7857	0.8736	0.5239

Table 45: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Four Channel (Quadraphonic) Systems Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	23	23.4000	24.7424	23.3873
2	8	6.0667	6.3769	6.6369
3	2	2.4980	2.4653	2.6906
4	0	1.2795	1.1296	1.1999
5	1	0.7464	0.5686	0.5594
6	1	0.4750	0.3039	0.2676
7	0	0.3217	0.1693	0.1302
⩾ 8	1	1.2127	0.2440	1.1280

Table 46: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Alkene and Alkyne Disproportionation Patents from Oppenheim[202]

Citations Per Patent	Observed Frequency	Expected Frequencies		
		Simon-Yule	Borel-Tanner	Negative Binomial
1	97	90.9689	95.6390	90.0757
2	15	17.3430	16.7981	12.6112
3	3	5.5539	4.4256	4.2171
4	2	2.2997	1.3819	1.6995
5	0	1.1156	0.4741	0.7432
6	0	0.6034	0.1727	0.3403
7	1	0.3533	0.0655	0.1605
8	0	0.2200	0.0257	0.0773
⩾ 9	1	0.5422	0.0174	1.0753

Table 47: Observed and Theoretical Frequency Distributions for Number of Citations per Patent for Semisynthetic Penicillins Patents from Ellis, Hepburn and Oppenheim[212]

DATA SET	NUMBER OF PATENTS	SIGNIFICANCE LEVEL	CRITICAL VALUE OF D	D_{max} SIMON-YULE	D_{max} BOREL-TANNER	D_{max} NEGATIVE BINOMIAL
IR 100 Award	71	0.10 0.05 0.01	0.1448 0.1614 0.1934	0.2790	0.1936	0.0343*
Cardiac Pacemakers and Defibrillators	63	0.10 0.05 0.01	0.1537 0.1713 0.2054	0.1284*	0.0628*	0.0358*
Four Channel (Quadrophonic) Systems	22	0.10 0.05 0.01	0.2528 0.2809 0.3367	0.1112*	0.0777*	0.0946*
Fibre Optic Devices for Visible Light	104	0.10 0.05 0.01	0.1196 0.1334 0.1598	0.0213*	0.0177*	0.0442*
Ring Pull Cans	64	0.10 0.05 0.01	0.1525 0.1700 0.2038	0.0626*	0.0334*	0.0364*
Under Water Holography	17	0.10 0.05 0.01	0.2863 0.3180 0.3809	0.1595*	0.1216*	0.1280*
Alkene & Alkyne Distribution	36	0.10 0.05 0.01	0.2033 0.2267 0.2717	0.0426*	0.0484*	0.0271*
Hovercraft	156	0.10 0.05 0.01	0.0977 0.1089 0.1305	0.0611*	0.0117*	0.0134*
Magnetic Bubble Memory	32	0.10 0.05 0.01	0.2109 0.2342 0.2809	0.0650*	0.1084*	0.0282*
Magnetic Bubble Memory (Dansey)	28	0.10 0.05 0.01	0.2250 0.2499 0.2997	0.0484*	0.0853*	0.0665*
Semi-Synthetic Penicillins	119	0.10 0.05 0.01	0.1118 0.1247 0.1494	0.0507*	0.0159*	0.0110*

* Accepted at 0.10 level of significance

Table 48: Summary of Kolmogorov-Smirnov One Sample Test Critical and Calculated Parameter Values for Observed and Theoretical Distributions of Patent Citations

FINANCIAL DATA

To obtain a parameter with which to measure the relative sizes of the proprietary organisations retrieved as patentees in the cephalosporin searches, it was decied to ascertain .their sales volumes. This was chosen as suitably indicative of size since it is the method adopted by the internationally recognised "Fortune 500" lists of the largest companies within and outside of the USA.

For the majority of patentees, the principal sources of sales figures were:

(a) CA 200, Chemical Age, 31 July, 1981
(b) Fortune 500, Fortune, 4 May, 1981
(c) Fortune Second 500, Fortune, 15 June, 1981
(d) Fortune Foreign 500, Fortune, 10 August 1981
(e) Diamond's Japan Business Directory, 1981 (Diamond Head Co., Tokyo)
(f) Million Dollar Directory, 1981 (Dunn and Bradstreet)

Sales figures for Research Corporation, Forest Laboratories and Ethicon Inc. were obtained from Standard and Poor's register of companies; however, in the case of Ethicon Inc. - a wholly owned subsidiary of Johnson and Johnson Inc. - the figure used is that for the parent company as no separate sales figure could be found for the subsidiary. Sales for Nelson Research & Development Company were taken from Middle Market Directory, 1978 also published by Dunn and Bradstreet.

Figures for Alfa Farmaceutici SpA, Sigma-Tau SpA, Scherico Limited, Mundipharma AG, Antibioticos SA, Cia. Internationale Farmacia Landerlan SA, Laboratorios Farmaceutico Quimico Lafarquim SA, Laboratorios Cusi SA, Stada Arzneimittel GmbH, Purdue Frederick Company and Pharmacia AB were provided through the generosity of Ciba-Geigy Limited, Basel, using their in-house maintained files.

Sales figures for Glaxo Holdings Limited and Wellcome Foundation Limited were ascertained from company annual reports.

Sales figures for Bristol-Banyu KK, Eiken Kagaku KK, Meiji Seika KK, Nippon Chemifar Company Limited, Ohta Seiyaku KK and Toshin Chemical Industries KK were obtained from Teikoko Ginko Kaisha Yoroku, published

by Teikoku Kohinsho Limited, Tokyo (1980), and for Seoul Pharmaceutical Industries KK from Kankoku Kigyo Chosa Coroku, published by Kankokui Seisansei Honbu, Seoul (1978) through the kindness of Nippon Gijutsu Boeki Company Limited, Tokyo.

The sales figure for Lepetit SpA was obtained from data cards of the European Services issued by McCarthy Information Limited, London. The sales figure for Societe Omnium-Chimique SA is that of the parent company (owning 100%), PRB Chemicals SA.

Organon NV is a wholly owned subsidiary of Akzo NV; no separate sales figure per se could be found for Organon. However, in the entry for Akzo NV in International Business Year Book 1977/78, published by The Financial Times Limited, London (1977), it is stated that 30% of the revenue of Akzo NV is derived from pharmaceuticals. Accordingly, the sales figure used in the tables for Akzo NV is only 70% of that taken from Chemical Age 200, the remaining 30% has been taken as the sales figure for Organon NV.

Although several sources were used for gathering this financial data, where possible sales figures reported for either 1978 or 1979 were used since the majority of figures taken from the Dunn and Bradstreet publications would appear to cover those years. However, it was not possible to check the exact period covered; Dunn and Bradstreet merely state that the figures used in the publications are the latest available at the time of going to press. No cognisance is paid to the differences in financial accounting periods, e.g., January through December or April through March. Neither is there any clear editorial policy on how sales figures are derived for trans-national corporations - such as whether or not figures for overseas subsidiaries have been consolidated; for example it is not known whether the sales figures for ICI Limited include figures for African Explosives SA (South Africa) or ICI (America) Inc.

Sales figures could not be found for the following patentees:

Aries Associates SA, France
Dobfar SpA, Italy
Caw Industries Inc., USA
Connlab Holdings Limited, Canada
Craf Sud SpA, Italy

Instituto de Farmacologica Espanola SA, Spain
Gema SA, Spain
Intellectual Property Development Corporation, USA
Istituto Biochimico Italiani di Loredana Lorenzini SAS, Italy
Lumac International NV, Netherlands Antilles
Pharmaco, Inc., USA
R & L Molecular Research, Canada
Sutures Inc., USA
Laboratoires Thekan SA, France
Etablissements Viridis, Liechtenstein

Additionally, no sales figure could be ascertained for the one Eastern Bloc company, KRKA-Farmacevtica of Yugoslavia.

In order to get some uniformity in converting sales figures reported in local currencies into USA $, exchange rates as at 31 December, 1980, supplied through the courtesy of National Westminster Bank Limited, were used. After conversion to US $, companies were listed in order of sales volume as shown in Table 49, which also shows the rank of each patentee by number of cephalosporin patents within the list of patentees in Table 16.

To ascertain whether there was a correlation betwen sales volume and the number of Cephalosporin patents per patentee, the Spearman Coefficient of Rank Correlation was determined for the two rankings shown in Table 49. The Spearman Coefficient, r, was determined to be 0.3369; with 142 patentees (as per Table 49) the significance limits for r at the 0.10, 0.05 and 0.01 levels are 0.1385, 0.1651 and 0.2169 respectively. The result thus indicates a high correlation between sales and Cephalosporin patenting activity.

It was also thought appropriate to ascertain whether a close relationship exists between sales and patenting activity in a more diffuse set of patentees, and whether any differences could be noted between industries. Accordingly it was decided to examine the patenting activities of the 1981 Fortune 500 as compiled by Worthy[254]. For each of the companies listed in the Fortune 500, US patenting activity was determined from lists published by OTAF[255] of industrial patenting activity in the USA for 1969-80. These lists include only companies with three or more patents in the time period covered; thus companies in the Fortune 500 not in the OTAF list were given an equal rank,

although some of these companies may have had one or two patents between 1969 and 1980. The companies were then ranked according to total number of patents (including those of subsidiary companies where these could be identified); the companies with their Fortune 500 and patenting activities, together with two-digit Standard Industrial Classification Codes, are given in Table 50.

The Spearman Rank Coefficient, r, was calculated for these two rankings and found to be 0.0518. The companies were then sorted in to industrial groups and ranked by sales and patenting activity within industrial group. Spearman Rank Coefficients were calculated for each group, other than those with 4 or fewer companies [Industry Codes: 21 (Tobacco); 25 (Furnitiure); 31 (Leather) and 46 (Jewellery, Silverware)]. The Spearman Rank Coeffients determined and corresponding significance limits are given in Table 51.

PATENTEE NAME	Sales in US $ Million	Rank by Sales	Rank by no. of Cephalo-sporins Patents
Hoechst AG	14809.4	1	21
Bayer AG	14269.8	2	22
E.I. du Pont de Nemours & Company	13652.0	3	57=
ICI Limited	13258.8	4	102=
Dow Chemical Company	10626.0	5	65=
Union Carbide Corporation	9994.0	6	102=
Procter & Gamble Company	8687.0	7	81=
Ciba-Geigy Limited	6510.4	8	6
Rhone-Poulenc SA	6470.0	9	29=
McDonnell Douglas Corporation	6066.3	10	81=
Ethicon Inc.	4212.0	11	102=
Akzo NV	3980.4	12	102=
Warner-Lambert Company	3479.2	13	65=
American Cyanamid Company	3453.9	14	39=
Asahi Chemical Industries KK	3385.8	15	17=
Hoffmann-La Roche Company Limited	3202.5	16	33=
Bristol-Myers Company	3158.3	17	7
Mitsubishi Chemical Industries KK	3140.2	18	65=
Pfizer Inc.	3029.3	19	26
Merck & Co. Inc.	2734.0	20	8
Sandoz Limited	2677.6	21	65=
Sumitomo Chemical Company	2624.5	22	20
Eli Lilly & Company	2558.6	23	2
Beecham Group Limited	2385.9	24	12
Parke Davis & Co.	2340.0	25	44=
Toray Industries Inc.	2293.1	26	81=
Showa-Denko KK*	2107.3	27	102=
Takeda Chemical Industries	2090.0	28	3
Abbott Laboratories	2038.2	29	81=
Mitsui Toatsu Chemicals Inc.*	1935.0	30	65=
Teijin KK	1915.0	31	19
Upjohn Company	1760.6	32	65=
Smith Kline & French Laboratories Inc.	1771.9	33	9
Ajinomoto KK	1734.2	34	42=
Organon NV	1705.9	35	102=
Mitsubishi Petroleum Company	1678.9	36	81=
E.R. Squibb & Sons Inc.	1675.8	37	4
American Home Products Corporation	1651.0	38	17=
Schering AG*	1595.8	39	81=
Unilever BV	1496.4	40	102=
Glaxo Group Limited	1434.1	41	5
Toyobo KK	1217.5	42	32
Kanebo Pharmaceuticals Limited	1185.9	43	33=
Nisshin Flour Milling Company Limited	1179.3	44	102=
Richardson-Merrell Inc.	1090.0	45	39=
Wellcome Foundation Limited	1026.4	46	102=
Kyowa Hakko Kogyo KK	977.4	47	35

Table 49: Cephalosporin Patentees Ranked by Sales showing Rank by Numbers of Cephalosporin Patents (excluding academia, private inventors, not-for-profit organisations)
(*From Cephalosporins update set only)

PATENTEE NAME	Sales in US $ Million	Rank by Sales	Rank by no. of Cephalosporins Patents
E. Merck AG	977.3	48	36
Amstar Corporation	965.0	49	102=
C.H. Boehringer Sohn GmbH	862.9	50	102=
Meiji Seika KK	814.9	51	14
Dynamit Nobel AG	812.2	52	102=
Sparamedica AG	790.3	53	102=
Sankyo Company Limited	762.3	54	10
Fujisawa Pharmaceutical Industries KK	663.5	55	1
Shionogi Limited	632.3	56	15
Miles Laboratories Inc.	595.0	57	102=
Boehringer Mannheim GmbH	531.8	58	65=
Scherico Limited	489.3	59	81=
Tanabe Pharmaceutical Company	481.8	60	65=
Kureha Chemical Industries KK	452.2	61	102=
Astra Pharmaceutica AB	444.8	62	42=
Eisai Company Limited*	438.7	63	81=
Gist-Brocades NV	436.6	64	27
Lepetit SpA	411.1	65	81=
Kyoto Ceramic Company Limited*	402.8	66	102=
Nippon Kagaku KK	391.7	67	28
Yamanouchi Pharmaceutical Company	364.7	68	11
Fisher Scientific Company	350.0	69	81=
Chugai Pharmaceuticals KK	338.5	70	54=
Daiichi Seiyaku Company Limited*	317.6	71	57=
Societe Omnium Chimique SA	279.0	72	102=
Syntex Corporation	277.4	73	48=
Banyu Pharmaceutical Company Ltd.	266.4	74	25
Novo Industri A/S	262.4	75	39=
Toyo Jozo KK	235.9	76	23
Dainippon Pharmaceuticals KK	227.9	77	38
Otsuka Pharmaceuticals KK	221.7	78	57=
Dr. Karl Thomae GmbH*	212.5	79	57=
Sanraku-Ocean KK	207.6	80	102=
Yoshitomi Pharmaceutical Industries KK	202.7	81	102=
Roussel-Uclaf SA	180.4	82	16
Hodogaya Chemical Industries KK	160.8	83	44=
Nippon Shinyaku KK	160.7	84	102=
Toyama Chemical Industries KK	137.9	85	13
Albert Rolland SA*	132.2	86	102=
Farmitalia SpA	118.8	87	29=
Fermion Oy	117.0	88	65=
Pierrel SpA	115.0	89	65=
Tokyo Tanabe KK	108.7	90	102=
Carlo Erba SpA	104.2	91	48=
Ono Pharmaceuticals KK	101.6	92	81=
Chemische Fabriken von Heyden GmbH	93.8	93	24
Bristol-Banyu KK	86.6	94	48=
Nikken Chemicals Company Limited	82.5	95	44=

Table 49: Cephalosporin Patentees Ranked by Sales showing Rank by Numbers of Cephalosporin Patents (excluding academia, private inventors, not-for-profit organisations), continued
(*From Cephalosporins update set only)

PATENTEE NAME	Sales in US $ Million	Rank by Sales	Rank by no. of Cephalo-sporins Patents
Nippi Inc.	81.1	96	102=
Chemie Grunenthal GmbH	76.1	97	57=
Alza Corporation	72.0	98	81=
Nippon Chemifar Company Limited	64.1	99	47
National Patent Development Corporation	60.0	100	102=
Teikoku Hormone Manufacturing Company	54.4	101	102=
ISF Italseber SpA	52.2	102	81=
Sigma-Tau SpA	48.0	103	81=
Tobishi Pharmaceuticals Company	41.9	104	65=
Purdue Frederick Company	40.0	105	102=
Recherche et Industries Therapeutique SA	38.1	106	48=
Toko Yakukin Kogyo KK	37.2	107	102=
Leo Pharmaceutical Products AB	36.6	108	37
Kissei Pharmaceutical Company Limited	33.0	109	57=
Laboratoires Merrell-Touraude SA	30.4	110	29=
Biochemie GmbH	28.8	111	48=
Grelan Pharmaceutical Company Limited*	25.9	112	81=
Lark SpA	25.8	113=	102=
Nikko Chemical Industries KK	25.8	113=	102=
Antibioticos SA	25.5	115	57=
Eiken Kagaku KK	25.3	116	102=
A. Gallardo SA	24.4	117	65=
Wakamoto Pharmaceutical Company	23.8	118	102=
Sawai Seiyaku KK*	23.2	119	102=
Laboratories Clin Midy SA	22.5	120	81=
Ohta Seiyaku KK	20.1	121	81=
Pharmacia AB	19.8	122	102=
Alfa Farmaceutici SpA	19.2	123	54=
Laboratoires Ferrer & Cia SA	16.2	124	102=
Teikoku Chemical Industries	14.5	125	54=
Forest Laboratories Inc.	14.0	126	81=
Seoul Pharmaceutical Industries KK	13.4	127	102=
Proter SpA	10.5	128	48=
Kyoto Yakuhin Kogyo*	8.5	129	65=
Toshin Chemical Industries KK	8.4	130	57=
Snam-Progetti SpA	7.2	131=	65=
Lab. Farmaceutico Quimico Lafarquim SA	7.2	131=	81=
Key Pharmaceuticals Inc.*	7.0	133	102=
Laboratorios Cusi SA	6.6	134	65=
Stada Arzneimittel GmbH	6.3	135	102=
Instituto Luso-Farmaco SarL	4.7	136	81=
Toho Pharmaceutical Laboratories Company	4.2	137	102=
Cia. Internationale Farmacia Landerlan SA	3.0	138	102=
Research Corporation	2.0	139	81=
Nelson Research & Development Company	1.5	140	65=
Kommanditbolaget Kockums Chemical AB	0.6	141	102=
Mundipharma AG	0.3	142	102=

Table 49: Cephalosporin Patentees Ranked by Sales showing Rank by Numbers of Cephalosporin Patents (excluding academia, private inventors, not-for-profit organisations)
(*From Cephalosporins update set only)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Exxon	29	3257	12	1
Mobil	29	2119	24	2
General Motors	40	5425	5	3
Texaco	29	2415	17	4
Standard Oil of California	29	932	59	5
Ford Motor	40	1949	29	6
Gulf Oil	29	1240	45	7
IBM	44	6467	2	8
Standard Oil (Indiana)	29	383	141	9
General Electric	36	11021	1	10
Atlantic Richfield	29	945	57	11
Shell Oil	29	2506	16	12
ITT	36	1962	28	13
Conoco	29	893	63	14
Du Pont	28	5916	4	15
Phillips Petroleum	29	4057	9	16
Tenneco	29	412	131	17
Sun	29	641	84	18
US Steel	33	1179	48	19
Occidental Petroleum	10	117	236=	20
United Technologies	41	2058	26	21
Western Electric	36	1196	47	22
Standard Oil (Ohio)	29	95	248=	23
Procter & Gamble	43	1271	43	24
Dow Chemical	28	4361	8	25
Getty Oil	10	16	360=	26
Union Carbide	28	2779	13	27
Union Oil of California	29	602	92	28
Eastman Kodak	38	4536	6	29
Boeing	41	816	71	30
Dart & Kraft	20	490	107	31
Chrysler	40	415	129	32
Caterpillar Tractor	45	2629	15	33
Westinghouse Electric	36	6203	3	34
R.J. Reynolds Industries	21	156	209	35
Goodyear Tire & Rubber	30	1576	36	36
Beatrice Foods	20	213	190	37
Xerox	38	3996	10	38
Marathon Oil	29	398	136	39
Ashland Oil	29	326	154	40
RCA	36	4534	7	41
LTV	33	74	269	42
Amerada Hess	29	-	432=	43
Cities Service	29	454	115=	44
Philip Morris	21	221	187	45
Rockwell International	41	2306	19	46
Bethelehem Steel	33	468	111=	47
Monsanto	28	3683	11	48
International Harvester	45	911	62	49
Esmark	20	-	432=	50

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
W.R. Grace	28	1276	42	51
3M	38	2231	21	52
McDonnell Douglas	41	667	81	53
Pepsi Co	49	26	338=	54
General Foods	20	502	105	55
Coca-Cola	49	50	298=	56
Gulf & Western Industries	34	338	149=	57
Armco	33	285	168	58
Allied Chemical	10	1902	30	59
Deere	45	833	69	60
Lockheed	41	483	109	61
Consolidated Food	20	65	278	62
Aluminum Company of America	33	584	94	63
Colgate-Palmolive	43	940	58	64
Continental Group	34	148	215	65
Coastal	29	-	432=	66
International Paper	26	316	156	67
Georgia-Pacific	26	141	221=	68
Raytheon	36	858	65	69
TRW	40	1487	37	70
Honeywell	44	2322	18	71
Ralston Purina	20	153	211=	72
Firestone Tire & Rubber Co.	30	510	102	73
Johnson & Johnson	42	592	93	74
Union Pacific	29	-	432=	75
American Can	34	488	108	76
Sperry	44	2080	25	77
Greyhound	20	-	432=	78
General Dynamics	41	508	103	79
Farmland Industries	29	6	401=	80
Iowa Beef Processors	20	13	373=	81
Borden	20	205	194	82
Weyerhauser	26	199	196	83
Charter	29	4	414=	84
Signal Companies	40	5	406=	85
American Brands	21	16	360=	86
Bendix	40	2204	22	87
Litton Industries	36	635	86=	88
General Mills	20	394	137=	89
IC Industries	20	-	432=	90
CPC International	20	264	171=	91
Texas Instruments	36	2248	20	92
Dresser Industries	45	844	68	93
CBS	48	230	179	94
Owens Illinois	32	1704	34	95
American Home Products	42	1161	49	96
United Brands	20	9	387=	97
Republic Steel	33	162	206	98
Champion International	26	387	140	99
National Steel	33	160	207	100

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Reynolds Metals	33	458	113	101
Textron	34	759	74	102
FMC	45	1820	32	103
Warner-Lambert	42	614	89	104
Kerr-McGee	29	95	248=	105
American Cyanamid	28	2666	14	106
Celanese	28	979	53=	107
NCR	44	861	64	108
Land O'Lakes	20	11	379=	109
Anheuser-Busch	49	82	259=	110
McDermott	34	17	356=	111
Inland Steel	33	132	228	112
Carnation	20	17	356=	113
Kaiser Aluminum & Chemical	33	297	164=	114
Eaton	40	998	52	115
PPG Industries	28	1862	31	116
Bristol-Myers	42	384	137=	117
Combustion Engineering	45	656	82	118
Diamond Shamrock	29	428	125	119
Hewlett Packard	38	688	79	120
Motorola	36	2197	23	121
BF Goodrich	30	856	66	122
Crown Zellerbach	26	131	229	123
Emerson Electric	36	421	128	124
Pillsbury	20	174	201	125
Pfizer	42	912	61	126
Boise Cascade	26	58	286=	127
Standard Brands	20	94	250=	128
Ingersoll-Rand	45	306	160	129
Norton-Simon	20	-	432=	130
AMAX	33	149	213=	131
Teledyne	45	429	124	132
H.J. Heinz	20	16	360=	133
Burlington Industries	22	222	185=	134
Time Inc.	27	18	353=	135
Northwest Industries	33	-	432=	136
Burroughs	44	1408	40	137
Levi Strauss	23	27	336=	138
Archer-Daniels-Midland	20	14	367=	139
Singer	36	1479	38	140
Control Data	44	226	180=	141
Merck	42	1667	35	142
St. Regis Paper	26	48	301=	143
Mead	26	401	135	144
American Standard	37	313	159	145
Borg-Warner	40	979	53=	146
Agway	29	9	387=	147
North American Philips	36	235	178	148
Martin Marietta	41	297	164=	149
Kimberly-Clark	26	432	122	150

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Avon	43	42	309	151
Nabisco	20	78	266	152
Campbell Soup	20	58	286=	153
Eli Lilly	42	1087	51	154
American Motors	40	27	336=	155
Kidde	45	144	217=	156
Dana	40	167	204=	157
Hercules	28	827	70	158
Pennzoil	29	20	347=	159
Quaker Oats	20	223	182=	160
Tosco	29	5	406=	161
Digital Equipment	44	85	257=	162
Gillette	34	348	146	163
Uniroyal	30	713	78	164
Owens-Corning Fiberglass	32	920	60	165
Johns-Manville	32	447	117	166
McGraw-Edison	36	423	126	167
American Broadcasting	48	-	432=	168
Kennecott	33	223	182=	169
Whirlpool	36	571	95	170
General Tire & Rubber	30	482	110	171
Revlon	43	34	323=	172
Gould	36	278	169	173
Ogden	37	8	390=	174
Colt Industries	33	133	226=	175
Kellogg	20	18	353=	176
NL Industries	28	330	153	177
American Petrofina	29	-	432=	178
Scott Paper	26	271	170	179
Fruehauf	40	90	254	180
Williams Companies	28	-	432=	181
Allis-Chalmers	45	957	56	182
Warner Communications	36	-	432=	183
White Consolidated Ind.	36	40	310=	184
Abbott Laboratories	42	637	85	185
INTERCO	23	-	432=	186
Penn Central	29	-	432=	187
Murphy Oil	29	-	432=	188
Jim Walter	26	4	414=	189
Koppers	28	530	98	190
J.P. Stevens	22	186	198	191
SCM	28	539	96	192
Gold Kist	20	7	396=	193
Times Mirror	27	4	414=	194
Olin	28	1233	46	195
Squibb	42	1159	50	196
Cooper Industries	45	47	303=	197
Marmon Group Inc.	33	11	379=	198
Asarco	33	30	329=	199
Emhart	45	226	180=	200

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
International Minerals & Chemicals	28	108	242	201
Oscar Mayer	20	73	270	202
SmithKline	42	739	76	203
MAPCO	10	4	414=	204
National Distillers & Chemical	28	314	158	205
Upjohn	42	1996	27	206
Central Soya	20	23	342=	207
Ethyl	28	966	55	208
Schering-Plough	42	301	162	209
Castle & Cooke	20	17	356=	210
Grumman	41	116	238=	211
Rohm & Haas	28	790	73	212
Anderson Clayton	20	17	356=	213
Sterling Drug	42	623	88	214
Stauffer Chemical	28	1264	44	215
Paccar	40	36	319=	216
Cummins Engine	40	67	275=	217
A.E. Staley Manufacturing	20	149	213=	218
Northrop	41	218	189	219
Joseph E. Seagram & Sons	49	-	432=	220
Clark Oil & Refining	29	-	432=	221
Union Camp	26	77	267	222
National Can	34	87	256	223
Baker International	45	137	224	224
AMF	47	514	100	225
Clark Equipment	45	406	134	226
Corning Glass Works	32	1278	41	227
Crane	33	63	279=	228
Allegheny Ludlum Industries	33	264	171=	229
General Signal	38	414	130	230
Chromalloy American	34	107	243	231
Cabot	33	141	221=	232
Superior Oil	10	15	364=	233
U.S. Gypsum	32	31	327=	234
Crown, Cork & Seal	34	56	292=	235
Polaroid	38	1721	33	236
Phelps Dodge	33	52	296=	237
Black & Decker Manufacturing	45	240	176	238
Heublein	49	-	432=	239
Evans Products	37	80	263=	240
Lear Siegler	40	360	144	241
Air Products & Chemicals	28	407	133	242
Westvaco	26	351	145	243
Sunbeam	36	147	216	244
Blue Bell	23	11	379=	245
Whittaker	37	144	217=	246
Chesebrough-Pond's	43	11	379=	247
Baxter Travenol Laboratories	42	524	99	248
Great Northern Nekoosa	26	4	414=	249
Timken	45	8	390=	250

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Hershey Foods	20	3	424=	251
Armstrong World Industries	22	430	123	252
Geo. A. Gormel	20	24	341	253
Harris	36	468	111=	254
Wheelabrator-Frye	45	71	273	255
MCA	48	38	315	256
Amstar	20	14	367=	257
Commonwealth Oil Refining	29	4	414=	258
Diamond International	26	129	231	259
Norton	32	286	167	260
St. Joe Minerals	10	30	329=	261
Crown Central Petroleum	29	-	432=	262
Avnet	36	19	351=	263
Sherwin-Williams	28	189	197	264
Pitney Bowes	44	422	127	265
West Point-Pepperell	22	29	331=	266
CF Industries	28	4	414=	267
GAF	28	852	67	268
Brown Group	31	31	327=	269
Gannett	27	-	432=	270
Richardson-Merrell	42	254	174	271
Hughes Tool	45	82	259=	272
Brunswick	47	433	121	273
Louisiana Pacific	26	-	432=	274
GK Technologies	33	-	432=	275
Pennwalt	28	635	86=	276
Zenith Radio	36	725	77	277
Hammermill Paper	26	46	305	278
Witco Chemical	29	105	244	279
Libbey-Owens-Ford	32	223	182=	280
AMP	36	1439	39	281
US Industries	45	130	230	282
Campbell Taggert	20	6	401=	283
R.R. Donnelley & Sons	27	26	338=	284
Knight-Ridder Newspapers	27	-	432=	285
Texasgulf	10	18	353=	286
Wheeling-Pittsburgh Steel	33	15	364=	287
Rexnord	45	236	177	288
G.D. Searle	42	513	101	289
International Multifoods	20	8	390=	290
Harsco	34	72	271=	291
Interlake	33	109	241	292
Akzona	28	444	119	293
ACF Industries	37	446	118	294
Lever Brothers	43	687	80	295
Parker-Hannifin	34	317	155	296
Ex-Cell-O	45	141	221=	297
Louisiana Land & Exploration	10	-	432=	298
Airco	28	456	114	299
McGraw-Hill	27	4	414=	300

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Cessna Aircraft	41	58	286=	301
Square D	36	341	148	302
Perkin-Elmer	38	302	161	303
GATX	37	-	432=	304
Universal Leaf Tobacco	21	-	432=	305
Johnson Controls	36	181	199	306
National Semiconductor	36	219	188	307
National Gypsum	32	85	257=	308
Cyclops	33	16	360=	309
Federal Co.	20	-	432=	310
Tektronix	38	344	147	311
Alumax	33	5	406=	312
Becton Dickinson	38	331	152	313
Willamette Industries	26	8	390=	314
Stanley Works	34	200	195	315
Springs Mills	22	11	379=	316
Joy Maufacturing	45	72	271=	317
Consolidated Aluminium	33	-	432=	318
Sundstrand	41	168	203	319
Kaiser Steel	33	33	325=	320
Amsted Industries	33	206	193	321
AM International	44	499	106	322
Lone Star Industries	32	3	424=	323
Midland Ross	45	334	151	324
Fairchild Industries	41	88	255	325
Lubrizol	28	298	163	326
Scovill	36	170	202	327
Jos. Schlitz Brewing	49	43	308	328
Adolf Coors	49	14	367=	329
NVF	33	3	424=	330
Reichhold Chemicals	28	92	252=	331
Newmont Mining	33	8	390=	332
Certain Teed	32	56	292=	333
U.S. Filter	45	14	367=	334
Anchor Hocking	32	155	210	335
Intel	36	96	246=	336
Twentieth Century Fox Films	48	3	424=	337
Morton-Norwich Products	28	262	172	338
Genesco	23	12	375=	339
ConAgra	20	-	432=	340
Pacific Resources	29	-	432=	341
Dover	34	112	240	342
Cincinnati Milacron	45	411	132	343
General Host	20	-	432=	344
Quaker State Oil Refining	29	-	432=	345
Hoover	36	67	275=	346
Belco Petroleum	29	-	432=	347
Potlatch	26	39	313=	348
Mattel	47	440	120	349
White Motor	40	37	316=	350

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Champion Spark Plug	36	69	274	351
Thomas J. Lipton	20	40	310=	352
National Service Industries	36	12	375=	353
Sybron	38	338	149=	354
Trane	45	126	232	355
Smith International	45	167	204=	356
Sperry & Hutchinson	22	-	432=	357
Memorex	44	63	279=	358
Masco	34	40	310=	359
Handy & Harman	33	6	401=	360
A-T-O	45	210	191	361
General Cinema	49	-	432=	362
Bangor Punta	41	47	303=	363
Arcata	27	7	396=	364
Monfort of Colorado	20	-	432=	265
Vulcan Materials	10	26	338=	366
Crouse Hinds	36	20	347=	367
Tecumseh Products	45	79	265	368
Revere Copper & Brass	33	12	375=	369
Cluett Peabody	23	61	283	370
Mohasco	25	29	331=	371
Southwest Forest Industries	26	-	432=	372
Peavey	20	7	396=	373
New York Times	27	-	432=	374
Cone Mills	22	3	424=	375
G. Heileman Brewing	49	-	432=	376
Federal Mogul	40	133	226=	377
Pabst Brewing	49	14	357=	378
General Instrument	36	159	208	379
Dayco	30	243	175	380
Saxon Industries	26	5	406=	381
Briggs & Stratton	45	94	250=	382
Ball	34	117	236=	383
Brockway Glass	32	29	331=	384
Cameron Iron Works	45	97	245	385
Ferro	28	121	235	386
Signode	34	116	238=	387
A.O. Smith	40	134	225	388
Columbia Motion Pictures	48	7	396=	389
Outboard Marine	47	393	139	390
Miles Laboratories	42	365	142	391
Peabody International	45	28	335	392
Hyster	45	35	321=	393
Purex Industries	43	80	263=	394
CBI Industries	44	-	432=	395
Dow Corning	28	646	83	396
Bemis	26	45	306=	397
Bally Manufacturing	47	36	319=	398
Thiokol	28	454	115=	399
Hart Schaffner & Marx	23	5	406=	400

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

COMPANY	INDUSTRY CODE	NO. OF PATENTS	RANK BY PATENTS	FORTUNE 500 RANK
Nashua	26	33	325=	401
Hobart	45	142	219=	402
Freeport Minerals	10	50	298=	403
United Refining	29	-	432=	404
Canon Mills	22	7	396=	405
Washington Post	27	-	432=	406
Big Three Industries	28	10	385=	407
H.K. Porter	33	39	313=	408
Data General	44	67	275=	409
Insilco	28	-	432=	410
Moore McCormack Resources	10	-	432=	411
Bell & Howell	38	791	72	412
Gulf Resource & Chemical	33	5	406=	413
Clorox	28	20	347=	414
Magic Chef	36	8	390=	415
Harnischfeger	45	96	246=	416
VF	23	-	432=	417
Scott & Fetzer	45	23	342=	418
Envirotech	45	142	219=	419
DPF	20	-	432=	420
Kane-Miller	20	-	432=	421
United Merchants & Manufacturers	22	57	291	422
Varian Associates	36	748	75	423
M. Lowenstein	22	9	387=	424
Avery International	26	56	292=	425
Nalco Chemical	28	533	97	426
McLouth Steel	33	-	432=	427
EG & G	38	58	286=	428
Dean Foods	20	-	432=	429
Dorchester Gas	29	-	432=	430
Dan River	22	12	375=	431
Idle Wild Foods	20	-	432=	432
Storage Technology	44	34	323=	433
Gerber Products	20	62	282	434
Collins & Aikman	22	21	346	435
Norris Industries	34	75	268	436
Bausch & Lomb	38	294	166	437
Maryland Corporation	26	52	296=	438
Hoover Universival	34	19	351=	439
Wallace Murray	34	92	252=	440
H.H. Robertson	34	125	233	441
Marley	45	22	344=	442
MacMillan	27	-	432=	443
Tyler	33	11	379=	444
Gifford-Hill	32	6	401=	445
Carpenter Technology	33	45	306=	446
Wm. Wrigley Jr.	20	13	373=	447
Kellwood	23	29	331=	448
National Starch & Chemical	28	222	185=	449
Wyman-Gordon	34	10	385=	450

Table 50: 1981 Fortune 500 Largest US Industrial Corporations Ranked by Sales and showing Rank by US Patents 1969-1980 (continued)

PAGE NUMBERING AS ORIGINAL

Industry Code	Definition	N	Spearman Coefficient R	Significance Limit 0.1 Level	Significance Limit 0.05 Level	Significance Limit 0.01 Level
-	All "Fortune 500"	500	0.518	0.0736	0.0877	0.1153
10	Mining, crude oil production	13	0.587	0.4748	0.5658	0.7294
20	Food	55	0.639	0.2238	0.2667	0.3505
22	Textiles, vinyl flooring	13	0.363	0.4748	0.5658	0.7294
23	Apparel	9	-0.138	0.6000	0.6833	0.8333
26	Paper, fibre and wood products	29	0.446	0.3108	0.3704	0.4868
27	Publishing, printing	13	0.539	0.4748	0.5658	0.7294
28	Chemicals	40	0.663	0.2634	0.3138	0.4125
29	Petroleum refining	40	0.824	0.2634	0.3138	0.4125
30	Rubber, plastic products	6	0.829	0.8286	0.8857	1.0000
32	Glass, concrete, abrasives, gypsum	16	0.838	0.4247	0.5061	0.6650
33	Metal manufacturing	38	0.711	0.2704	0.3222	0.4235
34	Metal products	23	0.572	0.3507	0.4179	0.5492
36	Electronic appliances	38	0.614	0.2704	0.3222	0.4235
37	Shipbuilding, railroad and transportation equip.	9	0.673	0.6000	0.6833	0.8333
38	Measuring, scientific, photographic equip.	15	0.746	0.4396	0.5238	0.6865
40	Motor vehicles	19	0.665	0.3877	0.4620	0.6071
41	Aerospace	14	0.829	0.4562	0.5436	0.7080
42	Pharmaceuticals	17	0.439	0.4112	0.4900	0.6440
43	Soaps, cosmetics	8	0.357	0.6429	0.7381	0.8810
44	Office equipment (includes computers)	13	0.940	0.4748	0.5658	0.7294
45	Industrial and farm equipment	43	0.673	0.2538	0.3024	0.3975
47	Musical instruments, toys, sporting goods	5	0.900	0.9000	1.0000	1.0000
48	Broadcasting, motion picture production	6	0.500	0.8286	0.8557	1.0000
49	Beverages	11	0.646	0.5294	0.6194	0.7724

Table 51: Spearman Rank Coefficients and Significance Limites for Sales and Patenting Activities of 1981 Fortune 500 Largest US Industrial Corporations

Industry Code	Definition	Spearman Coefficient R
44	Office equipment (includes computers)	0.940
47	Musical instruments, toys, sporting goods	0.900
32	Glass, concrete, abrasives, gypsum	0.838
41	Aerospace	0.829
30	Rubber, plastic products	0.829
29	Petroleum refining	0.824
38	Measuring, scientific, photographic equip.	0.746
33	Metal manufacturing	0.711
45	Industrial and farm equipment	0.673
37	Shipbuilding, railroad and transportation equip.	0.673
40	Motor vehicles	0.665
28	Chemicals	0.663
49	Beverages	0.646
20	Food	0.639
36	Electronic appliances	0.614
10	Mining, crude oil production	0.587
34	Metal products	0.572
27	Publishing, printing	0.539
48	Broadcasting, motion picture production	0.500
26	Paper, fibre and wood products	0.446
42	Pharmaceuticals	0.439
22	Textiles, vinyl flooring	0.363
43	Soaps, cosmetics	0.357
23	Apparel	-0.138

Table 52: Industries represented by the 1981 Fortune 500 Largest US Industrial Corporations ranked by Spearman Rank Coefficients determined for Sales and Patenting Activities

12: DISCUSSION

The objectives of the studies undertaken for this work were as follows: firstly, to look in detail at a particular technology, the Cephalosporins, to ascertain what types of pseudo-proprietary information could be gleaned from a study of the patenting activity in the technology concerned and, by an examination of the patent applications themselves (as abstracts in Derwent's Central Patents Index), to review the scientific/chemical developments taking place in this particular field of pharmaceuticals.

Secondly, having supplemented the patents data on Cephalosporins with data on other technologies, to see whether some bibliometric measurements which have previously been applied to patents data, and others which have not hitherto been applied to such data, are applicable to patents information retrievable from a large publicly accessible online database.

THE CEPHALOSPORINS

The Importance of Cephalosporins

A review of world antibiotic sales, as shown in Figure 48 indicates that Cephalosporins occupy an important place in the total antibiotic market[256]. Before the appearence of the latest generation of compounds, the two principal advantages which allowed cephalosporins to occupy a favourable position in the market place in competition with penicillins were (a) a lesser degree of sensitivity to beta-lactamases, and (b) the less frequent occurrence of allergies.

On the other hand, the relative daily costs of treating most infections with cephalosporins are four to five times the costs for penicillins - a consequence of the more laborious and costly isolation procedures for cephalosporins.

A senior executive of Roussel-Uclaf stated[257], in June 1980, that the world market for cephalosporins, including the hospital sector, is $1.5 billion, nearly 33% of the total antibiotic market. Furthermore, growth rate is 12-15% per year - higher than any other antibiotic.

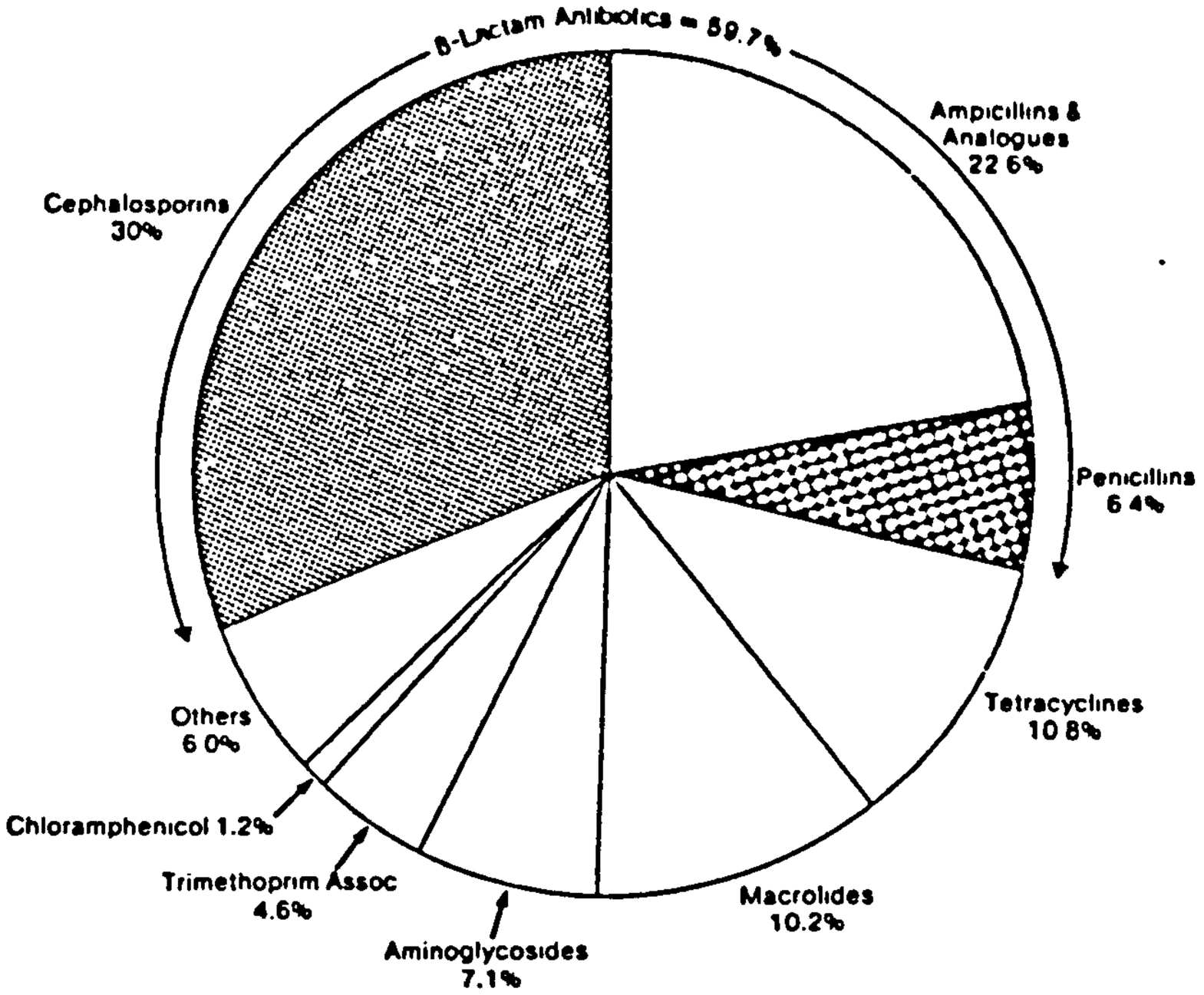


Figure 48: World Antibiotics Sales

The Cephalosporins patents data retrieved from the WPI online database as described in Appendix I, and analysed as shown in Chapter 11, has permitted the preparation of the following observations.

Who is working on Cephalosporins?

A complete list of the applicants is given in Table 16. In this table the applicants have been ranked according to the number of Cephalosporin applications assigned to each.

The top ranked twenty applicants have assigned to them 2,039 basic patents, representing 69.3% of the total of 2,944; Figure 49 illustrates the share of the applications each of these applicants has made. On the other hand 89 patentees had each only one patent and 29 had only two; the distribution of patents per patentee is shown in Figure 50.

Types of Applicant

An analysis of the types of patentee (Tables 9-12) showed that 75.5% were industrial proprietary organisations, a surprising 13.9% are independent inventors, 6.9% are working in academic institutes and 3.7% are not-for-profit organisations such as NRDC in the UK and Agence Nationale de Valorisation in France; Eastern Bloc pseudo-proprietary organisations have been included in the not-for-profit sector. This distribution is illustrated in Figure 51.

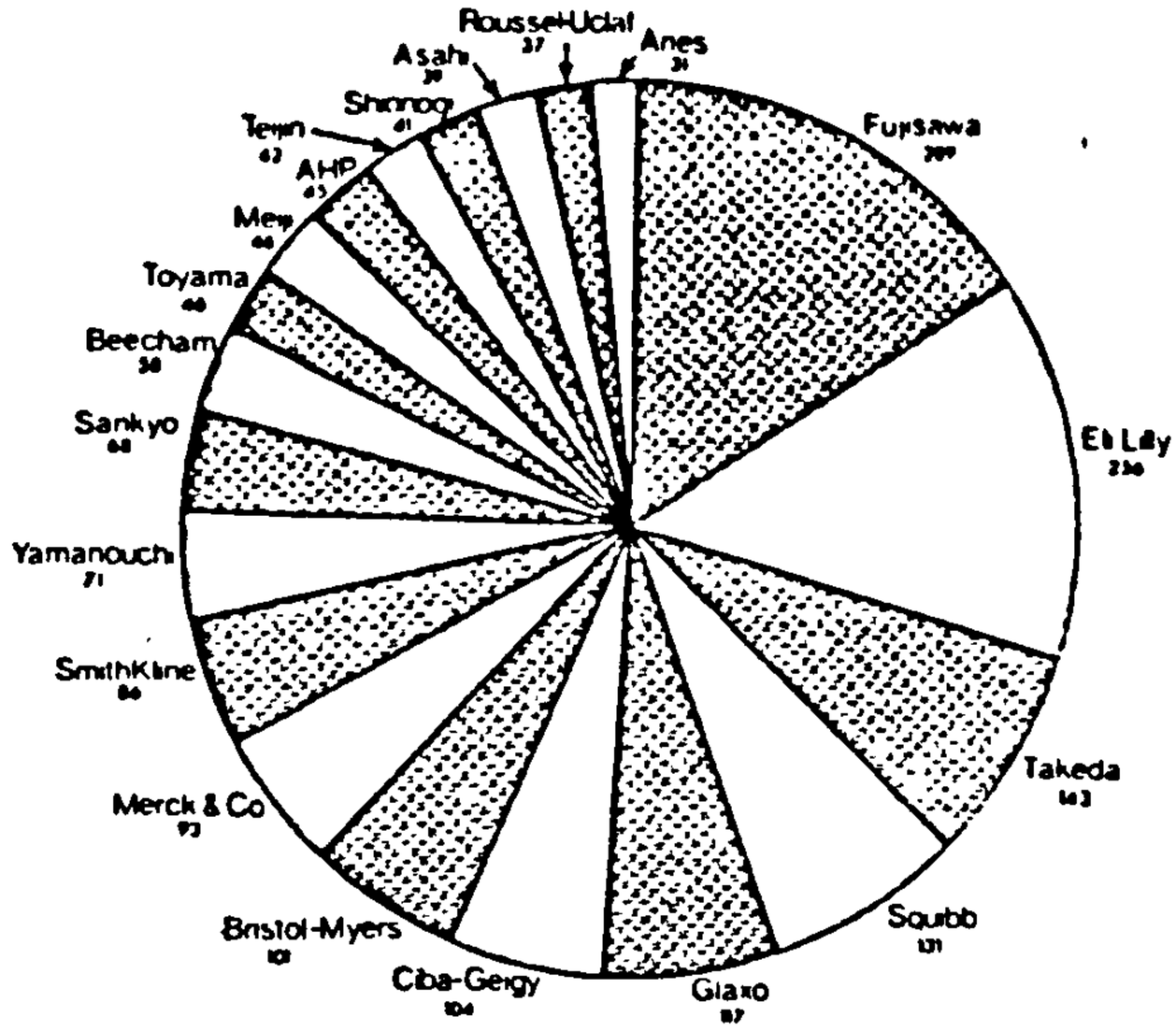


Figure 49: The Top Twenty Cephalosporin Patentees and their Shares of the 2039 Patents, Representing 69% of the Total, which they own

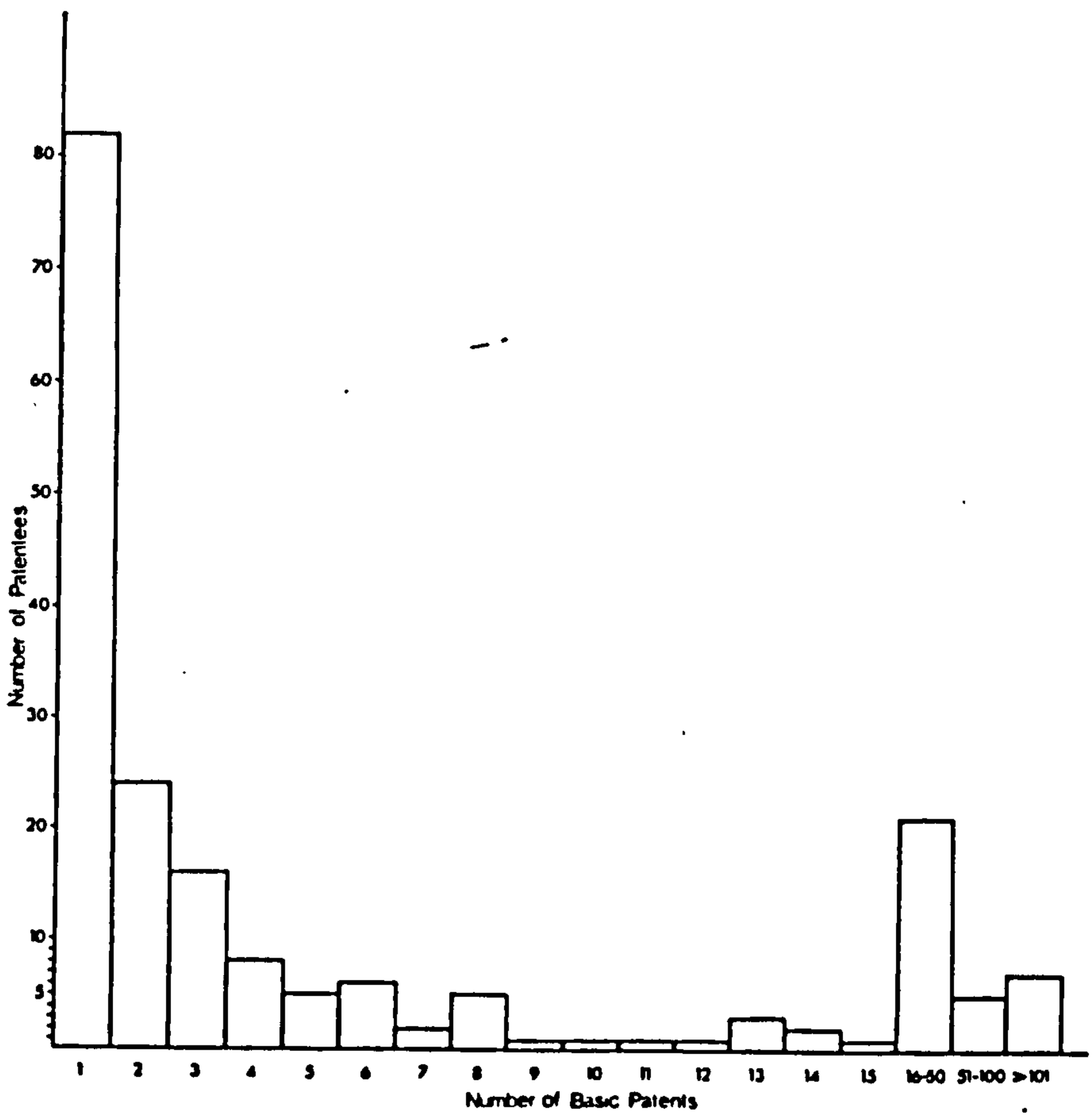


Figure 50: Distribution of Cephalosporin Patents amongst Patentees

Unlike other fields of technology, such as the mechanical disciplines, it is extremely difficult for independent inventors to sustain the financial involvement and risks associated with pharmaceutical R&D. Further examination of the 30 private inventors showed that for 11 of them their patents concerned compositions and for four of them the subject matter concerned the use of cephalosporins in biological culture and assay media. Three private inventors have patents concerning isolation/purification and one biosynthesis of cephalosporins; the remainder hold patents involving chemical synthesis of cephalosporins. It is thought that this latter group are not truly "private" inventors but industrial workers who have been rewarded with their names on patents which, at the time of this study, remained unassigned to a corporate entity.

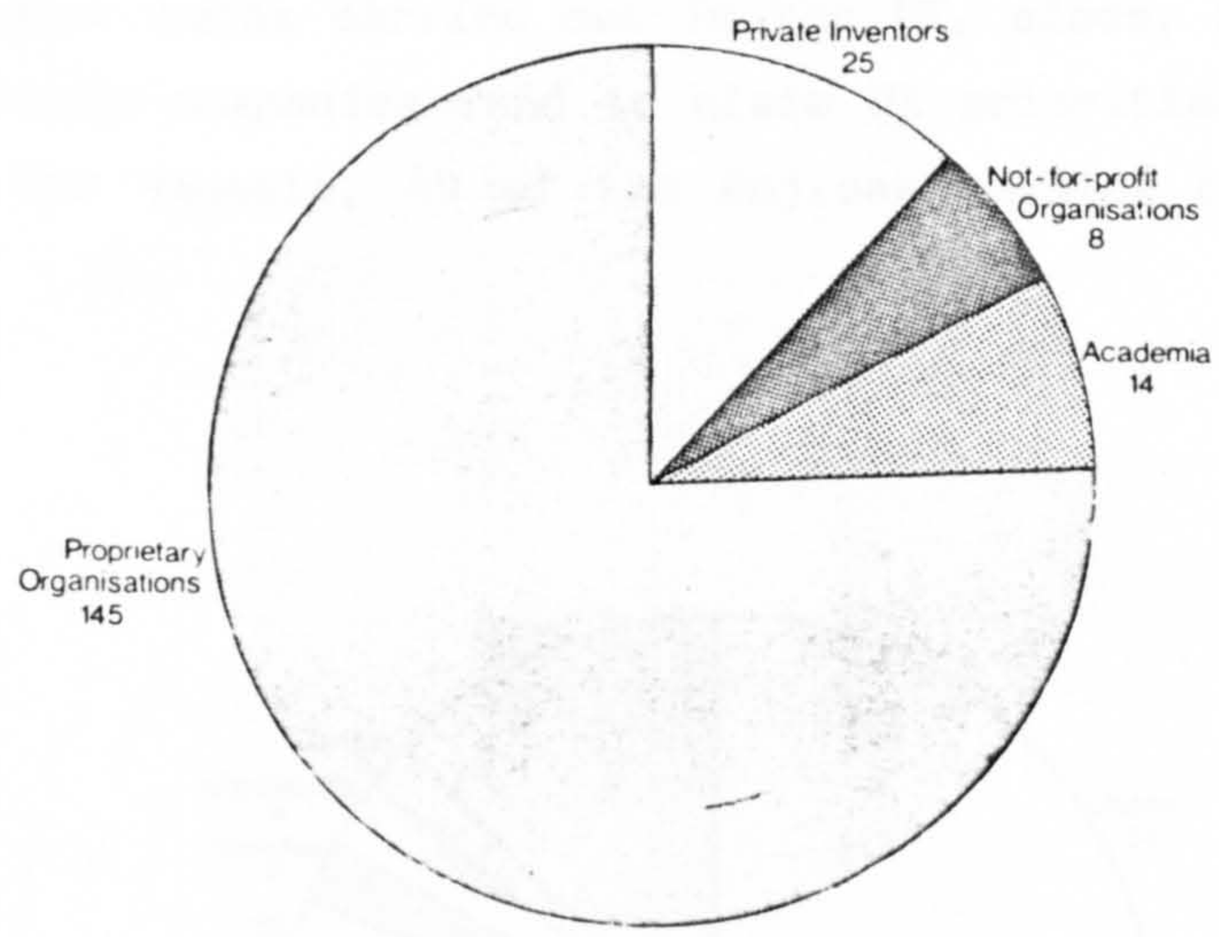


Figure 51: Types of Cephalosporin Patentee

Where is the work being conducted?

Two techniques have been used in the attempt to ascertain where the work on cephalosporins is being carried out. In the first method an analysis was made of the countries of domesticity of the patentees, other than those classed as private inventors (Table 13). For the trans-national corporations the country of domesticity was considered to be that of the parent company; for example, in the case of American Home Products Corporation some of their patents (total of 45) have originated from their wholly owned subsidiary company Ayerst Laboratories located in Canada - all these patents have been listed as if owned by AHP. This is illustrated in Figure 52.

From this analysis there is a clear indication that the greatest concentrations of workers in the field of cephalosporins are to be found in Japan and the USA.

It is reasonable to assume that the priority country claimed in the earliest priority for any applications is likely to be the country in which the work has been carried out (although this is not necessarily so as some companies, such as some based in Switzerland and Japan, will file first overseas - notably in the UK - to take advantage of a feature of UK patent law known as 'provisional then complete'). A study was made of the priority countries claimed on the basic patents. This, too showed that the majority of patents originated from Japan and the USA, with the UK in third position. As mentioned before, the figure for the UK is probably inflated, i.e. not truly representative of the work being carried out in the UK, since, for example, many of the Japanese companies tend to claim UK priorities on their applications. For example, 49 of the Fujisawa basics claim a UK priority.

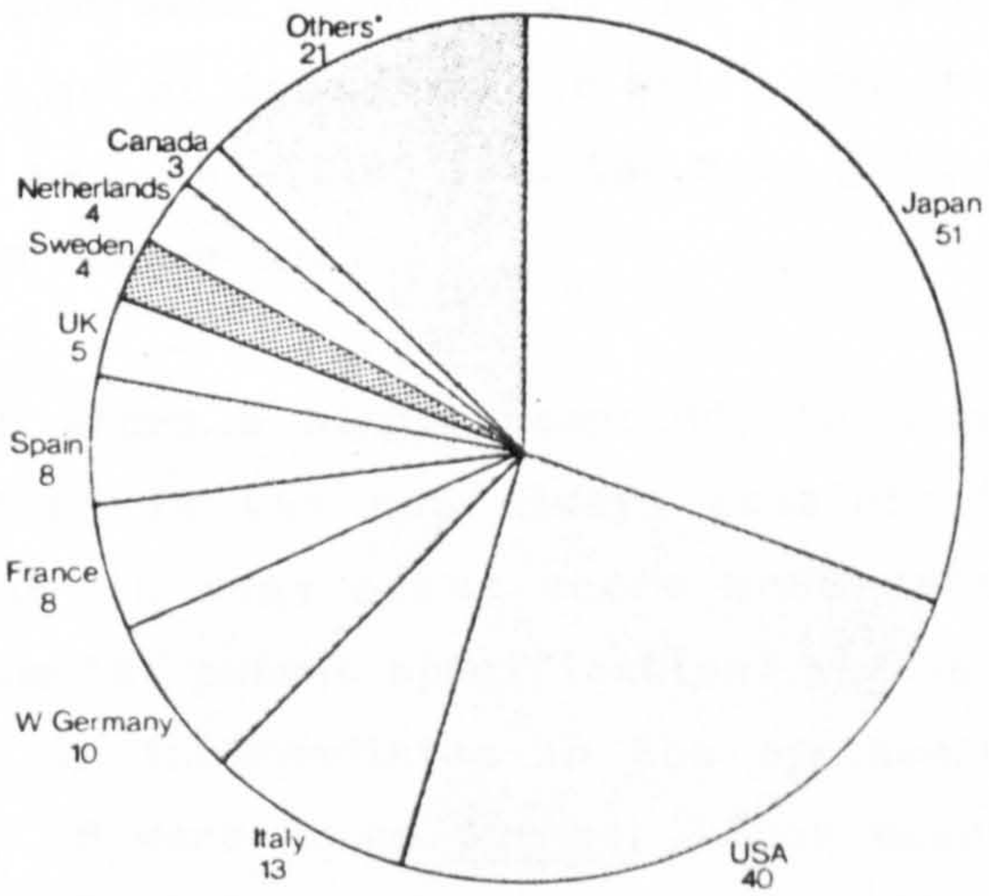


Figure 52: Countries of Domesticity of Cephalosporin Patentees (Excluding Private Inventors)

*Others:	Austria	1	Hungary	1	Poland	2
	Belgium	2	Israel	2	Portugal	1
	Canada	3	Korea	1	USSR	2
	Denmark	1	Liechtenstein	1	Yugoslavia	1
	Finland	1	Dutch Antilles	1		

The ratios of priority countries have changed over the years as additional organisations have moved in, and some companies have moved out, of cephalosporin technology and/or as R&D work has been less fruitful in patentable innovation; the changes in priorities claimed are shown schematically in Figure 53.

Whilst the foregoing may be true of other countries, and in part to Japan, it should be noted that one other factor greatly influenced patent filing activities in Japan in the mid-1970s. Japanese patent law was revised on January 1, 1976, whereby, for the first time, chemical substances (rather than processes for their manufacture), foodstuffs and drugs per se became patentable. Pending this revision in the law patentees withheld filing applications during 1975 and filed them only in a surge after the effective date of the revised law. As shown in Figure 54, this resulted in a dramatic drop in the number of pharmaceutical applications claiming Japanese priorities in 1975 - a fact which significantly influences any statistical and numeric analyses of patent activity covering this time period.

Subject Coverage of Applications

Each of the abstracts relating to the retrieved data was examined to asertain the type of invention for which protection was being requested. The data was classified into the main groups shown in Table 21 and illustrated in Figure 55.

In many cases where a single compound, or a group of compounds, had been synthesised it was not always possible to determine from the abstract (and, in many cases where more detailed study was found necessary, from the patent specification) whether the subject compounds were for use as intermediates in the synthesis of pharmacologically active drugs, or were drugs per se. Such cases have been classified under "synthesis"; only in those cases where it was specifically stated that the subject compounds were intermediates have the patents been classified accordingly.

Whilst the results obtained from classification of the retrieved data from the entire file indicate that the overwhelming number of applications have been for the synthesis of endproducts or intermediates, this pattern has not always been true.

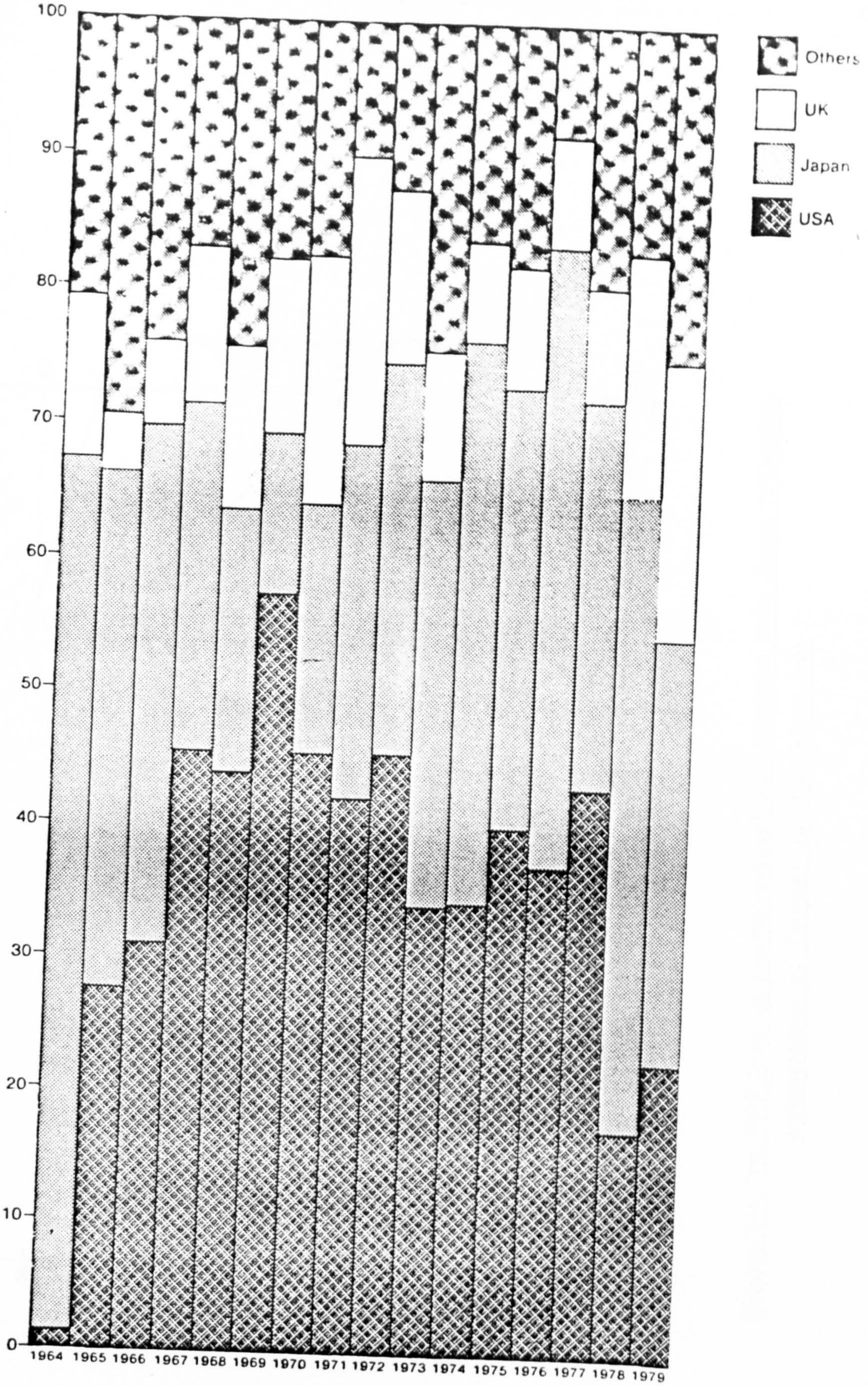


Figure 53: Changes in Priority Country Claimed in Cephalosporin Patents

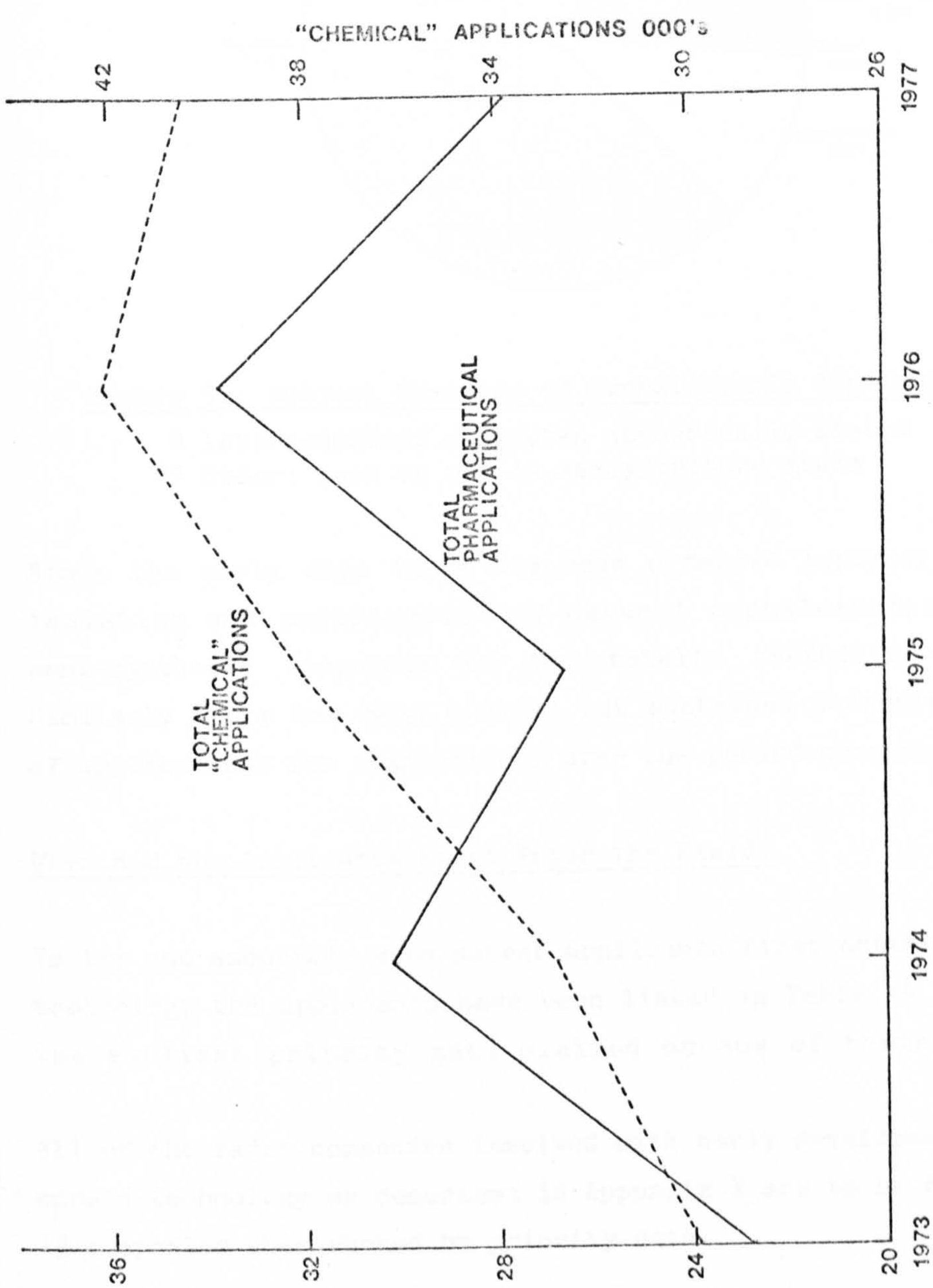


Figure 54: The 1975 Drop in Pharmaceutical Applications from Japan following Announcement of Changes in the Patent Law

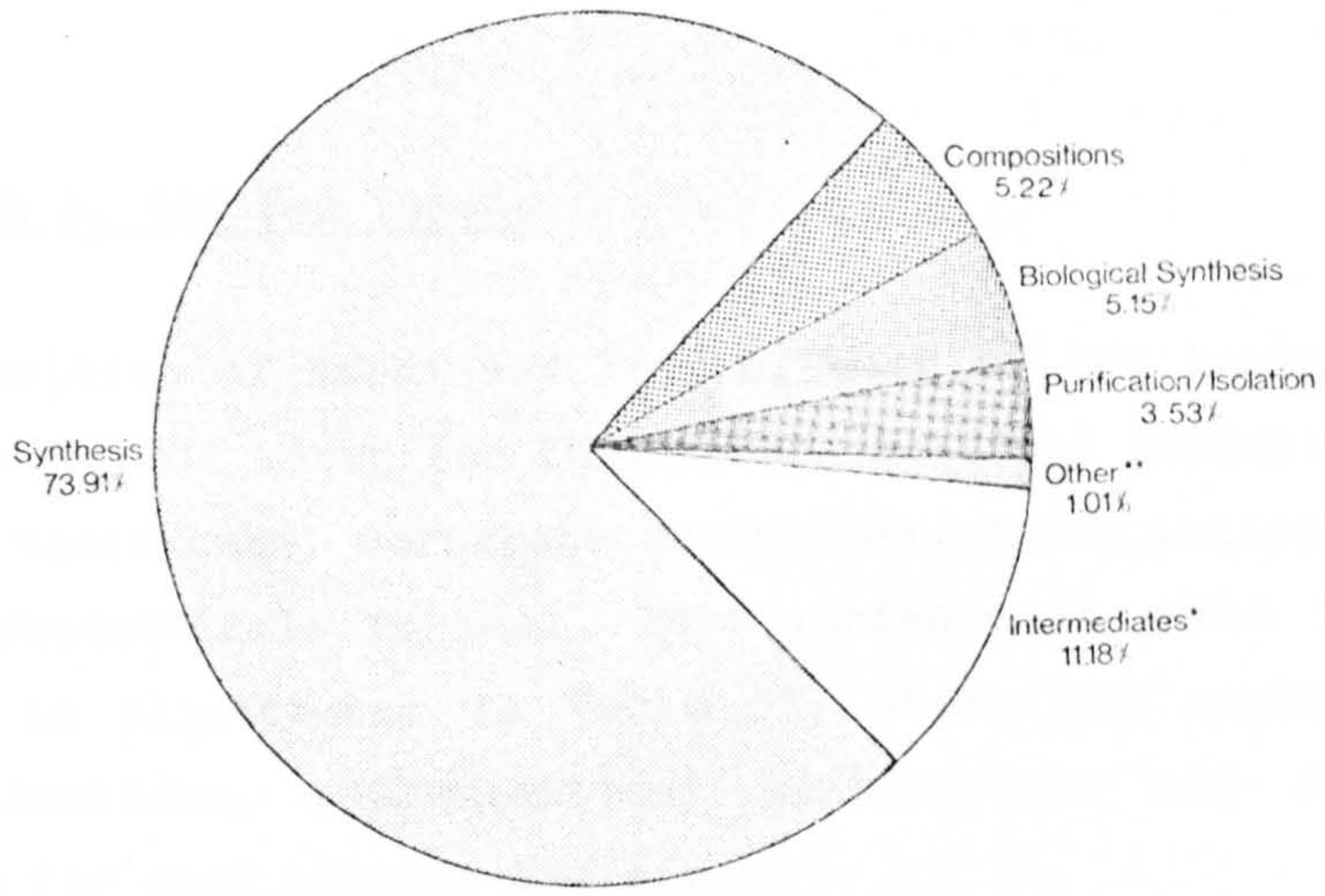


Figure 55: Subject Coverage of Cephalosporin Applications

* Intermediates: only when specifically stated
** Other: such as use in assay/culture media

Since the early days there has been a marked tendency away from the isolation and purification of natural cephalosporins through the semi-synthetic compounds to the totally synthetic cephalosporins. Similarly there has been a small but sustained increase in the number of applications for compositions over the period concerned.

When did the Applicants First Enter the Field?

To try and ascertain when patent applicants first entered cephalosporin technology the applicants have been listed in Table 14 in the order of the earliest priority date claimed on any of their applications.

All of the major companies involved with early developments in Cephalosporin technology as described in Appendix I are to be found in the top 13 companies when ranked by priority data.

It is generally considered that the lead time between initiating a pharmaceutical research project and having sufficient successful results to apply for a patent is around two years. This is borne out by the interval exhibited between the dates upon which agreements/licenses were entered into and the earliest priority dates for the companies concerned.

Amongst the major companies to have moved into the field more recently are Miles Laboratories and Warner Lambert in the USA, Kureha and Tanabe in Japan, Sandoz in Switzerland, Sigma-Tau in Italy and Wellcome in the UK.

A Closer Look at the Top Twenty

With the exception of Asahi and Teijin, each of the leading companies in the field is well known for their pharmaceutical products. However, in terms of their total corporate activities, their individual commitment to pharmaceuticals varies. This variance is given in Tables 17 and 18 and is illustrated in Table 53, where the numbers of total patent applications, pharmaceutical applications and cephalosporin applications for each company are given.

Commitment to pharmaceuticals varies from as low as 6.8% of total applications for Asahi to 97.4% for Squibb. As most of these companies are usually considered to be pharmaceutical it is of interest to note some of their other activities. For example, Glaxo is involved with baby and health foods, surgical instruments and hospital equipment. Ciba-Geigy is involved in agrochemicals, adhesives and dyestuffs. Beecham's main non-pharmaceutical activities are in the area of toiletries, cosmetics, food and drinks.

This pattern of involvement in other technologies is typical of the companies. Naturally related areas to pharmaceuticals, such as veterinary medicine, cosmetics and agrochemicals, are commonly pursued by the pharmaceutical houses.

Two of the Japanese companies (Asahi and Teijin) are more well known for products other than pharmaceuticals. Asahi is Japan's largest producer of synthetic fibres and additionally has interests in plastics, construction materials and printing systems; involvement in pharmaceuticals is a relatively new, but rapidly growing, area of interest for this company which has a declared policy of diversification - especially as the synthetic fibre demand decreases with the world recession.

Teijin too is heavily involved with manufacturing, processing and selling man-made fibres; other major interests are petrochemicals, foodstuffs and materials (mostly plastics) for civil engineering. Like

Asahi, Teijin is trying to diversify and as part of this policy has moved into pharmaceuticals in recent years.

Table 53 also indicates, within the broad category of pharmaceuticals, the individual company's involvement with cephalosporins. The most heavily committed company is Glaxo. Amongst the other comanies heavily committed to cephalosporins are Bristol-Myers, Eli Lilly, Fujisawa, Toyama and Meiji.

Not all the Top Twenty have been in Cephalosporin technology since the late 1950s when the NRDC was negotiating licence agreements with the companies mentioned earlier. Indeed eight of the Japanese companies only entered the field in the late '60s/early '70s. This is shown in the time-scale diagram given as Figure 56 based on Table 14.

A second time-scale diagram, Figure 57, based on Table 15, indicates when each of these companies first made known publically their cephalosporin interests through the medium of having the first of their patent applications published. The pattern closely follows that of the filing of applications, but is additionally important as it provides an indication of when other companies, perhaps not amongst the leaders, may have gleaned information to enable them to embark on parallel R&D effort - possibly involving "molecular roulette" techniques of chemical structure manipulation.

Figures 58 to 61 indicate how each of the Top Twenty has built up its bank of Cephalosporin patent applications.

Amongst those ranked 1 to 5 Fujisawa, Eli Lilly, Squibb and Glaxo show a sustained and continued involvement in Cephalosporins since the early 1960s. Takeda has only been in the field since the late 1960s (assuming again, that a patent application is filed only some two years after initiation of R&D programmes); in this time, however, the company has built up a commanding position and has evidentally diverted a great deal of effort into cephalosporin technology.

Of those companies ranked 6 to 10, Sankyo has, like Takeda, embarked on Cephalosporin work relatively late. The other four companies show continuing and steady involvement.

Company	Total Number of Patents	Total Number Classified Pharmaceutical	Total Number Cephalosporin Patents	Per Cent Classified Pharmaceutical	Per cent Cephalosporins of Total	Per Cent Cephalosporins of Pharmacueticals
Fujisawa	1815	1453	316	80.85	17.41	21.74
Eli Lilly	1621	1251	273	77.17	16.84	21.82
Takeda	3555	2278	153	64.07	4.30	6.71
Squibb	1711	1667	140	97.42	8.18	8.39
Glaxo	426	403	134	94.60	31.45	33.25
Ciba-Geigy	9216	3099	114	33.62	1.23	3.67
Bristol-Myers	899	693	109	77.08	12.12	15.72
Merck & Co.	3681	3230	103	87.74	2.79	3.18
SmithKline	1194	1096	88	91.79	7.37	8.02
Sankyo	2506	1294	87	51.63	3.47	6.72
Yamanouchi	876	802	82	91.55	9.36	10.22
Beecham	965	838	65	86.83	6.73	7.75
Toyama	550	436	59	79.27	10.72	13.53
Meiji	705	439	50	62.26	7.09	11.38
Shionogi	1811	1629	47	89.85	2.59	2.88
Roussel-Uclaf	1753	1470	46	83.85	2.62	3.12
AMHP	2123	1963	45	92.46	2.11	2.29
Asahi	9534	649	45	6.80	0.47	6.93
Teijin	8408	643	42	7.64	0.49	6.53
Sumitomo	8845	1577	41	17.82	0.46	2.59

Table 53: Commitment of Top Twenty Cephalosporin Patentees to (a) Pharmaceuticals and (b) Cephalosporins

Amongst the companies ranked 11 to 20 only Beecham and Roussel-Uclaf have sustained research effort in this area since the early days. Clustered in this group are a number of Japanese companies whose research efforts commenced around 1968 to 1970, soon after the first applications of the early workers (Glaxo, Squibb, Fujisawa, etc.) had been published.

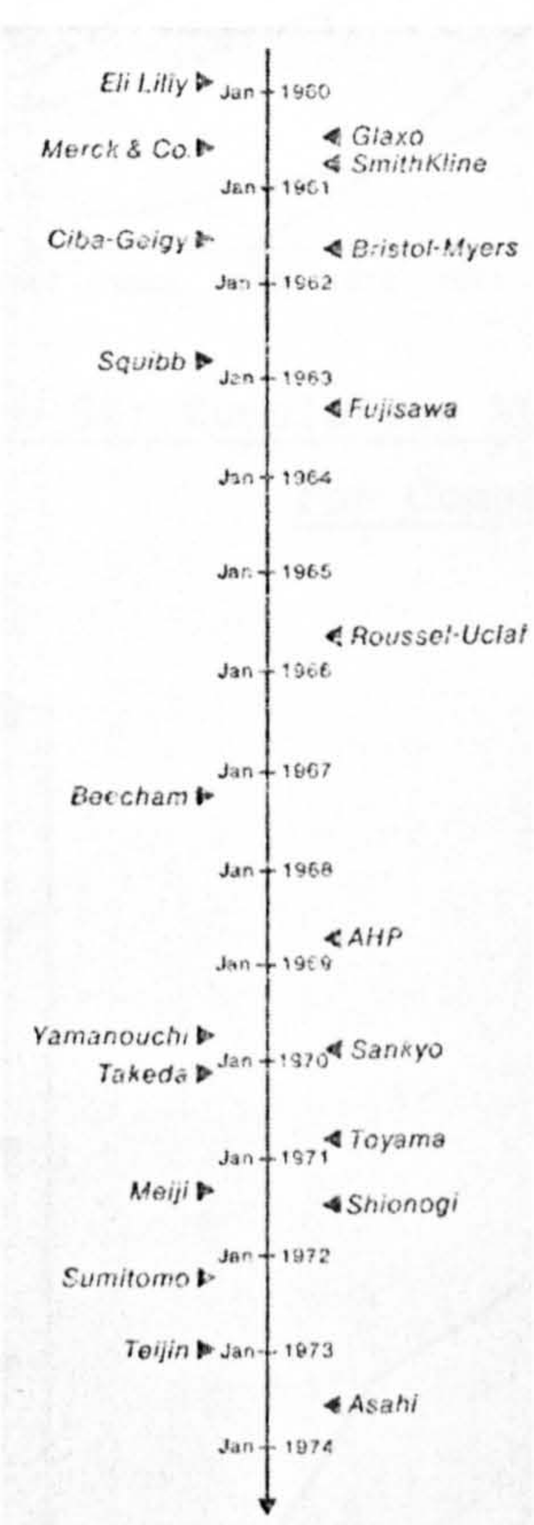


Figure 56: When the Top Twenty Cephalosporin Patentees entered the Field as Indictated by Earliest Priority Date

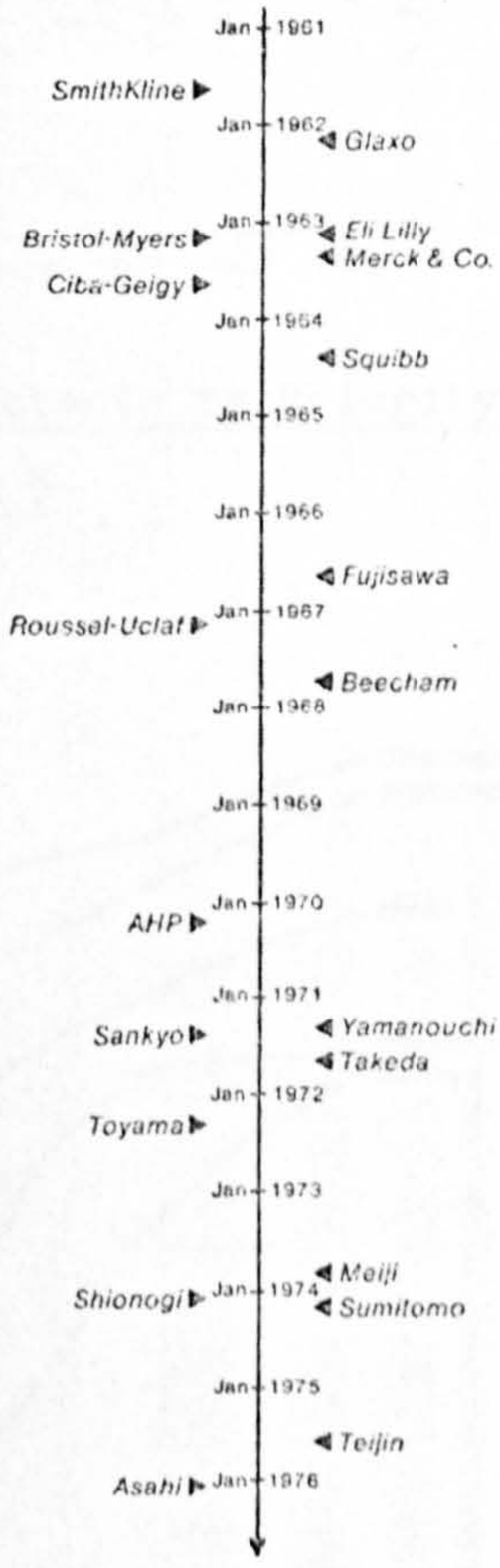


Figure 57: The First Published Application for Each of the Top Twenty Cephalosporin Patentees

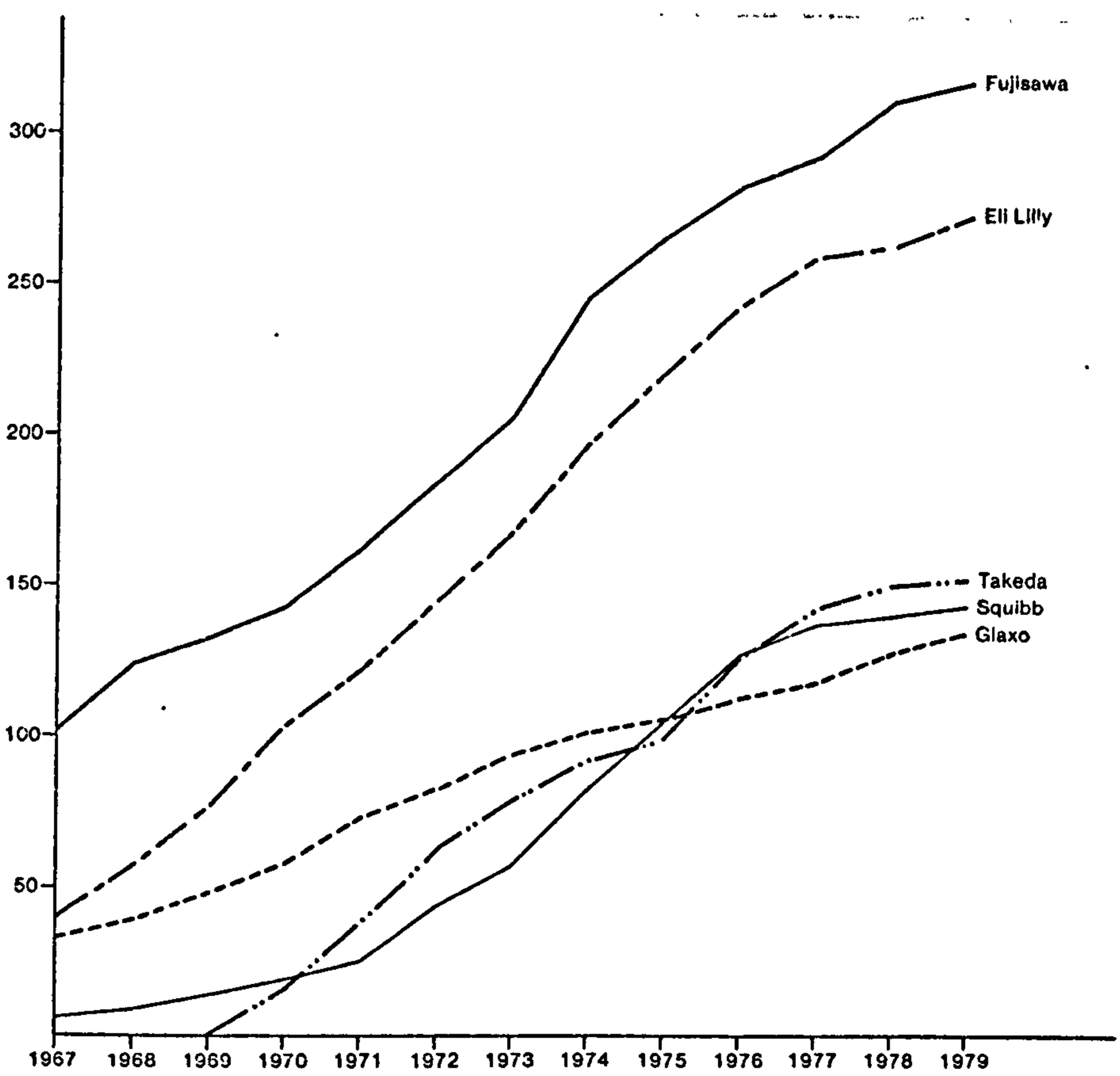


Figure 58: Cumulative Numbers of Basic Patents by Priority Year for Companies Ranked 1 to 5

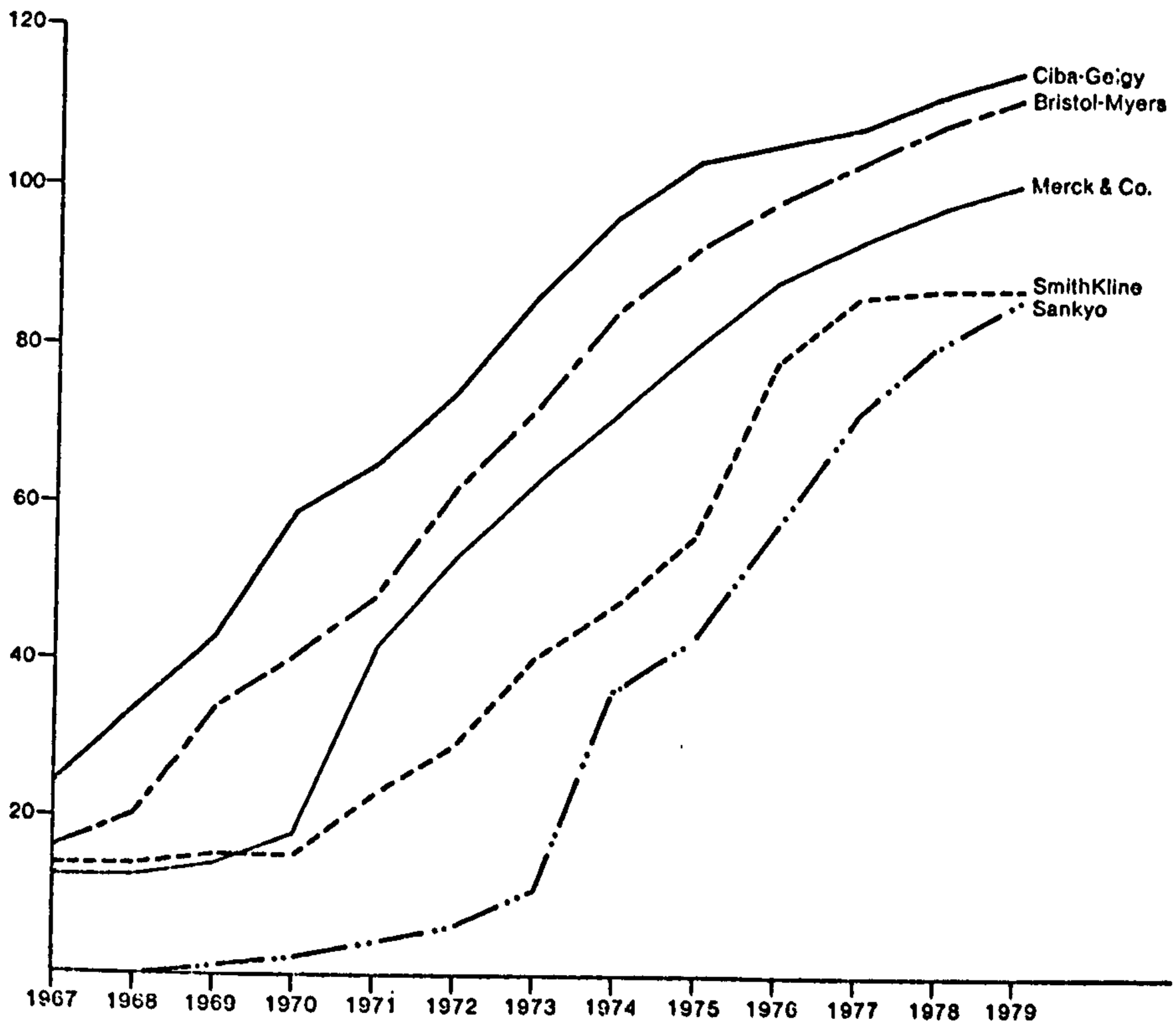


Figure 59: Cumulative Numbers of Basic Patents by Priority Year for Companies Ranked 6 to 10

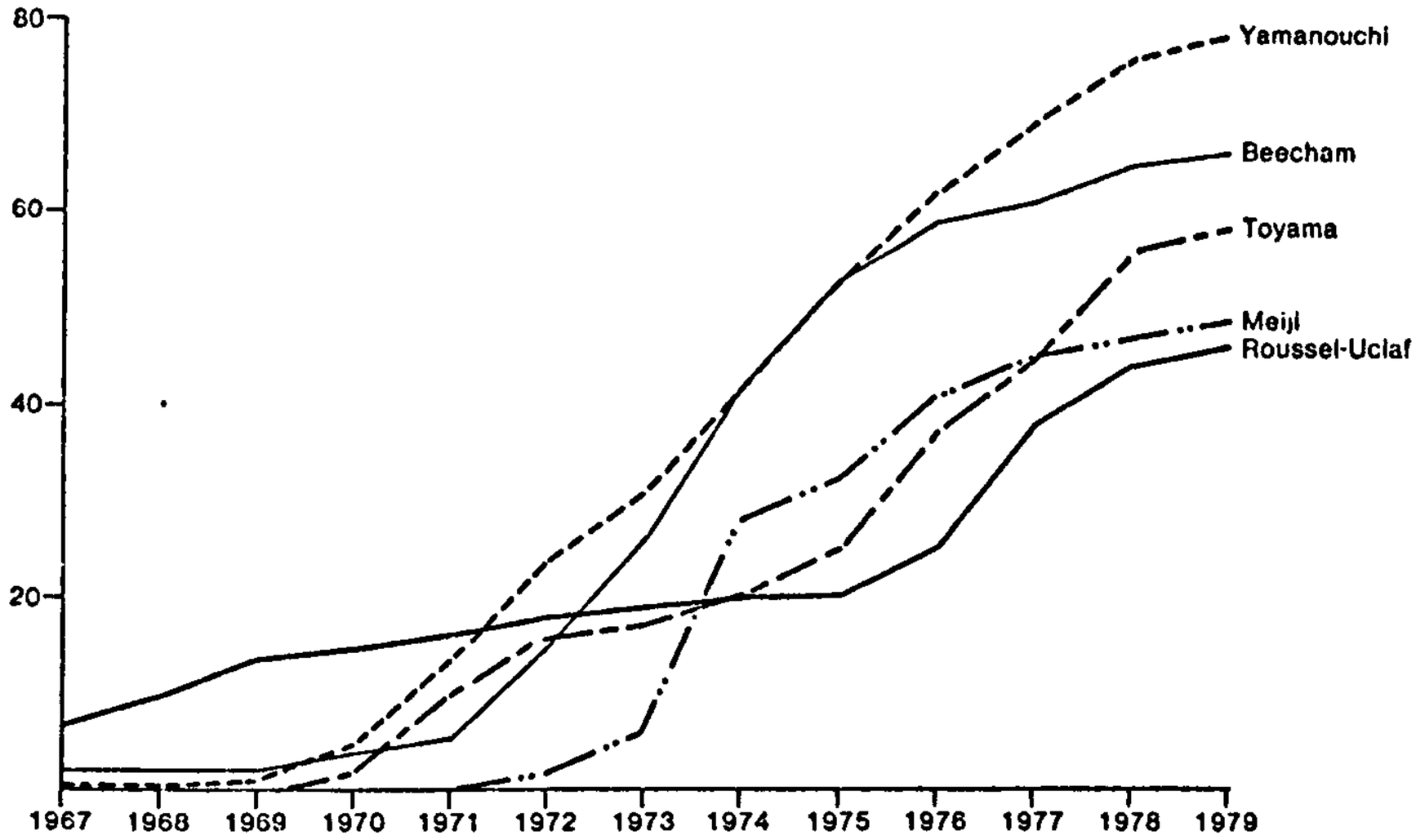


Figure 60: Cumulative Numbers of Basic Patents by Priority Year for Companies Ranked 11 to 15

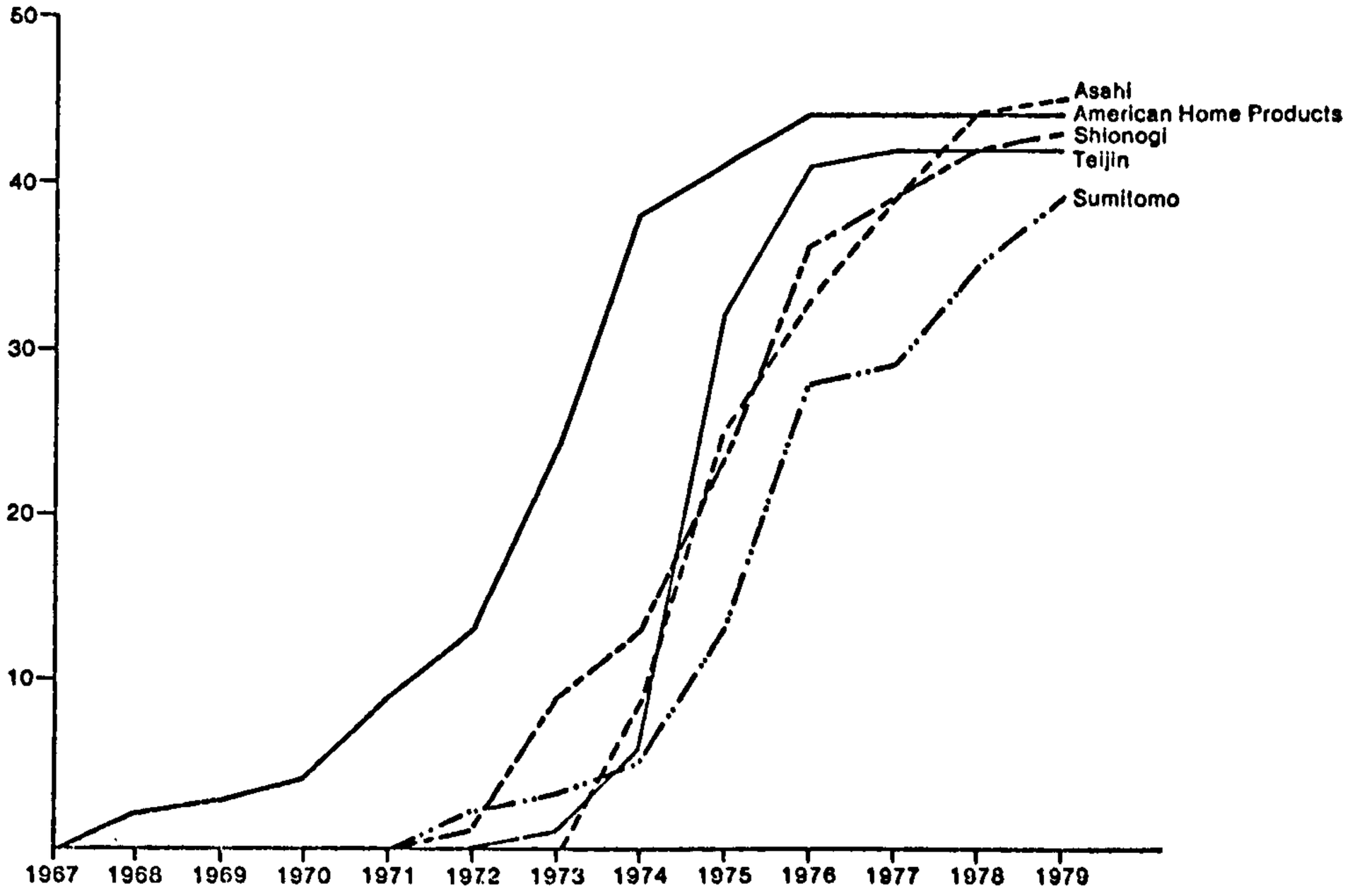


Figure 59: Cumulative Numbers of Basic Patents by Priority Year for Companies Ranked 16 to 20

A Growing, Steady or Declining Technology?

The number of priorities claimed each year on basic applications as shown in Figure 62, indicates significant increase between 1966 and 1974. This would appear to reflect major research effort from the mid-1960s to early 1970s. In 1975 there was a significant fall in the number of priorities claimed, but this is explained by the effects of changes in Japanese patent law referred to earlier. The number of priorities claimed did not quite recover to its former level in 1976, but since then has shown a significant decline.

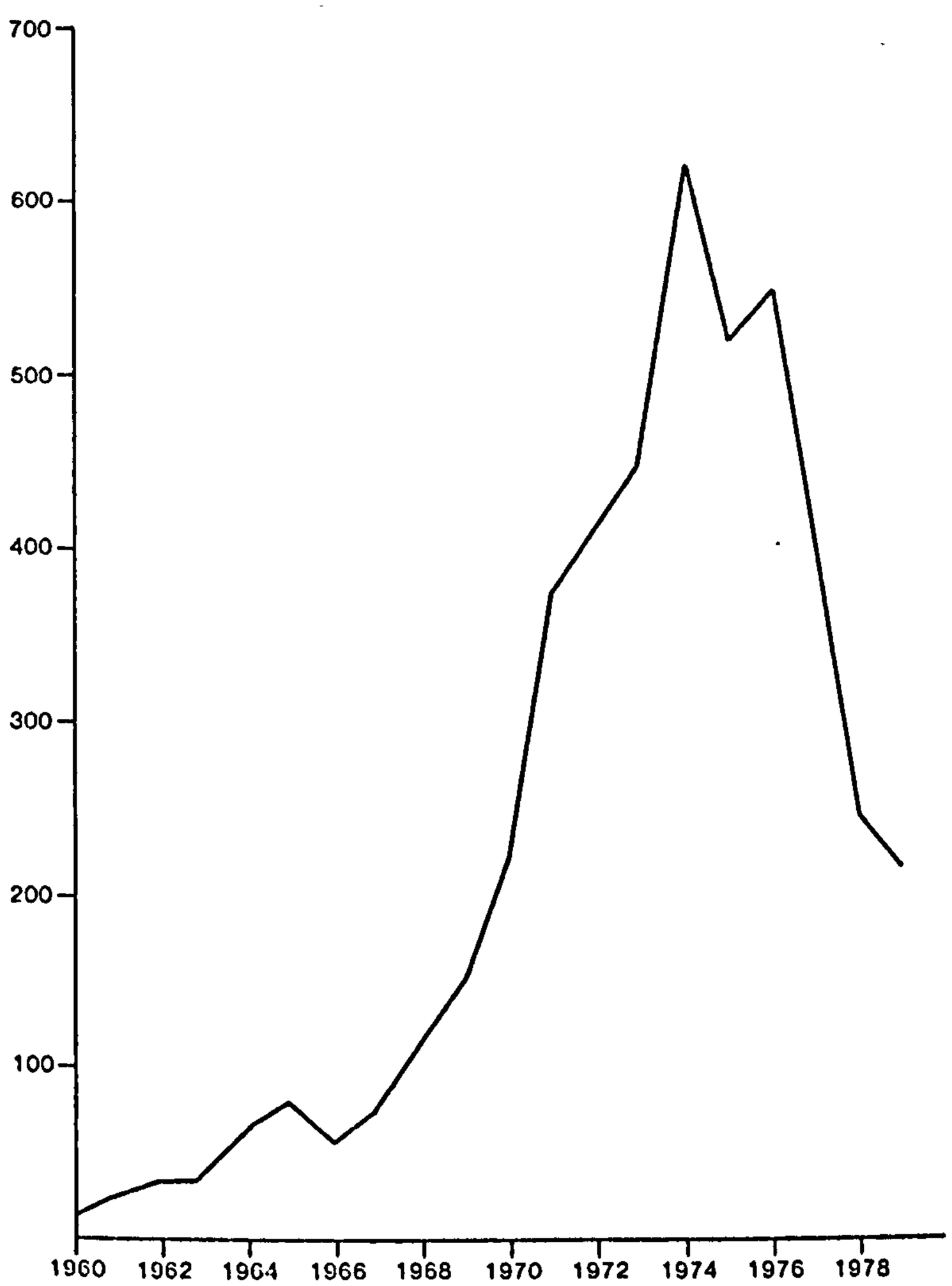


Figure 62: The Growth and Decline of Cephalosporin Priority Applications

The decline in patenting activity since 1976 can be attributed to (a) a decline in R&D effort, (b) the fact that the field of cephalosporins is becoming exhausted, with fewer patentable discoveries to be made, and (c) the fact that more recent applications have not yet been published and so have not yet entered the database. Probably all three factors are at work.

Whilst patent application counting as a measure of R&D effort effectiveness has received recognition as a suitable index, the technique has some drawbacks and is purely empirical.

Development in Cephalosporin Technology

A review of recent developments in Cephalosporin technology and an assessment of the thrust of the technology is given in Appendix I.

Whereas the foregoing indicates a decline in corporate research activity in this field, there is nevertheless a continuing steady flow of patent applications. Many of these, superficially at least, seem to be indicative of the pharmaceutical industry's propensity for "molecular roulette", i.e., company B, having noted a development by company A as disclosed in a patent application, attempts to develop further active compounds which are derivatives of company A's disclosed compounds but which, by modifying positional substitution, functional groups, etc., lie beyond the scope of the earlier application. Such "molecular roulette" is an example of the technology building on technology phenomenon.

Relationship Between Sales and Patenting Activity

As discussed in Chapter 4, several economists have stated that for a company to sustain effective R&D effort and thereby introduce innovative products in to the marketplace, there is a need for that company to have a sufficiently high sales volume to support the R&D effort.

According to Fortune magazine[258] there exists, for those engaged in R&D work in the USA pharmaceutical industry, a problem invariably described as that of "critical mass". The term is borrowed from the world of nuclear physics and refers to the amount of fissionable material necessary to create a chain reaction. In an atomic bomb, for example, fissionable material the size of a golf ball would be too small -

"subcritical". But if the mass is of baseball size, a self-sustaining reaction becomes possible.

In the pharmaceutical business today, the equivalent of that baseball is widely perceived to be an annual research budget of about $75 million. At that level and up, the proposition goes, a company can fund research on a broad spectrum of products, allow for the inevitable disappointments and, over time, very likely develop enough new products to support a sizeable marketing operation. Each of these products, the conventional wisdom continues, will have taken years to get to market, at a cost of perhaps $50 million - the price imposed by tough laws concerning safety and efficacy.

Another piece of conventional wisdom in the industry is that a company cannot rationally spend much more than 10% of its sales on research, a proposition suggesting that a $75-million research budget can be supported only by a company with at least $750 million in sales.

If these suppositions are correct and can be applied worldwide one could conclude that many of those companies with sales less than about £300 Millions may not be engaged in basic research. However, it is probable that the figure of $750 Millions for sales required to sustain research is too high since leading companies - well known to be committed to research - have sales below this figure, e.g., SmithKline, Fujisawa, Miles Laboratories and Sankyo.

Nevertheless, the studies reported herein for that sector of the international pharmaceutical industry concerned with Cephalosporin technology, indicate a positive correlation between sales and Cephalosporin patents. The Spearman Rank Correlation Coefficient, for 142 patentees ranked by numbers of patents and by sales, was found to be 0.3369 which is significant at the 0.10 level. This would confirm, at least for the particualr technological field, that the companies which are the most successful at inovating are those with the higher sales volumes.

Nolan, Oppenheim and Withers[74] found that overall, patenting in the pharmaceutical industry is positively correlated with profits and with sales, but for certain companies there was a significant negative correlation, whilst for others there was no significant correlation

either way. These authors also found that turnover was significantly correlated with both R&D and patenting.

In an earlier study, Reekie[25] examined the pharmaceutical industry's R&D activity at the national (UK), international and individual firm levels. In the national study the very smallest firms were found to perform proportionately less R&D than the medium to large sized companies. In the same study increasing returns to scale were discovered for R&D effort. Reekie concluded that the hypothesis that very small firms are optimal for introducing technology changes was unsupported. Individual company case studies cofirmed this and indicated that firms had to be at least large enough to cover the entire British market before they could support the expense required to participate in some minimum level of innovating activity.

In Reekie's international study, however, the contending hypothesis that the largest concerns were optimal also received little support. The firms of greatest R&D intensity were found to be those of around the size grouping of the existing largest UK domestic concerns, although a second but lower optimum was also observed at a size level considerably larger than this but still short of that of the industry "giants". On the other hand, economies of scale in R&D appeared to be unexhausted even at the level of the largest R&D efforts. However, although the giant firms conducted more R&D than any other size of firm, and although they appeared to be enjoying unexhausted scale economies, because of their lower R&D intensity levels, giant firms did not produce per unit of sales as much output of R&D as did each of two smaller size groupings of firms.

Schwartzman[31], in discussing the R&D efforts of the USA pharmaceutical industry, demonstrates that the largest companies discover relatively more new drugs than do smaller firms, regardless of the measure of the number of discoveries. Schwartzman's measures included number of new chemical entities (NCEs) placed on the market, NCE data weighted by sales, by novelty, medical importance, number of prescriptions and corporate output measured by number of patents. Schwartzman found that sales-size was less closely correlated with the number of patents than with the other measures of research output, but that the elasticity of research output does increase with firm size.

No cause-effect relationship can be drawn from this study or the previous ones. It is not clear if high patenting causes high sales, high sales cause high patenting or whether they are, in fact, both controlled by other external variables.

In considering which other factors may have an effect on the sales-R&D effort relationship, it is to be borne in mind that the pharmaceutical manufacturers compete for sales chiefly by seeking to discover and develop new drugs

To discover new drugs, laboratories must synthesize thousands of new compounds and test them in animals. Few compounds survive these tests and go on to clinical (human) tests, and only a tiny fraction become medically successful marketed drugs. Few prospective drugs satisfy the demands for proof of efficacy in the treatment of disease and of safety against serious side effects. Adding to the uncertainty, very few of the marketed drugs win large sales. Manufacturers cannot predict the sales of new drugs before doctors have had time to learn about their properties, and very few drugs become popular and financially successful. It is difficult to predict the winners of this game. A few popular drugs have earned large profits, but these are the exceptional successes which have provided the resources for financing the major companies' activities and the incentive for the continued search for new drugs. What is forgotten frequently is that most drugs have small sales. The return from the large investment in research and development is highly uncertain.

Thus, factors which may influence the relationship may include the unpredictable occurence of undesirable side-effects and failure of pharmacologically active compounds to meet stringent legislation concerning safety. Having met with such requirements, effective advertising/marketing campaigns muust be undertaken to bring this new product to the notice of the medical profession and, perhaps more importantly, persuade them to prescribe the new drug at the expense of other drugs available for the treatment of the same ailment which are proven and firmly established in the market place. Furthermore, in those countries such as the UK with a public health care programmes, physicians, especially those in state run hospitals, may not be totally free to prescribe whatever they like, and so the relations with the state may have a bearing on sales.

The study of the broader span of technologies represented by the Fortune 500 companies indictates that there are considerable differences between different industries in the relationship between patenting activity and sales. The Spearman Rank Coefficients found for all industries (r= 0.518, 0.10 Level of Significance = 0.074) indicates a strong relationship between sales and patenting activity.

However, as shown in Table 51, r varies from -0.138 for the Apparel industry to 0.940 for the Office Equipment (including computers) industry. Table 52 shows these industries ranked according to the determined values of r. In this set of data, those classed as Pharmaceutical (17 companies) gave r = 0.439 (0.05 Significance Level = 0.490), i.e., a rather weaker relationship than exhibited by the Cephalosporin patentees.

As with the Cephalosporin data, it is not possible to establish causal-effect relationships with this broader set of patenting-sales data. Furthermore, although one might expect a higher correlation between sales and patenting for the high-technology industries and a lower correlation for services (such as broadcasting and motion picture production) or with traditional industries e.g. industrial and farm equipment, Table 52 does not reveal such a trend; musical instruments, toys and sporting goods exhibit a Spearman Rank Coefficient of 0.900 yet electronics and appliances have one of only 0.614.

Just as the comments on the pharmaceutical industry given above indicate an array of other possible influencing factors, so too there are such factors applicable to each of the industries in this study.

It may also be possible that, just as Schwartzman[31] showed that a lower correlation exists between sales and R&D effort measured by patenting activity, other measures of R&D might be more appropriate, e.g., new products launched. Similarly, the measures of firm size by sales volume may not be the best parameter and firm sizes as indicated by profit, percentage of sales devoted to R&D, manpower or capital may be more appropriate. Further work in this area is recommended.

BIBLIOMETRIC STUDIES

Bradford-Zipf "Law"

The Bradford-Zipf bibliographs given in Figures 19 to 26 for eight of the patents data sets studied, indicate that generally patents data fits into the pattern obtained with journal literature studies inasmuch as each data set bibliograph exhibits a clear nuclear zone, a log-linear zone and a subsequent deviation from a log-linear relationship which, in the case of Cephalosporins, Cyclopropane Derivative Insecticides, Videodiscs and Terephthalic Acid Production data sets give a characteristic Groos Droop with the same indication of arcing. Arcs are noticeable in the other four bibliographs, i.e., Air Cushion Vehicles, Genetic Enginering, Pressure Sensitive Adhesives and Pharmacologically Active Pyrazolones; however, in these four cases the arcs lie above the extrapolated log-linear line.

Calculations for N and R(N), representing total patentees and total basic patents respectively, as given in Table 23, show considerable deviation from the observed values. For Cephalosporins, Cyclopropane Derivative Insecticides and Terephthalic Acid Production observed N and R(N) were lower than the calculated values; for Videodiscs observed N and R(N) were higher and lower respectively than calculated values. It is noted that these four data sets are those which exhibit the Groos Droop, whilst for the other four data sets observed values of N and R(N) were all higher than the corresponding calculated values.

It is of interest to note that three of the technologies (Cephalosporins, Cyclopropane Derivative Insecticides and Terephthalic Acid Production) exhibiting the Groos Drooop, are each "chemical" technologies which have been covered by Derwent since 1963, 1965 and 1966 respectively, whereas with the exception of Pharmacologically Active Pyrazolones and Genetic Engineering, the other technologies have only been covered by Dewent since 1974.

In those cases, where calculated values of N and R(N) are higher than observed values, the indication of "missing" patentees and "missing" basic patents is explained by the limited country coverage of WPI. This limitation originated in two ways: firstly, only 26 patent issuing authorities are coverd, and secondly, a number of those countries which are covered have only been included in the service since 1974 or later.

This latter point is most significant in the case of Cephalosporins since the data here presented clearly shows a most rapid growth in patenting activity in the period from 1968 to 1974 - after which a marked decline has been observed.

The "missing" patents may be assumed, therefore, to have been filed in Australasia, Latin American and Third World Countries generally - none of which are included in the WPI service. Doubtless a number of these applications will have originated from the most active patentees identified in this study. The "missing" patentees - probably each with only one or two patents - will tend to be smaller pharmaceutical houses and independent inventors.

Similar explanations may be given for the other data sets, although for those technologies covered in the database only since the mid-1970s it is probable that the retrievable data just does not extend back enough to enable the construction of conventional bibliographs, albeit that interpretation of the bibliographs for patents shows considerable differences between observed and calculated values for total numbers of patentees and patents.

This study represents the first time that the Bradford-Zipf Law has been applied to patents data. This novel application of the bibliograph technique shows that patents data seems to conform to the same patterns as those observed with journal literature.

However, there can only be a partial analogy between the clustering of articles in a particular journal and the clustering of patents by particular patentees; nevertheless, the analogy that certain patentees can be expected to receive more than their "fair share" of patents on a given technology is present. Clearly, as indicated earlier, the motivations for an author to publish a paper in a learned journal and the propensity for an inventor to apply for a patent are different, irrespective of whether the author or inventor are academic, corporate or government employees, or even totally independent.

Numerous uses have been made of the bibliograph: items borrowed from a library, users ranked by number of items they borrow, number of items cited and the index terms assigned to documents. These uses of the Bradford-Zipf distribution have value for library decision-making, since the distribution allows for the prediction of regularity in a

variety of events. Broadly speaking, this regularity is characterised by both concentration and dispersion of specific items of information over different sources of information. Thus for a search on some specific topic, a large number of relevant articles will be concentrated in a small number of journals; the remaining articles will be dispersed over a large number of titles. Knowledge of sources and their items permits prediction of core collections, core users and core index terms.

Since the Bradford-Zipf Law appears from this study to be applicable to patents information, it could be used on a similar way as librarians apply it to decision-making. In an analogous way patents information users could use Bradford-Zipf to identify the major patentees, those patentees whose applications are not worth bothering with, and those patentees whose applications should be searched for in a patents database.

One application to which Bradford-Zipf is applied is in the evaluation of the quality of abstracting services, i.e., the comprehensiveness of the service in covering all relevant literature. This achieved by determining, from the bibliograph derived data, the percentage of the total theoretical papers which it covers. Whilst Table 23 indicates considerable differences between observed and theoretical numbers of patents and patentees, it is to be noted that these differences, at least in part, must be attributed to (a) the changes in subject coverage, (b) the changes in country coverage, and (c) the partial coverage of the total number of patents worldwide by the WPI/WPIL database. Sviridov[259] has stated that globally there are about 1 million patent documents per year; at a weekly input level of 10,000 documents per week in 1982, WPI/WPIL is only covering 50 to 55% if the total documents. One aspect of this which it is considered worthy of further study is that the bibliographs used in this study were constructed using figures of basic patents per patentee, whereas using total patent families per patentee may give a different set of results.

Vector Analysis Graphs

Figures 27 to 37 give vector analysis graphs for each of the eleven patents data sets studied; in each case, with the exception of the Cephalosporins data sets, the final data point represents the patenting activity as recorded in the data base for 1978. As the retrievals were

conducted in mid-1981 these data points may be misleading as the database would have contained all those applications filed up until the end of 1978 which appeared from those countries publishing patents without examination under the so-called "18-months" system; but the applications from countries such as the USA, publishing only after examination, several years after the filing of an application, would not yet have been included. For the original Cephalosporins data set a similar situation prevailed, with dates two years earlier; for the updated data set, the 1978 data point has been used as the retrieval was conducted 32 months after the end of 1978. Thus, in the discussion which follows, the location of the penultimate data point and the characteristics of the penultimate vectors are considered.

(a) Cephalosporins

For the original data set, the 1976 data point is located in Quadrant I, indicating that the technology was in the Development Stage. The relative length of the 1975/1976 vector with the other vectors, the former being relatively large, indicates that this state is relatively certain, whilst the fact that the 1975/1976 vector is only moderately parallel to the bisecting line of the quadrant indicates that the trend appraisal is only moderately certain.

For the updated Cephalosporins data set, the 1978 data point lies in Quadrant II, indicating that the technology is in the Research or Perfection stage; that is to say that in the time interval between the two data sets, the technology had progressed from Development and that, in all probability, whilst manufacturing processes may have been initiated, and indeed more Cephalosporin containing medicaments have become available on the market, R&D activities had slackened off and research was being concentrated elsewhere, for example, in the new Olivanic and Clavulanic Acids classes of antibiotics. The 1977/1978 vector lies quite parallel to the vector bisect, but is only relatively short in length thus indicating that the trend appraisal is quite accurate, but because of this relative shortness it is probably transient and a further shift should be expected.

(b) Air Cushion Vehicles

The 1977 data point lies in Quadrant III indicating a Fully Mature or Declining Stage. Both the direction and length of the 1976/1977 vector

indicates that the interpretation is reasonably accurate. Whilst the graph exhibits a certain amount of closing, the general appearence is that research activity has been polarised between Quadrants I and III; this would indicate that there is a continuation of research in this technology, but that such improvements that are made are quickly implemented and that a step-wise development occurs rather than a steady flow of improvements exhibited by the Cephalosporins.

(c) Cyclopropane Derivative Insecticides

The 1977 data point lies in Quadrant I indicating the technology is in a Development Stage. Both the length and direction of the 1976/1977 vector indicate a high degree of certainty for this interpretation. The overall appearance of the graph indicated a bias towards Quadrant II (Research or Perfection) and some polarisation with Quadrant IV (also indicative of Research or Perfection). The more recent shift to Quadrant I would thus be indicative of a previously unknown group of derivatives with insecticidal activities.

(d) Videodiscs

In this case also the 1977 data point lies in Quadrant I, again indicative of a Development Stage. Whilst the relative length of the 1976/1977 vector would indicate a reasonable accuracy in this interpretation, its direction indicates the opposite as it is almost parallel to the y-axis rather than to the vector bisect. On the other hand, the overall appearence of the graph shows a concentration of data points in Quadrant I which is in keeping with the fact that this is indeed a developing technology.

(e) Genetic Engineering

Once again the 1977 data point lies in Quadrant I, however, both the length and direction of the 1976/1977 vector indicate that the accuracy of the interpretation that the technology is in the Development Stage is not too strong. However, the overall appearance of the graph shows that with the exception of the 1974 data point, all others lie in Quadrant I, confirming the known fact that this is a developing technology.

(f) Terephthalic Acid Production

The 1977 data point lies in Quadrant II, indicative of the technology being in a Research or Perfection stage; this interpretation is confirmed by both the direction and relative length of the 1976/1977 vector. Whilst the graph exhibits a certain amount of closure of vectors, the overall appearance is that there is a polarisation of data points between Quadrants II and IV, both quadrants indicating the same stage. In all probability, as this is a technology which has been in existance for many years, the state of the art is one of Perfection rather than of Research and that recent applications are for process patents which involve minor modifications to marginally improve yields rather than significant new synthetic techniques.

(g) Pressure Sensitive Adhesives

In this case the 1977 data point lies in Quadrant III, i.e., Fully Mature or Declining Stage. Whilst the direction of the 1976/1977 vector indicates that this interpretation is reasonably accurate, the length of the vector does not offer the same degree of confirmation. Again the overall appearance of the graph indicates a polarisation between Quadrants I and III with a concentration of data points in the former. The 1975/1976 and 1976/1977 (and also 1977/1978) vectors are however each directed towards Quadrant III indicating the interpretation that this is a mature/declining technology is correct.

(h) Pharmacologically Active Pyrazolones

The overall appearance of the graph is that of polarisation of data points between Quadrants I and II, although the 1977 data point lies in Quadrant I indicating a Development Stage. Both the direction and length of the 1976/1977 vector indicate that the interpretation is reasonably accurate. The movement of vectors between Quadrants I and IV may be interpreted as indicative of a series of research efforts resulting in new pyrazolone derivatives which require little further research to bring them into the market place; having produced such a product, research continues until such time as another efficacious compound is identified and marketed, and so on and so forth. In this technology, however, it is possible that more recent developments could be in formulation rather than new effective compounds.

(i) Olivanic and Clavulanic Acid

It is known that these two technologies represent some of the latest developments in the technology of antibiotics. It is not surprising, therefore, that in both cases the 1977 data point lies in Quadrant I and that the lengths of the 1976/1977 vector indicate a high degree of accuracy in this interpretation. For Olivanic Acid the direction of the 1976/1977 vector further confirms this, although the direction of the 1976/1977 vector for Clavulanic Acid indicates a weaker confirmation. In both cases, the concentration of data points lies in Quadrant I.

The Vector Analysis technique is a relatively new, and virtually untried, method for technology asessment. Other than the original work of the Japanese Patent Office, and the use of the technique by OTAF, vector analysis has not hitherto been used and certainly not in such a wide variety of technologies as in this study.

This study represents a major confirmation of the value of Vector Analysis in providing a good indication of the state-of-the-art in any technology and thus can be used with a reasonable amount of confidence in technology forecasting. It is strongly recommended that it be more widely used in the future; it would be most desirable if future analyses of technologies include a patent vector diagram to support any assertions made.

RELATIONSHIP BETWEEN BRADFORD-ZIPF AND VECTOR ANALYSIS GRAPHS

Vector Analysis graphs are relatively complicated to construct, and require far more effort than the relatively simple Bradford-Zipf graphs. Bearing in mind that the degree deviation from the log-linear relationship exhibited by Bradford-Zipf plots is considered to be an indication of incompleteness, an attempt has been made to see if a measure of this incompleteness can be correlated with the technology assessment derived from the Vector Analyses. To do this measurements have been made of the relative length of the portion of the Bradford-Zipf graph which shows deviation to the nuclear and log-linear zones; referring to Figure 63, a factor of BC/AB has been calculated for the Bradford-Zipf plots given in Figures 19 to 26.

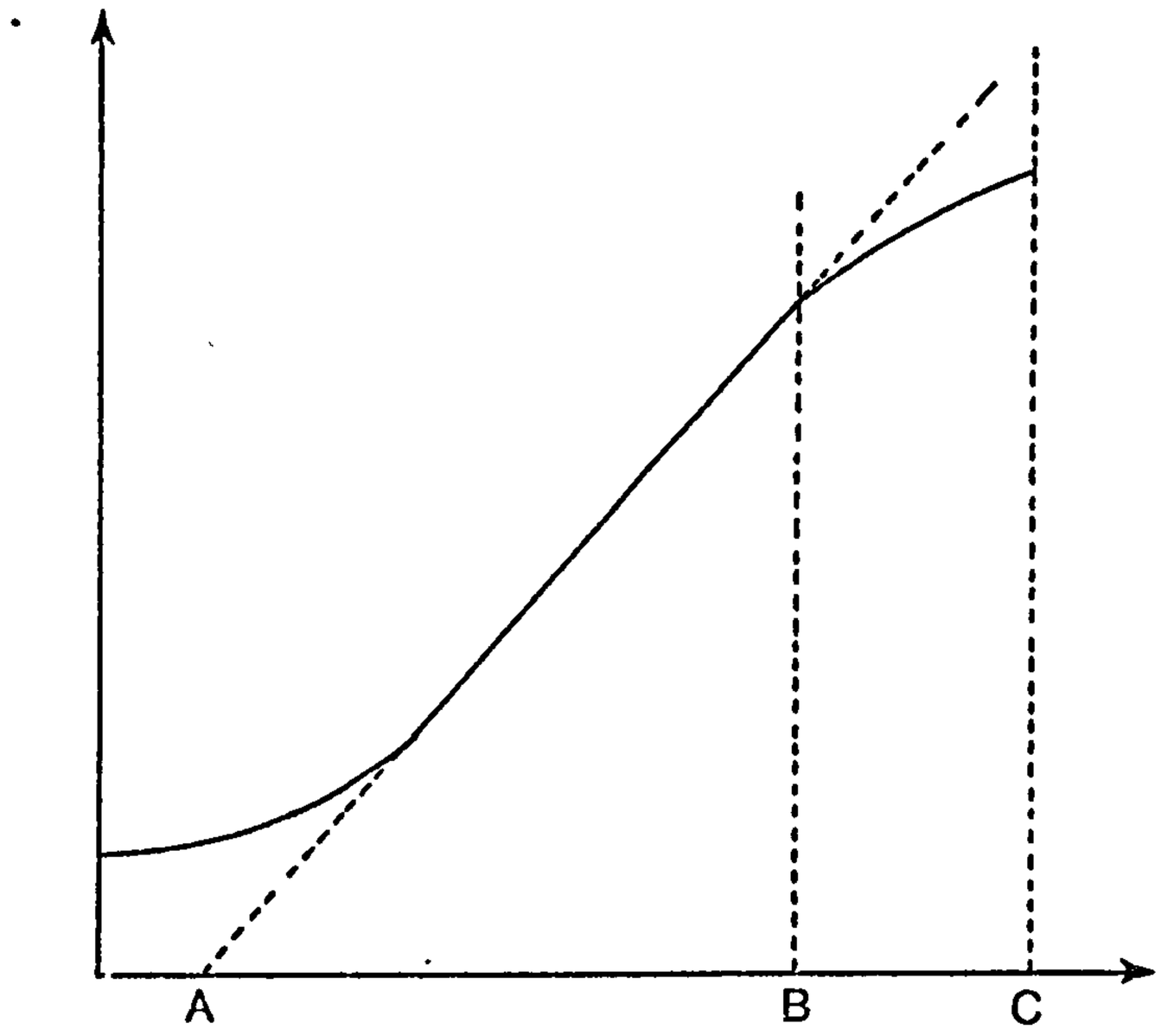


Figure 62: The Bibliograph Segments

Comparing this factor with the Vector Analyses interpretations indicates that values of BC/AB less than 0.55 correspond to an assessment in Quadrant III, values of 0.55 to 0.80 to Quadrant II and values greater than 0.80 to Quadrant I. However, the values of BC/AB for Genetic Engineerng and Pharmacological Pyrazolones, both of which gave 1977 data points in Quadrant I of the Vector Analysis graphs, were 0.43 and 0.36 which correspond more Quadrant III; as far as the Genetic Engineering data is concerned the data points are however clustered in Quadrant I, but such clustering is not so obvious in the case of the pyrazolones.

If in fact deviation from the log-linear relationship is an indication of completeness of the data set, then there is no reason to expect that the more mature a technology is, then the lesser the amount of deviation; yet this is precisely the result that has been obtained. It may well be, therefore, that a scale of values for BC/AB can be established which will give a quick empirical indication of the state of a particular technology by interpretation of Bradford-Zipf plots.

The indication of a possible relationship between Bradford-Zipf bibliographs and Vector Analysis diagrams is intriguing. Had time permitted, this study would have been extended to elaborate on this aspect of patents statistics; this area is one for which further research is certainly desirable.

FREQUENCY DISTRIBUTIONS FOR PATENTS PER PATENTEE

Figures 38 to 47 give Lotka's Law graphs for the patents data sets examined. These are based on calculated values for Lotka's exponent ranging from 0.24 (Clavulanic Acid) to 1.91 (Pyrazolones). Beacuse of these results it is clear that Lotka's empirical inverse square law does not hold for collections of patents data. In fact, this is not very surprising since, as shown in Table 6, relatively few studies have in fact confirmed Lotka's "Law" although a few have given values for the exponent which are close to 2.

This observation, obtained from a comprehensive survey of the literature, is surprising in the sense that hitherto Lotka's "Law" has generally beeen considered as proven and is widely used in bibliometrics. A first consideration of the results obtained in this study would indicate that patents data does not fit Lotka's "Law"; further consideration leads to the question: Is Lotka's "Law" widely applicable? If it is not, as previous studies would seem to indicate, then the non-conformity of patent data to Lotka would appear to fit the rule rather than be the exception.

At the expense of being repetitive it must by stated again that the motivations for publishing an article in a learned journal differs in several respects from those which lead to a patent application. For example, commercial considerations are of prime importance in deciding whether to seek a patent application whereas the decision of whether to publish a journal article by, for example, academic workers may well be influenced by a desire to maintain, or even advance, personal status within the academic community. Furthermore, since there is evidence that the major portion of technological progress which is published in patents is never published elsewhere, it is likely that had Lotka, and subsequent workers, studied patents literature or the total collection of patents plus journal literature for a given technology, Lotka's inverse square "Law" may never have been postulated.

The "failure" of fitting patents data to Lotka's "Law" led, in this study to a consideration of the possible applicability of other frequency distribution models to the observed data. Some of these distributions have only been used once or twice before in bibliometric studies; certainlly they have not received the attention that Bradford-Zipf and Lotka distributions have. To achieve this and to bring the

applications of some of the little-known distributions into the domain of any information worker with access to a microcomputer, a series of programs written in easy-to-use BASIC language were developed - although some were based on earlier studies by other research workers. The same programs, without modification, were usable with both patents per patentee and citations per patent data sets; they are applicable to any data sets which need frequency distribution analysis, such as in econometrics.

From Table 36 it is seen that when testing a selection of theoretical frequency distributions to the patents data sets studied, only the Negative Binomial distribution was found to fit all the observed distributions at the 0.01 Level of Significance for values of the Kolmogorov-Smironov D_{max} parameter. The Borel-Tanner and Simon-Yule distributions were found to closely fit observed values in all cases other than the Cephalosporins data sets but generally values of D_{max} for these distributions were higher than those for the Negative Binomial Distribution.

These results are similar to those observed by Rao, who found that the Negative Binomial gave a theoretical distribution which closely fitted journal literature data when tested with the χ^2 test, and the observations of Coile in respect of the Simon-Yule distribution when tested by the Kolmogorov-Smirnov Test.

These results indicate that bibliometricians, who hitherto have generally restricted their studies to the well-known frequency distributions such as Lotka's "Law", should broaden their investigations to include a wider selection of distributions such as the Negative Binomial, Simon-Yule and Borel-Tanner distributions. As a possible topic for further study, it is suggested that some of these lesser known distributions are applied to data sets published by various authors which have tested their data against Lotka's "Law" to see if better fits between observed and theoretical observations can be obtained; not least of all, their applicability to Lotka's original data used in his 1926 studies should be tested.

FREQUENCY DISTRIBUTIONS FOR PATENTS CITATIONS

As shown in Table 48, the Negative Binomial distribution was found to provide theoretical distributions which fitted all the observed data

sets. Both the Borel-Tanner and Simon-Yule distributions gave frequencies of citations per patent which fitted all but one set of observed data but in nearly all cases values of Kolmogorov-Smirnov D_{max} were lower for the Negative Binomial than the other two frequency distributions.

IMPLICATIONS OF THE APPLICABILITY OF THE NEGATIVE BINOMIAL DISTRIBUTION

Rao has shown that the Negative Binomial distribution described the patterns of scientific productivity under the success-breeds-success condition, when using this distribution in reference to journal articles, in a wide variety of social circumstances. The results obtained in this study show that this distribution is equally applicable to scientific productivity as indicated by the patent literature, although as indicated above, the motivations to apply for a patent may differ from those leading to publications of a journal article.

If patenting activity does follow the success-breeds-success phenomenom, then by analogy to the activities of journal article authors, i.e., that the probability that an author who has already published n articles in a given time interval will publish a further article increases as n increases, it may be concluded that successful patentees are more likely to apply for further patents. Furthermore, if, as indicated in the studies of sales vs. patenting activity, the latter is correlated with sales volumes, it is axiomatic that firms which are successful innovators are most likely to be those already established with a good market share for their product.

APPLICATIONS OF THE RESEARCH REPORTED HEREIN

It is clear from this study that, whether for technological forecasting or for pseudo-proprietary information, statistical measurements of patenting activity are necessary to provide a most complete picture. Because of the author's management role in Derwent Publications Limited he has been able to influence that company's development plans such that it is proposed early 1983 to instal a suite of statistical manipulation computer programs in the same host computers as the WPI/WPIL databases so that the many users of the patents database will be able to quickly and easily derive meaningful patents statistics to assist them in their research and policy making decisions.

RECOMMENDATIONS FOR FURTHER RESEARCH

There are several areas where further study is warranted. Firstly, with regard to the Cephalosporins, a more detailed look into the relationship between types of novel compound and priority and publication dates for the applications by patentees within the compound type might well shed some light on how extensive, or otherwise, is "molecular roulette".

Secondly, in regard to patenting vs. sales data, further studies are recommended using different measures of firm sizes, for example, profit, percentage revenues and profit devoted to R&D, number of new entities placed on the market, capital investment and manpower.

Thirdly, in respect of the Bradford-Zipf bibliographs, similar graphs should be constructed and extrapolated using the total number of patents, i.e., basics plus all family members, per patentee rather than just the numbers of basic patents. In such a study, consideration of problems associated with the patent procedure protocols of cognating, dividing-out and continuations-in-part is essential. Furthermore, in counting family members, allowance must be made for the issue of an initial unexamined document, followed by an examined document and then, for some countries, the granted document.

There is a requirement for a simple method for technological assessment. Some thoughts on how this may be acheieved using Bradford-Zipf plots have been given; further study in this area is considered to be appropriate. The relationship between Bradford-Zipf bibliographs and Vector Analysis diagrams need further study.

Similarly, it is thought that the closeness of fit between observed and calculated frequency distribution may provide an indicator of the state of the art: the closer the observed data is to the theoretical data (as calculated from the Negative Binomial distribution) then the greater the likelihood that development in the technology has attained a steady data. This possibility is also considered to be suitable for further study.

This work clearly shows that some lesser-known frequency distributions are more applicable in bibliometric studies than more widely accepted ones. It is suggested that these frequency distributions are tried

against other data sets to ascertain their possible wider applicability than has so far been demonstrated. In particular, it is recommended that they be applied to Lotka's data upon which he formulated his "Law".

Finally, but not exhausting the possibilities, it is considered appropriate to see whether similar observations on patenting activity would be obtained if a distinction was made, especially, for chemical technologies, between process patents and non-process patents. Process patents for large and successful companies can bring about economies of scale not achieveable by smaller organisations; it would be of interest to see whether such patents enhance the ability of larger corporations to forge ahead of their smaller competitors.

APPENDIX I : THE CEPHALOSPORINS

Abraham and Loder[260] have given an account of the early developments in the technology of the Cephalosporins; their work has been used as the basis for the historical description given here.

The old medical literature contains many references to the use of soil and certain plants in the treatment of local infections. They might well have been sources of antibiotic forming micro-organisms. In 1877 Pasteur and Joubert reported that anthrax bacilli did not grow in urine if it was infected by aerobic bacteria. A similar effect was observed when anthrax bacilli were administered together with other bacteria to animals.

In 1928 Fleming noted that one of his bacterial cultures was markedly inhabited by a contaminating mould of the genus Penicillium. Later, in 1939-41, penicillin (as the agent was named by Fleming) was isolated in pure form and its production started. This was the dawn of the age of antibiotics.

The demonstration that penicillin, produced by Penicillium notatum during fermentation, possessed both therapeutic effectiveness and a low order of toxicity in humans prompted enormous efforts by many workers to isolate, identify, characterise and synthesise analogous therapeutically efficacious substances.

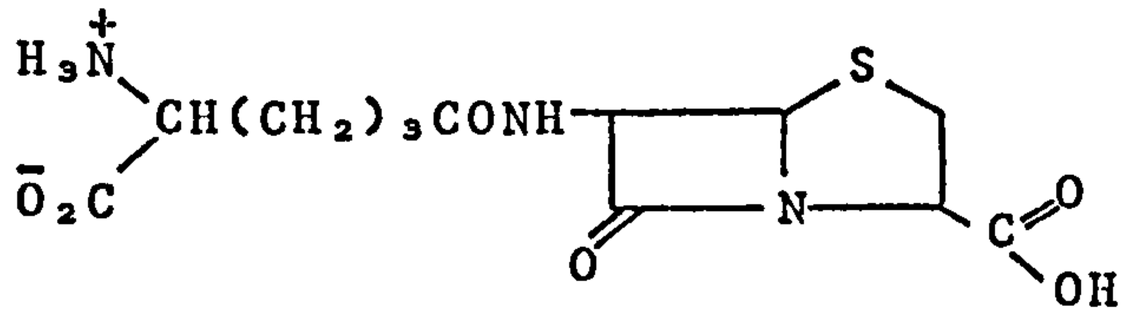
One such worker was Guiseppe Brotzu of Sardinia. Brotzu began his work in 1945 by examining the microbial flora of seawater near a sewage outlet at Cagliari, supposing that the process of self-purification of the water might, in part, be due to bacterial antagonism. From a location, which is now reclaimed land, he isolated a fungus which he concluded was similar to Cephalosporium acremonium. When cultivated on agar this wild strain of Cephalosporium secreted material which inhibited the growth of a variety of gram-positive and gram-negative bacteria. Selection of colonies from many serial cultures led to the isolation of a strain which produced significant amounts of antibacterial material when cultivated in glucose-starch broth. From the filtrates of such cultures a crude active concentrate was obtained after precipitation of inactive products with ethanol.

Both culture filtrates and crude active concentrates were tested clinically in Sardinia with encouraging results. However, Brotzu was unable to interest anyone in Italy in his discovery and wrote with details of his work and findings to Dr. Blyth Brooke in London. Brooke wrote, in 1948, to Sir Howard Florey who arranged for investigations to be continued at the Dunn Schol of Pathology at Oxford; Brotzu sent a culture of his organism to Oxford in September 1948 for work to commence.

Initial work at Oxford by Heatley showed that the culture fluids contained an acidic antibiotic which was readiliy extractable into organic solvents. After July 1949, culture fluid production was carried out at the MRC's research establishment at Cleverdon, Somerset. Burton and Abraham, at Oxford, commenced studies on the active material; in particular they worked on the antibiotic extractable into organic solvents, but it soon became clear that this material - named cephalosporin P since it showed activity only against certain gram-positive bacteria - was not the antibiotic described by Brotzu.

In August 1949 a second antibiotic was found to be present in the culture fluid of the Cephalosporium species by workers at Oxford. This substance remained in the aqueous phase after the extraction of cephalosporin P, and was discovered independantly by workers at Cleverdon in the following October. It was active against gram-negative as well as gram-positive bacteria and was named cephalosporin N. Cephalosporin N was shown to be responsible for the antibacterial activity first observed in Sardinia four years previously.

Abraham and Newton showed in 1953 that cephalosporin N was a new type of penicillin yielding the characteristic aminoacid penicillamine on acid hydrolysis. In 1954 these workers proved conclusively that it had the following structure:

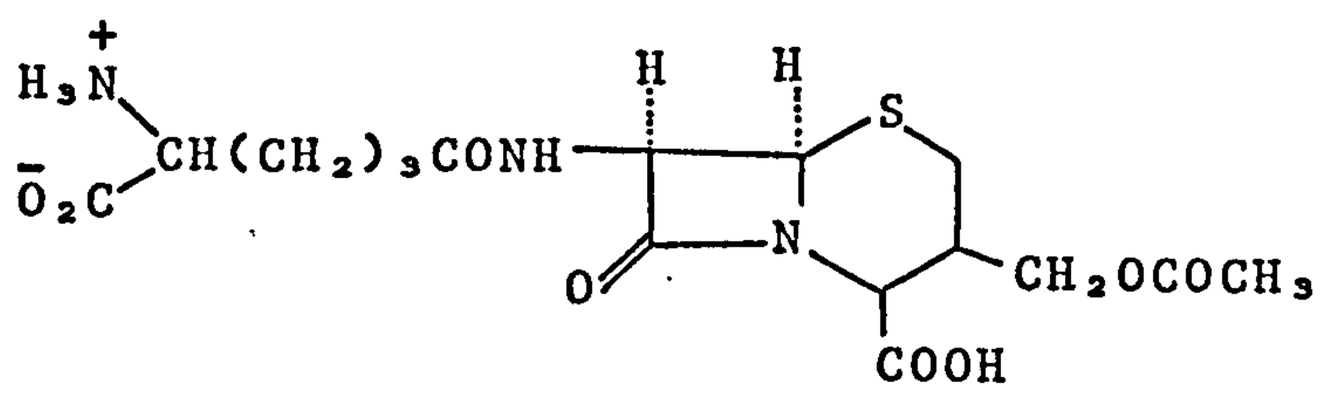


Cephalosporin N was then renamed penicillin N.

In September 1953, Newton and Abraham discovered a second hydrophilic antibiotic amongst the metabolic products of the Sardinian Cephalosporium strain. This substance, cephalosporin C, was first encountered during the chemical studies of penicillin N and was obtained by chroma-

tographic separation from penicillin N on an Amberlite IR4B column. Because priority had been given to chemical studies in penicillin N, no further work was carried out on cephalosporin C until 1954. The new antibiotic was found to inhibit growth of Staplylococcus aureus, Salmonella typhi and Escherichia coli although its potency was only about one tenth of that of penicillin N. However, despite its low activity, the compound immediately aroused interest since, although it resembled pencillin N it differed from the latter in not yielding penicillamine on hydrolysis and being much more stable in dilute acid. Of even more significance was the fact that it was resistant to hydrolysis by penicillinase from B. subtilis. This suggested the possibility that cephalosporin C contained a modification of the penicillin ring system with potentially valuable properties.

Biological and chemical studies were then embarked upon; the former showed that cephalosporin C was effective against a number of penicillin-resistant strains of Staphylococccus aureus, it was innocuous to mice when given intravenously in high doses, and would protect mice from infection with penicillin-resistant staphylococci when given subcutaneously. Chemical studies at Cleverdon and Oxford enabled the following structure to be proposed in April 1959:



This structure was later confirmed by X-ray crystallographic analysis. Attention was then given to the synthesis of the cephalosporin ring system and of cephalosporin C. As it seemed possible that one or more of the antibiotic substances obtained from the Sardinian Cephalosporium species might be of medical interest, and in accordance with MRC policy, applications for patents were made from time to time by workers at Oxford and the Antibiotics Research Station at Cleverdon. Such applications were assigned to the National Research and Development Corporation (NRDC) which had been set up in the UK in 1949 under an Act of Parliament (the Development of Inventions Act, 1948) with the function of protecting, developing and exploiting inventions in the public interest.

Several pharmaceutical companies expressed interest in the cephalosporins at an early stage. The Distillers Company (Biochemicals) Ltd. made

contact with the Oxford workers in 1954 and considered the possibility of providing a supply of penicillin N.

In 1955 Imperial Chemical (Pharmaceuticals) Ltd. initiated connection with Abraham with the object of being made aware of current research on penicillin N and cephalosporin C. An informed suggestion was made to the Oxford group in 1955 by Eli Lilly & Company that a liaison be established for the purpose of producing cephalosporin C. However, when NRDC asked all UK pharmaceutical companies with fermentation facilities to assist in the production of cephalosporin C, only Glaxo showed interest.

Meetings between Glaxo Ltd. staff and the Oxford and Cleverdon groups were initiated in 1956 under the aegis of the NRDC. The limiting factor in research work at that time was the difficulty of obtaining cephalosporin C in substantial quantities from the low yielding Cephalosporium species. However, in 1957, a higher yielding mutant (No. 8650) allowed 100gm. of cephalosporin C to become available to Glaxo; some of this was used in experiments to confirm the chemical structure.

In the following year, the director of the Eli Lilly patent division, A.M. van Arendork, approached NRDC and discussed a proposal for a programme aimed at the fermentation production of substances structurally related to cephalosporin C, including the molecule nucleus, an idea stemming from work in progress on the isolation of the penicillin nucleus, 6-aminopenicillanic acid, by E.H. Flynn et al. NRDC and Eli Lilly signed an agreement in January 1959; the project was not successful, but they entered into a general option agreement early in 1960 under which Eli Lilly received Cephalosporium sp. mutant 8650 and access to technical information; this enabled the company to make significant contributions to cephalosporin technology.

Additional pharmaceutical companies were, by that time, showing interest in the cephalosporins. E.R. Squibb & Co. obtained a general option for a license from NRDC in 1959. In 1960 more USA firms, Merck and Company, Chas. Pfizer and Company and Smith, Kline and French Laboratories entered into option agreements. CIBA in Switzerland and Farmitalia in Italy also entered into option agreements in 1960. In 1961 a similar agreement was made with Fujisawa Pharmaceuticals Company of Japan.

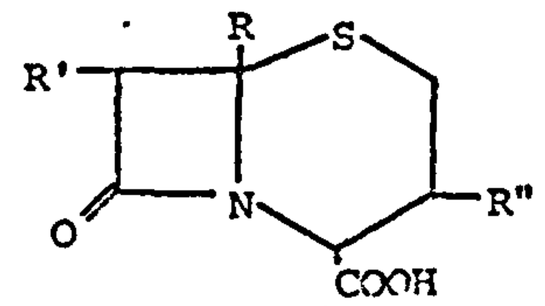
Up until this time it had been hoped that cephalosporin C would itself be a useful therapeutic agent in the treatment of penicillin-resistant staphylococcal infections, even though its low potency would mean administration by intravenous infusion. The preparation of methicillin (2,6-dimethoxyphenylpenicillin) from 6-APA, and the demonstration of its antibacterial properties, made this unlikely. Thus a great deal of effort went into the search for a method of preparing 7-aminocephalosporanic acid on a large scale.

Most of these searches concentrated on an enzymatic method of splitting the D-α-aminoadipyl side chain from cephalosporin C; but in 1960 Lilly Research Laboratories discovered a chemical method of doing this enabling 7-amino cephalosporanic acid to be obtained in higher yields; details of this work were reportred to NRDC. Meanwhile work at Glaxo and Eli Lilly had led to the fermentation production of cephalosporin C in quite large quantities and intensive studies of the properties of derivatives of this compound soon led to the introduction of two semisynthetic cephalosporins, Cephalothin and Cephaloridine, into medicine. Other derivatives soon followed in this increasingly popular group of antibiotics. As with the penicillins, the acylamido residue was modified as well as the new substituent, the acetoxymethyl group.

The bacterial cell wall is the target for the selective action of the β-lactam antibiotics. An inhibition of synthesising as well as hydrolysing enzymes results in a destruction of the peptidoglycan network of the cell wall. The main target seems to be a transpeptidase which catalyses cross-linking of peptide chains.

The table which follows gives details of the main cephalosporin derivatives commercially available in late 1979; most of the proprietary preparations listed were marketed in the United Kingdom.

Only the following preparations were listed in the Monthly Index of Medical Specialities (MIMS) for November, 1979. The launch dates for these products have been supplied through the courtesy of Glaxo Holdings Limited; the gaps in the dates and brand names are attributed to the complicated cross-licensing arangement which exists between Glaxo, Lilly and the NRDC.



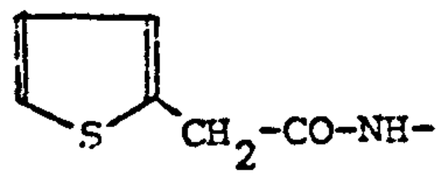
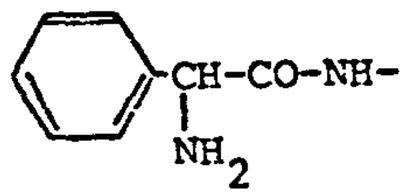
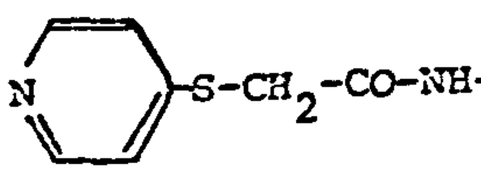
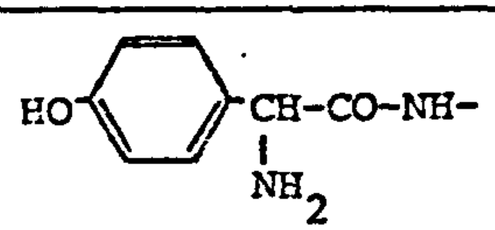
R	R'	R"	APPROVED NAME	DERIVATIVE	PROPRIETARY NAME (MANUFACTURER)
H	HOOC-CH(CH$_2$)$_3$CONH- NH$_2$	-CH$_2$OCOCH$_3$	cephalosporin C	-	-
H	N≡C-CH$_2$-CONH-	-CH$_2$OCOCH$_3$	cephacetrile	Na salt	Celospor (Ciba-Geigy; Grunenthal)
H		-CH$_2$OCOCH$_3$	cephalothin	Na salt	Averon-1 (Alfa-Farmaceutici); Cephation (Meiji); Ceporacin (Glaxo); Cepovenin (Glaxo; Hoechst); CET (Glaxo); Coaxin (Tobishi); Keflin (Lilly); Lospoven (Hoechst); Microtin (Leo); Seffin (Glaxo); Synclotin (Toyo Jozo); Toricelocin (Torii)
H		-CH$_2$OCOCH$_3$	cephaloglycin	Dihydrate	Kafocin (Lilly); Kefglycin (Lilly)
H		-CH$_2$OCOCH$_3$	cephapirin	Na salt Benzathine	Brisfirina (Bristol-Myers); Brisporin (Bristol); Bristocef (Bristol); Cefadyl (Bristol); Cefa-Lak (Bristol); Cefaloject (Bristol); Cefatrex (Bristol-Myers); Cefatrexil (Mead-Johnson); Today (Bristol-Myers) Ceta-Dri (Bristol)
H		-CH$_3$	cefadroxil	-	Duricef (Mead-Johnson); Oracefal (Bristol)

Table 54: Principal Cephalosporin Antibiotics

Based upon Index Nominum, 1980 (Societe Suisse de Pharmacie, Zurich, 1980)

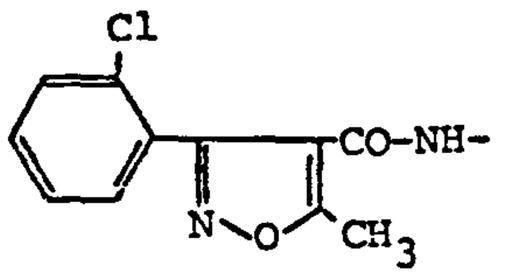
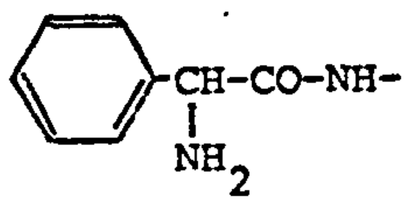
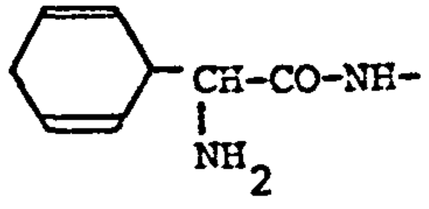
R	R'	R"	APPROVED NAME	DERIVATIVE	PROPRIETARY NAME (MANUFACTURER)
H		$-CH_2OCOCH_3$	cephoxazole	-	Cepoxillin (Glaxo)
H		$-CH_3$	cephalexin	-	Cefadine (Antibioticus); Cefa-Iskia (Iskia); Cefalival (Valles Mestre); Cefaloto (Lifepharma); Cefaxin (Bristol); Cefexin (Novag); Cepexin (Glaxo) Cephalomax (Daisan); Ceporex (Glaxo); Ceporexine (Glaxo); Cepoven (Glaxo); Chemosporal (Erba); Derantel (Nippon Chemiphar); Garasin (Wakamoto); Iwalexin (Iwaki); Keflex (Lilly); Larixin (Toyama); Lexibiotico (Llano); Lorexina (Crosara); Madlexin (Meiji); Mepilacin-DS(O) (Kanto); Neolexina (Asla); Ohlexin (Ohta); Oracef (Lilly); Oroxin (Kyoritsu); Ortisporina (Turro); Palitrex (Bristol); Pyassan (Chinoin); Rinesal (Kissei); Salitex (Banyu); Sartosona (Sastre); Sefaktin (Leiras); Segoramin (Takata); Sencephalin (Takeda); Septilisin (Montpellier); Syncel (Toyo Jozo); Taicelexin (Taiyo); Tokiolexin (Isei); Torlasporin (Torlan); Xahl (SS Pharmaceutical)
				Monohydrate	Domucef (Medici Domus); Keforal (Lilly); Latoral (Dukron); Losporal (Hoechst)
				Na salt	Alfaspoven (Alfa-Farmaceutici)
H		$-CH_3$	cephradine	-	Anspor (SK&F); Cefro (Sankyo); Cefrum (San Carlo); Citicef (C.T.); Dicefalin (Squibb); Eskacef (SK&F); Medicef (Medici Domus); Megacef (Beytout); Sefril (Squibb; Heyden); Velosef (Squibb)

Table 54: Principal Cephalosporin Antibiotics (continued)

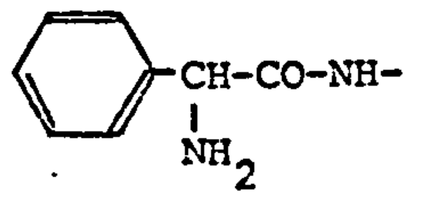
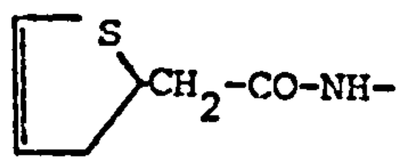
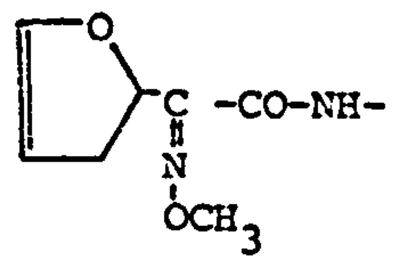
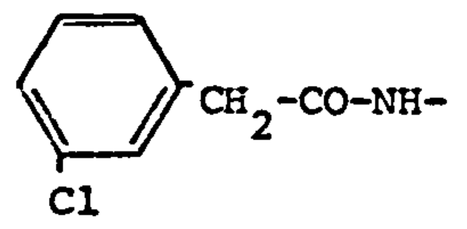
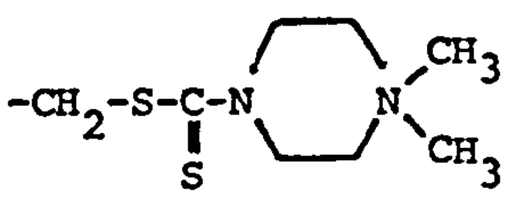
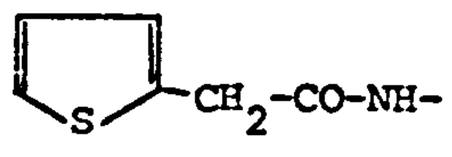
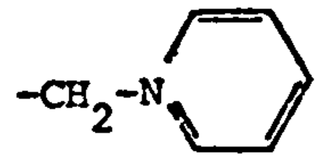
R	R'	R"	APPROVED NAME	DERIVATIVE	PROPRIETARY NAME (MANUFACTURER)
H		-Cl	cefaclor	-	Ceclor (Lilly); Distaclor (Dista)
OCH_3		$-CH_2OCONH_2$	cefoxitin	Na salt	Mefoxitin (MSD); Mefoxin (MSD)
H		$-CH_2OCONH_2$	cefuroxime	hydrochloride Na salt	Zinacef (Glaxo) Curoxim (Glaxo); Ultroxim (Duncan)
H			cephachlomezine	-	Cephachlomezine (Shionogi)
H			cephaloridine	-	Aliporina (Asla); Ampligram (Hermes); Cefalescord (Callol); Ceflorin (Glaxo); Cepaloridin (Glaxo); Cepalorin (Glaxo); Ceporan (Glaxo); Ceporin (Glaxo) Cer (Glaxo); Cilifor (CEPA); Coridine (Elanco); Dinasint (Proter); Glaxoridin (Glaxo); Intrasporin (Torlan); Keflodin (Lilly); Kefspor (Lilly); Kelspor (Lilly); Latorex (Ducron); Lauridin (Crosara); Lloncefal (Castillon); Loridin (Lilly); Sintoridyn (ISF); Totalmicina (Emyfar)

Table 54: Principal Cephalosporin Antibiotics (continued)

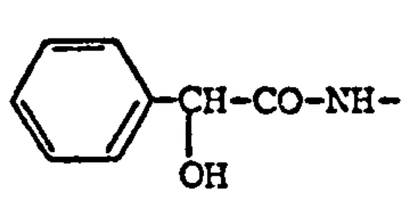
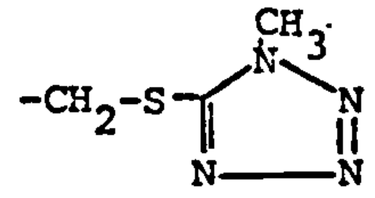
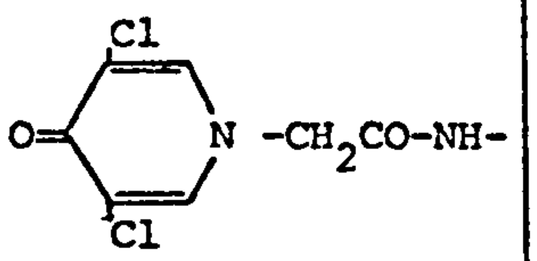
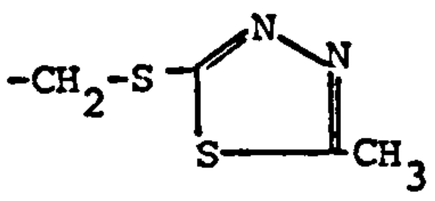
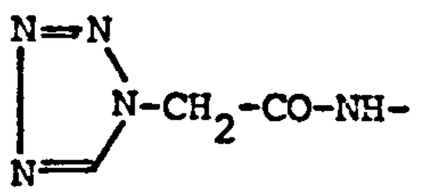
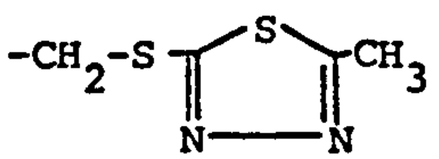
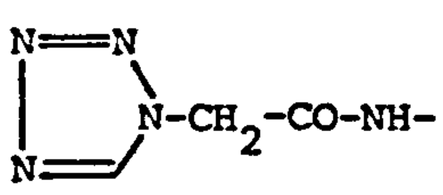
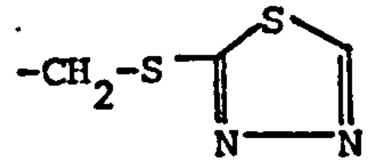
R	R'	R"	APPROVED NAME	DERIVATIVE	PROPRIETARY NAME (MANUFACTURER)
H			cefamandole	naphthate	Kefadol (Lilly); Mandokef (Lilly); Mandol (Lilly)
H			cefazedone	Na salt	Refosporin (E. Merck)
H			cefazolin	Na salt	Ancef (SK&F); Cefacidal (Allard); Cefalomicina (Bago); Cefamedin (Fujisawa); Cefamezin (Erba); Celmetin (Astra); Elzogram (Lilly); Gramaxin (Boehringer Mannheim); Kefzol (Lilly); Novaporin (Dista); Totacef (Bristol); Zolicef (Bristol-Myers)
H			ceftezole	Na salt	Celosrin (Fujisawa); Falomesin (Chugai)

Table 54: Principal Cephalosporin Antibiotics (concluded)

		Date of Introduction into	
		UK	USA
Keflin (Cephalothin)	Lilly	-	May 1975
Ceporin (cephaloridine)	Glaxo	November 1964	March 1968*
Kefzol (cefazolin)	Lilly	June 1974	November 1973
Ceporex (cefalexin)	Glaxo	December 1969	-
Keflex (cefalexin)	Lilly	November 1969	December 1970
Velosef (cephadrine)	Squibb	October 1972	August 1974
Mefoxin (cephoxitin)	Merck	October 1978	November 1978
Distaclor (cefaclor)	Dista	February 1979	August 1979**
Kefadol (cefamandole)	Lilly	April 1978	October 1978***
Zinacef (cefuroxime)	Glaxo	April 1978	-

* as Loridine ** as Celcor *** as Mandol

Table 55: Cephalosporins Listed in MIMS, November 1979

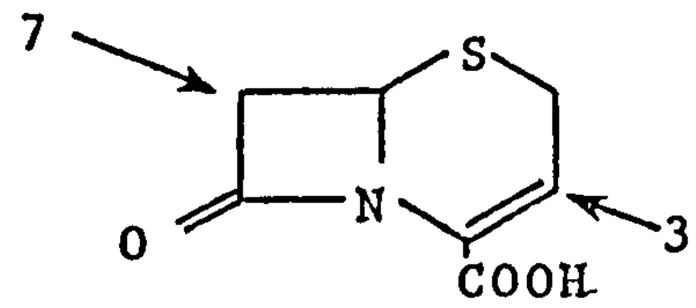
Developments in Cephalosporin Technology

In collaboration with Michael Gray, Patents Liaison Officer of Glaxo Holdings Limited, whose assistance is gratefully acknowledged, patents published from December 1977 to February 1981 have been examined in greater detail using CPI abstracts in order to identify recent developments in the field and the direction of research. The subject matter of the 703 basic patents relating to cephalosporins published during the period has been classified. In particular, a distinction has been drawn between patents relating to novel final products and those describing chemical processes for the preparation of known compounds. There is no separate classification for purification/isolation. During this period there were, as would be expected, very few patents describing the isolation of compounds from biological sources and these have been grouped with the 'Biological Synthesis' patents. Patents describing procedures for the purification of known compounds are included in the Chemical Process classification. There are separate classifications for intermediates and compositions.

As would be expected, the majority of applications have been for novel final products, and the classification encompasses compounds with a vast array of structural variations. However, a number of trends can be identified and the patents have been further classified according to the structures of the compounds covered.

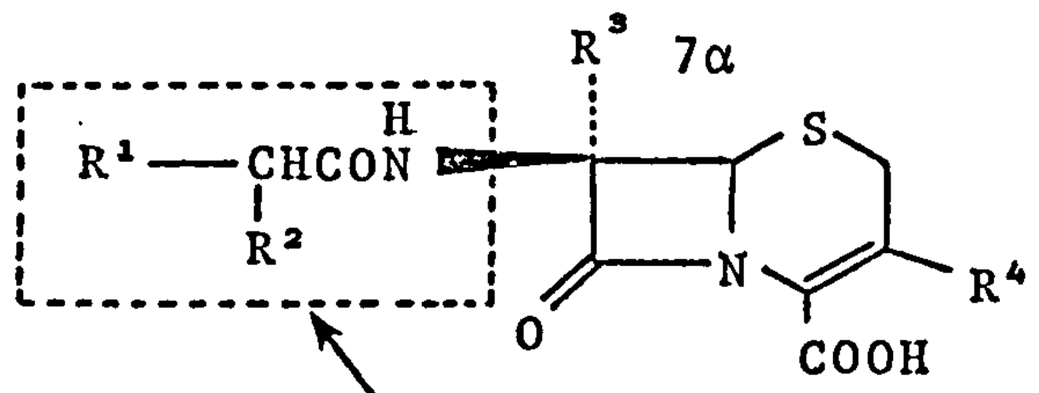
Before describing the structural classifications in detail, it is first necessary to explain something of the chemical structure of cephalosporins and the biological objectives of much of the research represented by the patents published during this period.

There are two principal positions on the cephalosporin nucleus, the 3- and 7-positions, at which different groups can be introduced in an attempt to improve the biological properties. Much of the research effort has been directed to



cephalosporin nucleus

modifications at the 7-position since this generally has the more profound effect upon activity. The 7β-substituents in just about all the active cephalosporins are substituted acetamido groups:



substituted acetamido group at 7β-position

In the early cephalosporins R^1 was often a phenyl ring which itself could carry substitutes, or a heterocyclic ring such as furyl or thienyl.

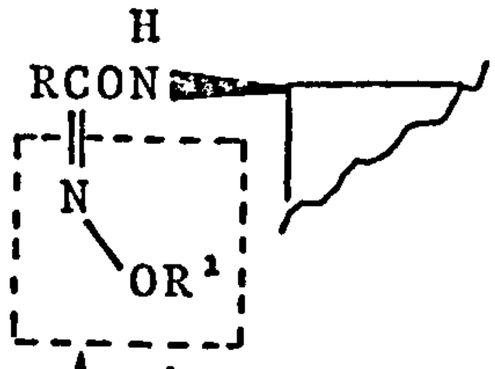
The group R^2, known as the α-substituent, could be a hydrogen atom, or a substituent such as an amino group ($-NH_2$). The first cephalosporins to be marketed, cephalothin and cephaloridine, both have the same 7β -substituent in which R^1 is a thienyl ring and R^2 is a hydrogen atom.

In cephalexin R^1 is a phenyl ring and R^2 an amino group. The structures of all named compounds referred to in this section are given in Table 56.

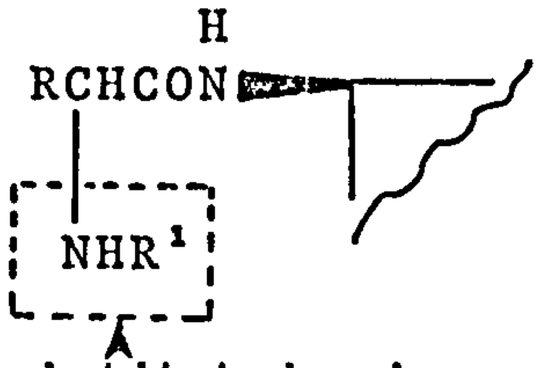
The principal objectives of cephalosporin research from the start have been twofold, namely to increase the level of antibacterial activity and to broaden the spectrum of activity, i.e. increase the number of bacterial species against which the compounds are active. The period under consideration here has seen the arrival of the so-called 'third generation' cephalosporins, which generally have very high levels of

activity and an extremely broad spectrum, the activity extending to bacteria, such as the Pseudomonas species, not previously susceptible to cephalosporins.

In order to achieve this broad spectrum of activity, it is necessary for the compounds to have at least some measure of stability to β-lactamase enzymes produced by bacteria that can inactivate cephalosporins (and penicilins and other β-lactam antibiotics). Increased stability to β-lactamases can generally be achieved either by introducing certain groups at theα-position of the 7β-substituent or by introducing a substituent as the 7 α-position of the cephalosporin nucleus (see diagram above). The group at the α-position of the 7β-substituent can be an oxime group, as found in the 'second generation' compound cefuroxime, or a substituted amino group:

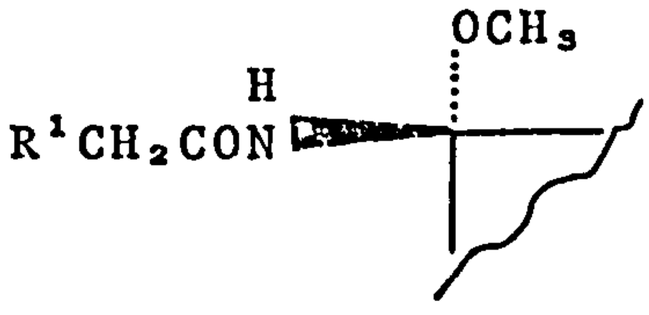


oxime group



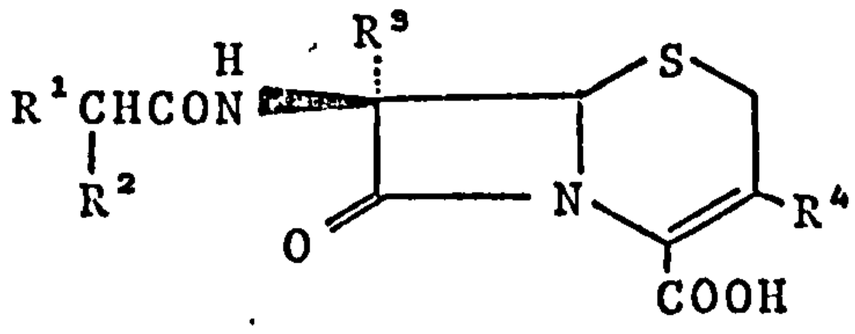
substituted amino group

The 7α-substituted compounds generally have a methoxy group at that position



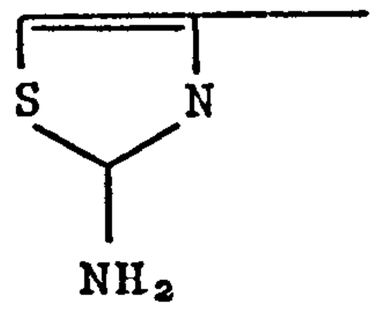
The 7α-methoxy substituted cephalosporins are also known as cephmycins.

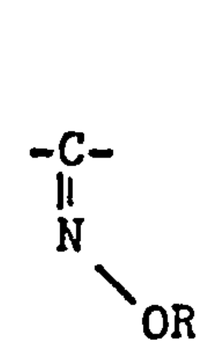
Many of the new cephalosporins patented during the period under consideration can, therefore, be represented by the following structure:



and this is used as the basis for the classification according to structure used in this section.

The major class of compounds are those in which R^1 is an aminothiazolyl group:



In this class the grouping  usually represents an oxime group and R^3 is generally a hydrogen atom.

Other significant classes are those in which the α-substituent R^2 is an acylamino group -NHCOR or a ureido group -NHCONRR^1 and these have been termed 'α-Acylamino' and 'α-Ureido' respectively. The 7α-methoxy cephalosporins, i.e. R^3 is $-OCH_3$, are classified separately.

The group at the 3-position, R^4, is usually a substituted methyl group $-CH_2R$. However, a number of compounds have been prepared in which a halogen atom, hydroxyl group, alkoxy group, alkylthio group or similar such substituent is bonded directly to the cephalosporin nucleus. These are classified as '3-Halogen etc'.

In an attempt to improve activity, researchers have prepared, usually by total synthesis, a variety of ring systems analogous to the cephalosporin nucleus. The most frequent modification is to replace the sulphur atom in the six-membered dihydrothiazine ring by an oxygen atom and these compounds are classified separately as 'Oxycephalosporins'. Other compounds with a modified ring structure are classified under 'Total Synthesis'

Compounds not falling within any of the above classifications and in which R^1 is a heterocyclic ring other than aminothiazolyl have been classified under 'Non-Aminothiazolyl Heterocycles'. There is a large diverse group of compounds which cannot be accommodated in any of the above classifications and these are classified as 'Other Novel Compounds'.

In quite a number of instances patents fell within more than one classification and when this situation arose the patent was classified according to what was considered to be the main point of novelty in the compounds.

The distribution of the patents into these various classifications is shown in Figure 64. In order to identify whether the classifications are expanding or contracting the period has been examined in two halves, each of 83 weeks. The results for the two halves and the total period are given in Table 57 and this facet will be discussed in more detail later.

Aminothiazolyl

This has clearly been the single most active area of research and in order to fully understand the reasons for this it is necessary to go back beyond the period under consideration.

Takeda's Belgian Patent No. 823861 was published in 1975 and was the first disclosure of cephalopsporins having an aminothiazolyl group in the 7β-substituent. One of these compounds has been marketed by Takeda as cefotiam, which has a high level of antibacterial activity. However, it has no substituent at the α-position of the 7β-group and is somewhat susceptible to β-lactamase degradation.

Since then cefotaxime (Roussel-Uclaf; British Patent No. 1580621) and cefmenoxime (Takeda; British Patent No. 1536281) have been the subject of patent applications. Both have oxime substituents at the α-position of the 7β-group and have similar high levels and broad spectra of activity. Cefotaxime has been marketed by Hoechst/Roussel and cefmenoxime is believed to be undergoing clinical trial.

Four compounds, which have been the subject of patents published during the period under examination, are believed currently to be undergoing clinical trial and these are ceftizoxime (Fujisawa; German Patent Application 2810922), ceftazidime (Glaxo;UK Patent Application 2025398) cefatriaxon (Hoffmann-La Roche; UK Patent Application 2022090) and cefodizime (Hoechst; German Patent Application 2714880). Cefotaxime, cefmenoxine, ceftizoxime, cefatriaxon and cefodizime all have the same 7β- substituent and differ only in their 3-substituent. Ceftizoxime is notable in that it simply has a hydrogen atom at the 3-position.

All the compounds have very high activity, but ceftazidime is reported to have the broadest spectrum of activity, including activity against

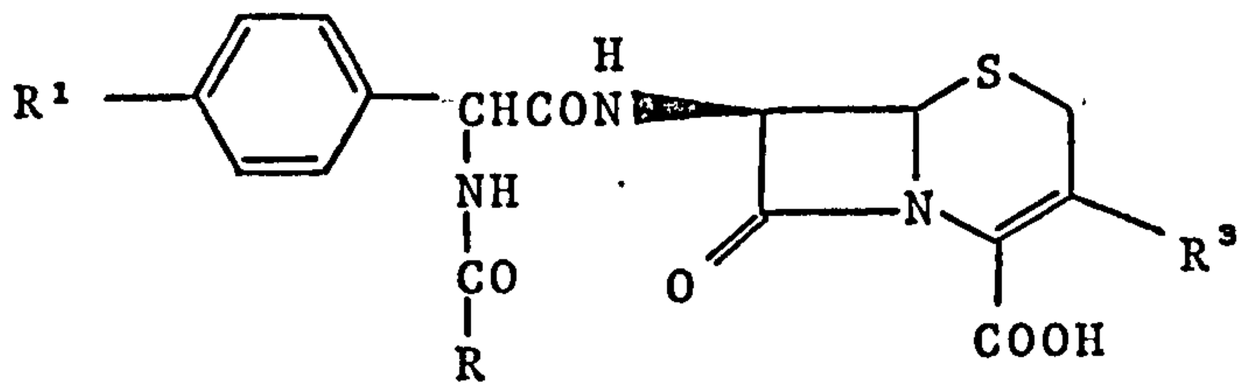
Pseudomonas organisms, and the greatest stability to β-lactamases of the new cephalosporins.

In all during the period there were 93 basic patents, that is 13.2% of the total cephalosporin patents, published relating to aminothiazolyl cephalosporins.

The majority of these described modifications of either the oxime substituent or the 3-substituent.

α-Acylamino

7.4% of the total cephalosporin patents published during the period related to cephalosporins having an α-acylamino group in the 7β-substituent. Many of the compounds described can be represented by the structure:



in which R^1 is a hydrogen atom or a substituent such as hydroxyl, R^2 is usually a nitrogen-containing heterocyclic ring which may itself carry substituents and the 3-substituent R^3 can be any conventional 3-substituent. It will be noted that the 7-substituent is derived from that found in cephalexin.

An α-acylamino compound having the code number SM1652 (Japanese Patent Application 54030197) is being jointly developed by Yamanouchi and Sumitomo and is currently undergoing clinical trial. Three other similar compounds CN 92,982 (Warner Lambert; European Patent Application 15771), CN 106,947 (Warner Lambert) and AC 13709 (Ajinomoto; Japanese Patent Application 55076887) are currently believed to be undergoing pre-clinical development. The structures of AM 1652, CN98,982 and AC 1370 are given in Table 56.

The structure for CN 106,947 is not known at this time, but it is believed to be an α-acylamino compound.

α-Ureido

These compounds are a particular form of α-acylamino compounds, but in view of their numbers (7.4% of the total cephalosporin patents) have been classified separately. In order to appreciate developments in this area it is also necessary to go back before the period under consideration. This work appears to have been inspired by developments in the penicillin field, a number of penicillns, such as azlocillin, mezlocilin and piperacillin, having analogous structures.

Toyama describe cefoperazone, which is analogous to the semi-synthetic penicilin piperacillin, in British Patent No. 1508071. Cefoperazone, which is licensed to Pfizer, was launched in Germany during early 1981, and has a very broad spectrum of antibacterial activity, including activity against Pseudomonas species. However, it does have some susceptibility to β-lactamase degradation, as this is reflected by some of the more recent patent applications.

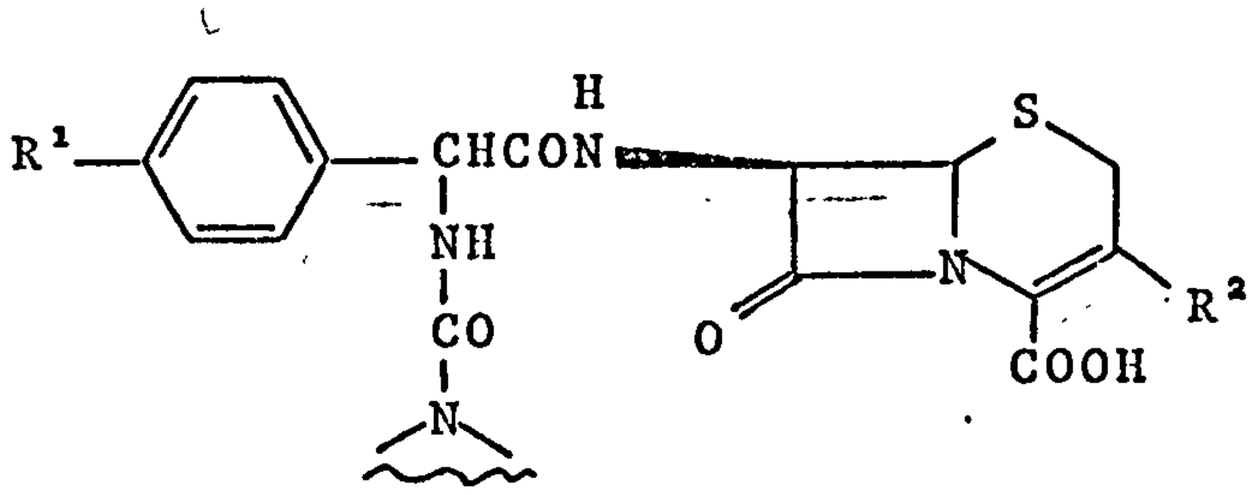
Thus, Pfizer (French Patent 2442053) describe compositions of cefoperazone with their β-lactamase inhibitor, penicillanic acid 1,1-dioxide (sulbactam). Toyama (UK Patent Application 2017493) also describe compositions of cefoperazone with a β-lactamase inhibitor such as clavulanic acid. These two patents are included in the 'compositions' classification.

Toyama in Japanese Patent Applications 54022388, 54022389, 54022391 and 54103888 and UK Patent Aplication 2009161 describe 7α-methoxy derivatives of cefoperazone and it analogues. The 7α-methoxy substituent improves the β-lactamase stablity of the compounds.

Toyama (UK Patent Application 2005676) describe the dimethylacetamide adduct of cefoperazone, which is used to purify the compound.

Boehringer Ingelheim's subsidiary Dr. Karl Thomae have described an α-ureido cephalosporin derivative (Code No. VX-VD-2; European Patent Application 21176 or 22494) whose exact structure is not yet known. The compound is reported to be considerably more active than cefoperazone.

Many of the compounds described in the patents published can be represented by the structure:



in which R^1 is a hydrogen atom or substituent such as hydroxyl and the group $-N\langle\!\{$ represents a 5 or 6-membered ring which carries additional substituents and may contain additional hcteroatoms. R^2 may be a variety of conventional 3-substituents.

7α-Methoxy

Cefoxitin (Merck; British Patent 1348984) and cefmetazole (Sankyo; British Patent 144920) are 7α-methoxy cephalosporins (cephamycins) published during the mid 1970's. As indicated above, the 7α-methoxy group confers β-lactamase stability to the compounds.

Sankyo have described analogues of cefmetazole (Japanese Patent Applications 52144690 and 52136194) and processes for its preparation (Japanese Patent Applications 54092985, 5410887 and 54135791).

Two new cephamycins, MT-141 (Meiji Seika; UK Patent Application 2040926) and cefotetan (Yamanouchi; Japanese Patent Application 54157591), are believed currently to be undergoing clinical trial. MT-141 is said to be between 3 and 300 times more potent than cefmetaxole and cefoxitin in treating gram negative and anaerobic infections in experimental animals. Cefotetan is very stable to β-lactamases and has a broad spectrum of activity. However, it does not have significant activity against Pseudomonas organisms.

Oxacephalosporins

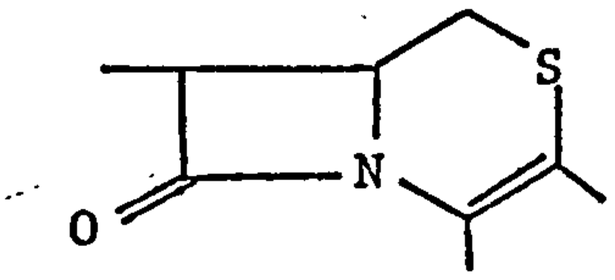
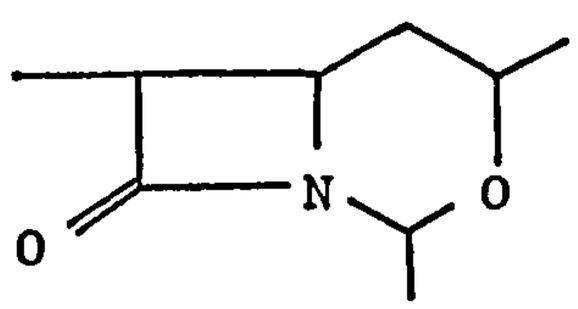
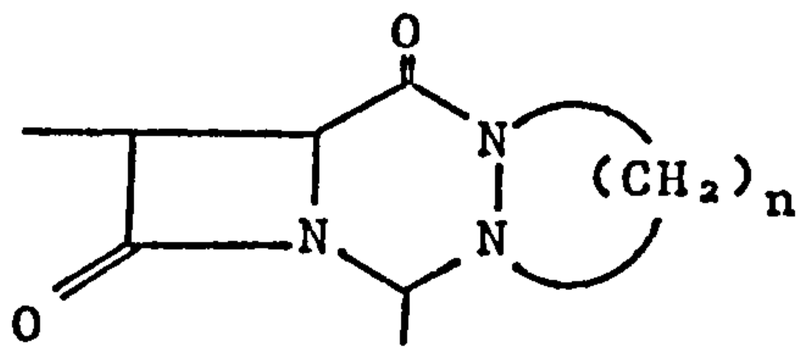
Moxalactam (Shionogi; British Patent 1547351) was published just before the period under examination. It has activity similar to other 'third generation' cephalosporins and is licensed to Eli Lilly, who have recently launched it in West Germany. During the period Eli Lilly have described a sodium salt (Belgian Patent 882489) and the diammonium salt (US Patent 4252953) of moxalactam.

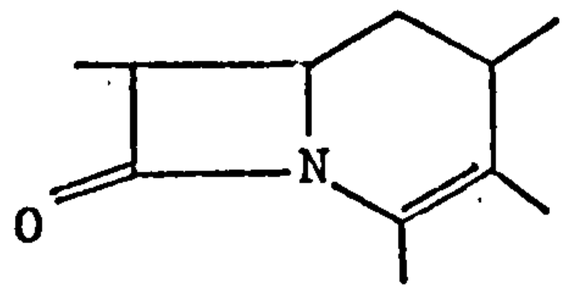
Shionogi have patented various analogues of moxalactam, including the 3-thiadiazolylthiomethyl analogue (German Patent Application 2837264), analogues having a halogen substituent on the phenyl ring in the 7 β-group (German Patent Application 2818985), α-ureido analogues (German Patent Application 2739448) and analogues having a hydrogen or halogen atom or an alkoxy group at the 3-position (German Patent Application 2735854).

Fujisawa have patented the oxacephalosporin analogue of ceftizoxime (UK Patent Application 2014562) and Meiji Seika the corresponding analogue of MT-141 (Belgian Patent No. 885999).

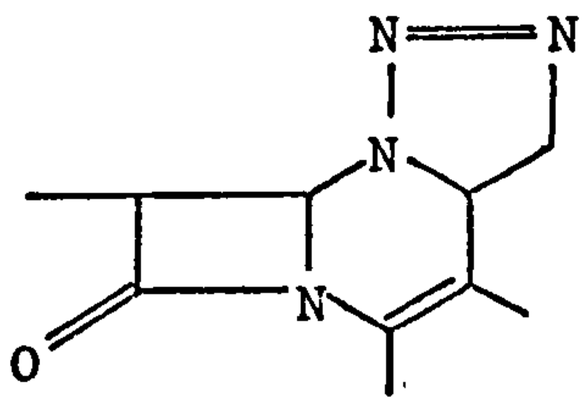
Total Synthesis

A number of different ring systems have been synthesised as alternatives to the cephalosporin nucleus, and the principal ones are summarised below:

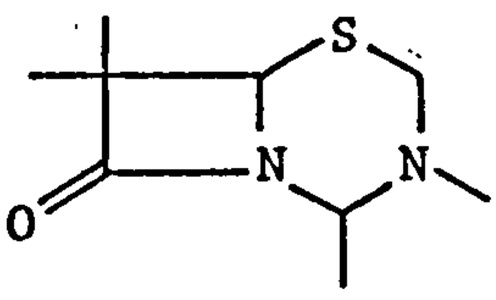
Ring System	Patentee	Patent No.
	Smith Kline	US 4072674 US 4103086
	Smith Kline	Belgian 858356 US 4122262 US 4187375
	Smith Kline	US 409387



Kyowa Hakko	Belgian 875053
Kogyo	Belgian 875054
	German 2952413
	European 14475
	European 14476



Beecham	European 4134



Fujisawa	European 17138

None of these ring systems would appear to have better properties than the natural cephalosporin nucleus.

3-Halogen etc

A variety of different groups have been attached directly to the cephalosporin nucleus. Thus, Ciba-Geigy describe (US Patent 4147864) a number of 3-hydroxy and alkoxy compounds which are analogous to the 3-methoxy cephalosporin cephrozadine.

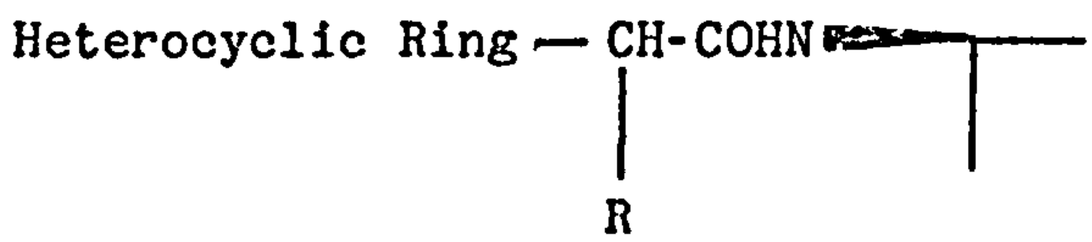
3-Alkylthio compounds, i.e. compounds in which a sulphur atom is bonded directly to the cephalopsorin nucleus, are described by Merck (US Patent 4150156 and South African Patent 76/6941) and 3-halogen derivatives are described by Eli Lilly (US Patents 41088515 and 4252950), which are analogous to their marketed compound cefachlor.

The interest in this group of compounds lies in the fact that many of them, including ceproxadine and cefachlor, are active when administered orally, whereas the majority of cephalosporins are inactive orally and only active when given by injection.

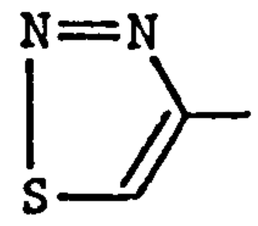
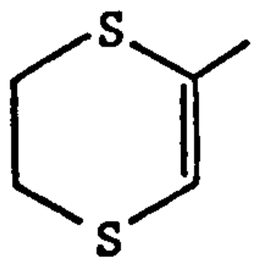
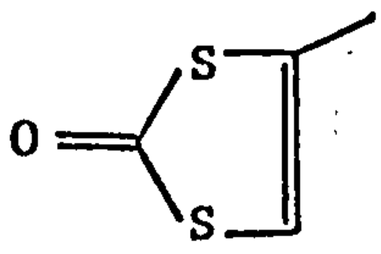
Non-Aminothiazolyl Heterocycles

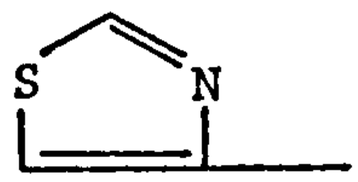
Before the discovery of the aminothiazolyl cephalosporins, heteorcyclic rings (when present) in the 7β-substituent were typically thienyl (as in cephaloridine) and furyl (as in cefuroxime). Bristol Myers (Belgian Patents 856785 and 858112 and US Patent 4180685) and Smith Kline (Belgian Patents 856636 and 856637) describe analogues of cefuroxime having different substituents at the 3-position.

In the hope of emulating the activity found in aminothiazolyl cephalosporins, a number of heterocyclic rings have been introduced into the 7 β-substituent, i.e.

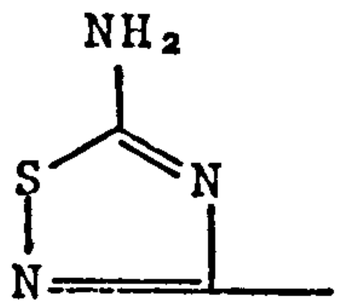


Some of these are listed below:

Ring System	Patentee	Patent No.
	Fujisawa	German 2814641 Belgian 859384
	Fujisawa	German 2758159 Japanese 54128594 Japanese 54155310
	Fujisawa	



Hoechst German 2822860
European 17238



Ciba Geigy European 22245

There is no evidence to suggest that introduction of any of these rings has led to improved activity.

Other Novel Compounds

This is an extremely heterogenous group and there are no obvious trends within it.

Chemical Processes

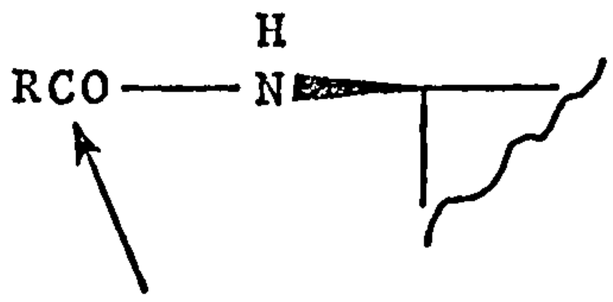
The patents in this classification are predominantly concerned with processes for the preparation of established compounds. A few examples can be quoted to illustrate this.

Toyama describe a number of processes for preparing cefoperazone (Japanese Patent Applications 52151187, 53025589, 53031688, 53044584 and 54022391). Eli Lilly describe a process for the preparation of cefotaxime (US Patent 425295) and Bristol Myers describe a process for the preparation of ceforanide (US Patent 4118563).

Biological Synthesis

The patents in this area of biotechnology fall into a number of groups such as the products of cephalosporin C or cephamycin C by fermentation or their isolation from fermentation broths - see, for example, Japanese Patent Application 50155696 (Meiji), German Patent Application 2908848 (Shionogi), European Patent Application 9363 (Takeda) and Japanese Patent Application 55003750.

Other developments include the removal of acyl groups from the 7-substituent using an enzyme to yield a 7β-amino compound, i.e.





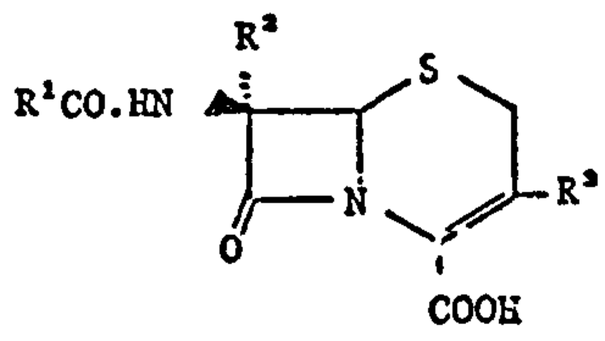
- see for example Japanese Patent Application 53139791 and 53059045 (Asahi) - and the reverse process, i.e. the introduction of an acyl group in to a 7β-amino compound, using an enzyme - see for example Japanese Patent Application 54110395 (Banyu).

No developments of particular note were found in the 'Compositions' and 'Intermediates' classification.

Research Trends

The most marked trend shown by comparing patent publications in the first half of the period (December 1977 - July 1979) with those in the second half (August 1979 - February 1981) is the significant increase (7.9% to 19.9%) in the patenting of aminothiazolyl cephalosporins. The interest in this highly active group of compounds is reflected by the fact that one such compound is now marketed (Cefotaxime) and five others are in various stages of clinical trial.

Other areas have generally been stable or have shown small decreases in patenting, as in the α-acylamino and α-ureido areas. There were, however, marked decreases in the 'Other Novel Compounds' (23.0% to 14.4%) and 'Chemical Processes' (25.8% to 17.0%) classifications and a significant increase in the 'Compositions' (4.3% to 9.0%) classification, and no explanation can be given for these changes.



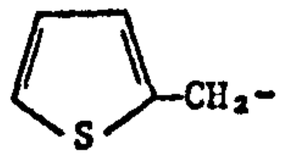
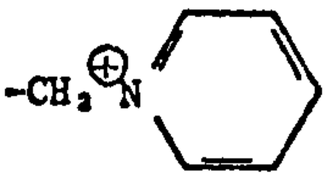
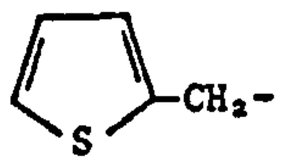
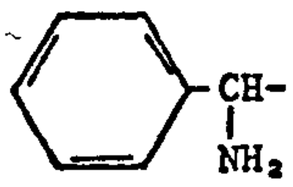
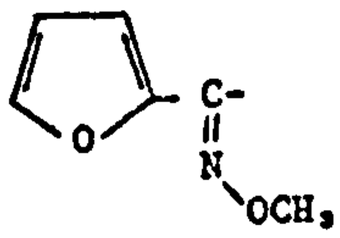
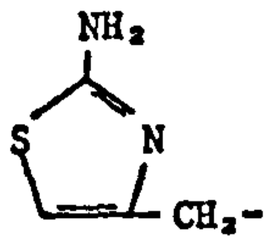
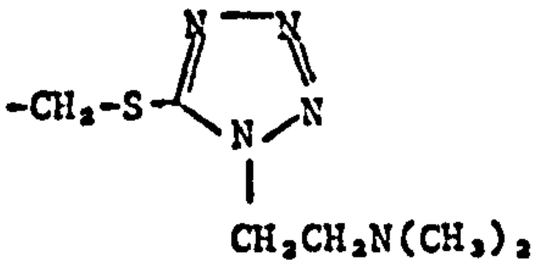
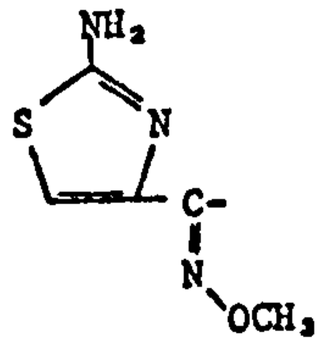
Compounds	R^1	R^2	R^3
Cephaloridine		H	
Cephalothin		H	$-CH_2COCH_3$
Cephalexin		H	$-CH_3$
Cefuroxime		H	$-CH_2OCONH_2$
Cefotiam		H	
Cefotaxime		H	$-CH_2OCOCH_3$

Table 56: Structures of Named Cephalosporins

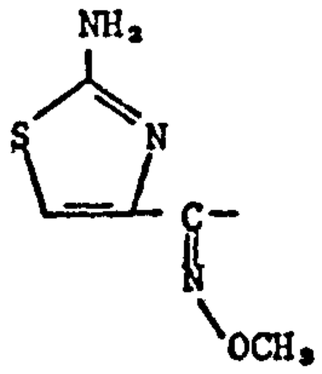
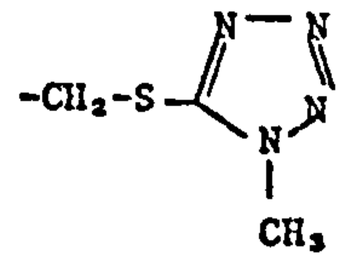
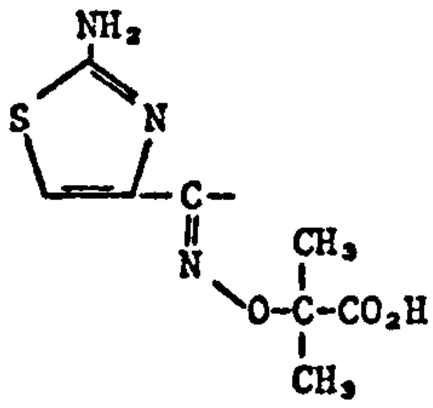
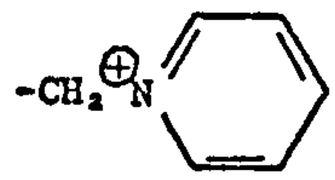
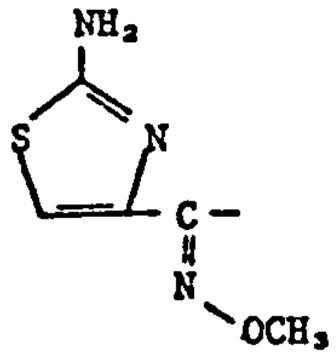
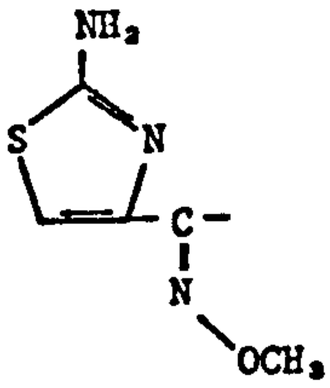
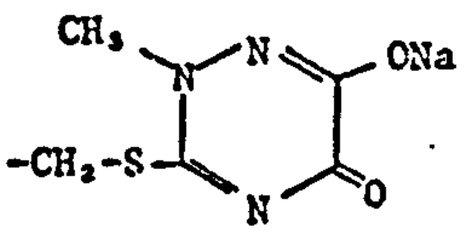
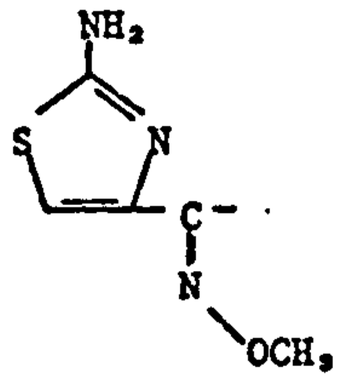
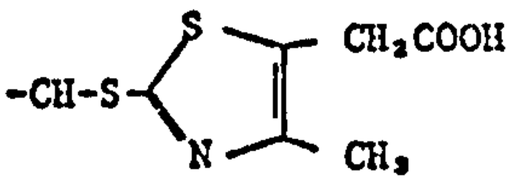
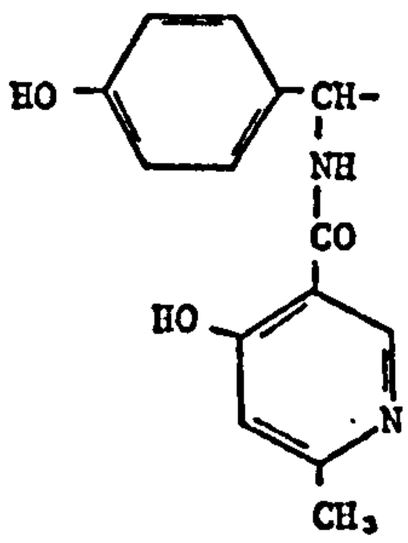
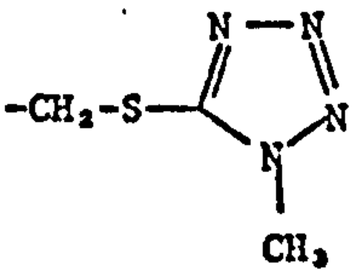
Compound	R^1	R^2	R^3
Cefmenoxime		H	
Ceftazidime		H	
Ceftizoxime		H	H
Cefatriaxon		H	
Cefodizime		H	
SM 1652		H	

Table 56: Structures of Named Cephalosporins (Continued)

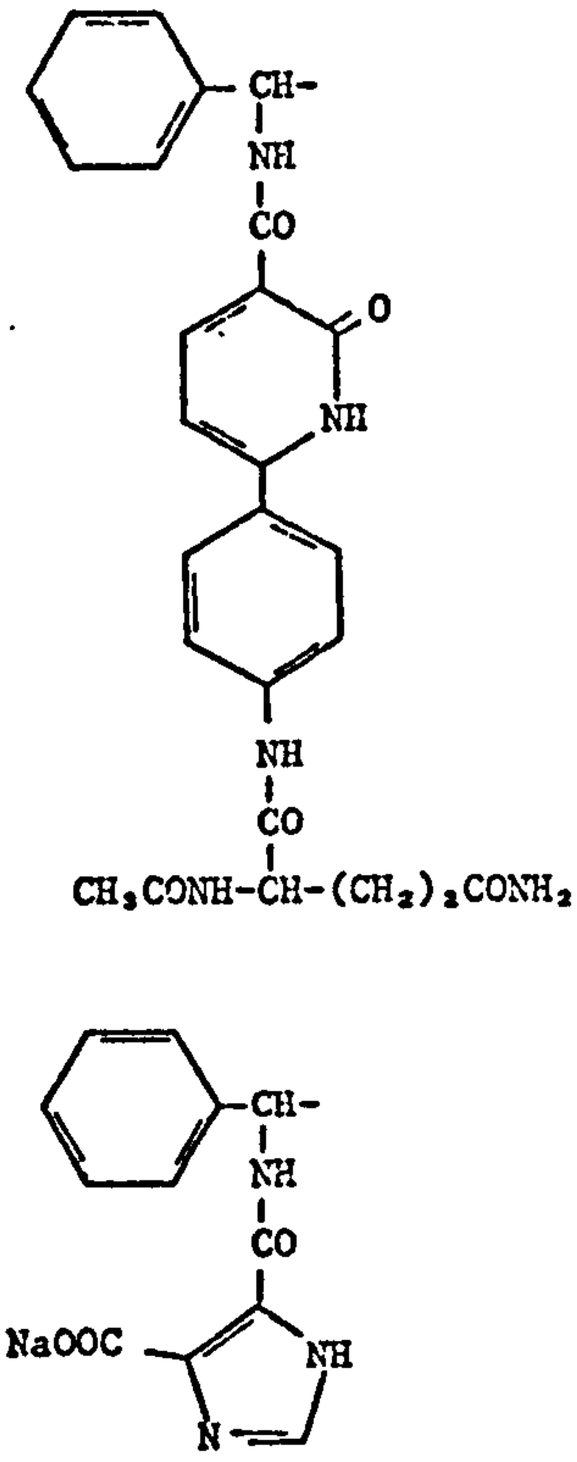
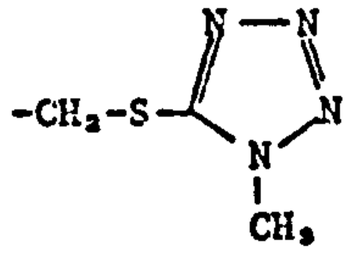
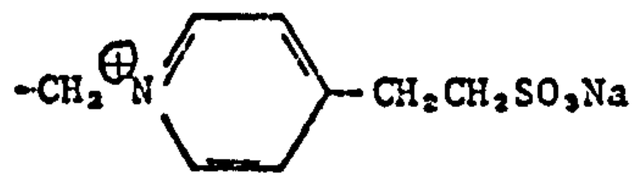
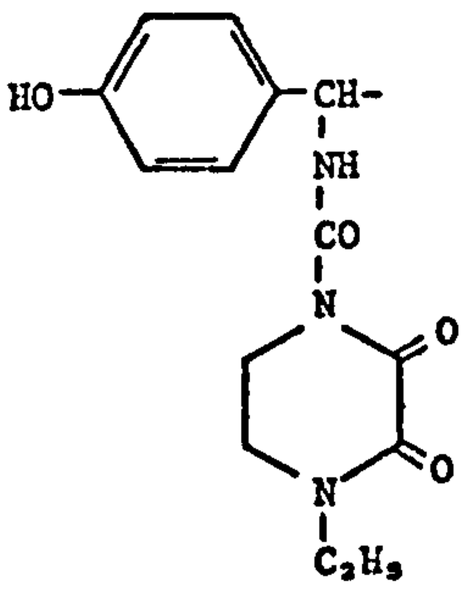
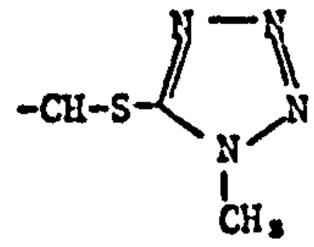
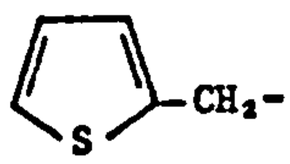
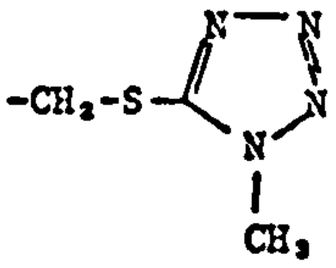
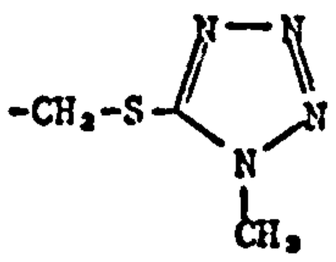
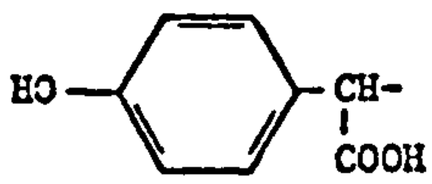
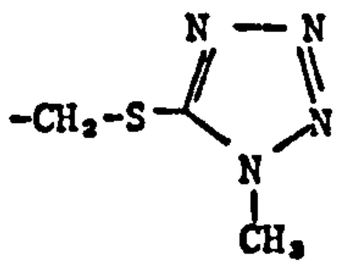
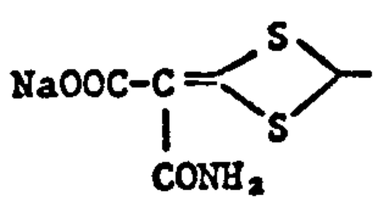
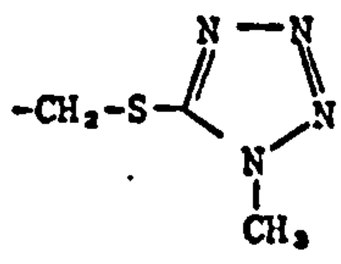
Compound	R^1	R^2	R^3
CN 92982		H	
AC 1370		H	
Cefoperazone		H	

Table 56: Structures of Named Cephalosporins (Continued)

Compound	R^1	R^2	R^3
VX-VD-2	A – CH(NH–CO–NH)–C(OH)=N–C(X)=N	H	$-CH_2Y$
	The groups represented by A, X and Y are unknown		
Cefoxitin		$-OCH_3$	$-CH_2OCONH_2$
Cefmetazole	$NCCH_2SCH_2-$	$-OCH_3$	
MT-141	$HOOC-CH(NH_2)-CH_2S-CH_2-$	$-OCH_3$	
Moxalactam*		$-OCH_3$	
Cefotetan		$-OCH_3$	

* The sulphur atom in the 6-membered ring of the cephalosporin nucleus is replaced by an oxygen atom.

Table 56: Structures of Named Cephalosporins (Continued)

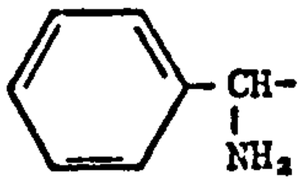
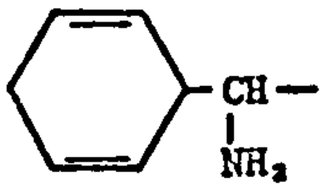
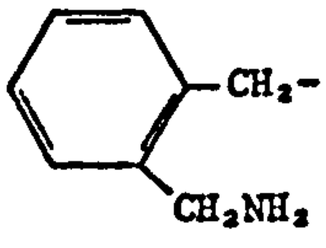
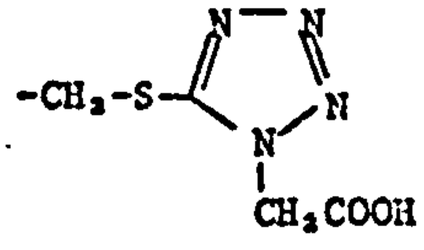
Compound	R^1	R^2	R^3
Cefachlor		H	-Cl
Cefroxadine		H	$-OCH_3$
Ceforanide		H	

Table 56: Structures of Named Cephalosporins (Concluded)

CLASSIFICATION	Dec 77 - July 79	Aug 79 - Feb 81	TOTAL	%
Aminothiazolyl	31	62	93	13.2
α-Acylamino	32	20	52	7.4
α-Ureido	33	19	52	7.4
Oxacephs	11	7	18	2.6
Non-Amino thiazolyl heterocycles	23	12	35	5.0
3-Halogen, etc.	7	10	17	2.4
7-Methoxy	12	12	24	3.4
Total Synthesis	8	12	20	2.8
Other Novel Compounds	90	45	135	19.2
Intermediates	13	15	128	4.0
Chem Processes	101	53	154	21.9
Biological Synthesis/ Isolation	13	17	30	4.3
Compositions	17	28	45	6.4
	391	312	703	100

Table 57: Classification of Recent Cephalosporin Patents

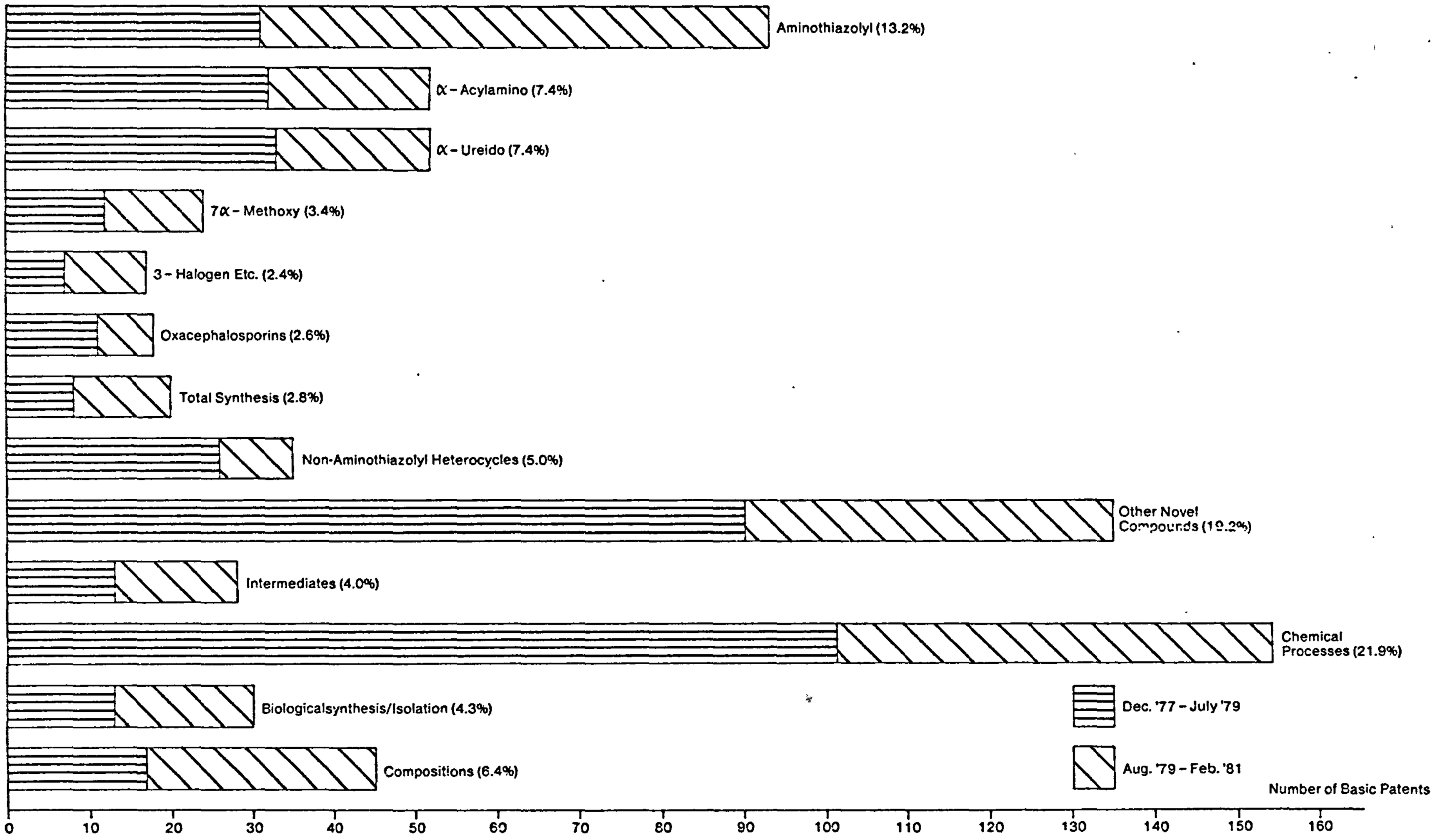


Figure 64: Subject Matter Distribution of Cephalosporin Patents

Retrieval of Cephalosporin Patents

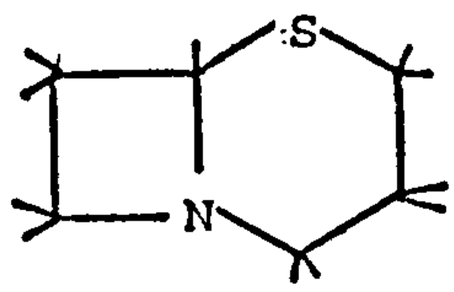
The Derwent WPI Files, of which the CPI file is a subset, are loaded for remote online interactive access on System Development Corporation (SDC) computers located in Santa Monica, California, USA, and in Tokyo, Japan.

The Farmdoc (CPI Section B) punch card code in use prior to 1981 was comprised of five subcodes defined within the online database by subheadings as follows:

Subheading	Code	Starting Date
B1	Natural Products	1970
B2	General Chemical	1970
B5	Steroid	1963
B	Galenical	1976
B	Non-steroid	1963-1969

Searches were, therfore, carried out in subcodes B, B1 and B2.

Position 3 in column 1 (searched as 013) of the Natural Products code (B1) is specifically for cephalosporins, whilst position 0 in column 27 (searched as 270) in the General Chemical (B2) and 1963-1969 Non-steroid (B) subcodes is specific for the fused ring heterocyclic nucleus of the cephalosporin structures (I) whether or not it is present unsaturated.



(I)

When searching for positions 013 and/or 270 these needed to be qualified within the search statements with the relevant subheadings to avoid retrieval of irrelevant data, including not only data in other Farmdoc codes but also data coded, for example, in the Plasdoc (polymer) code where the same punch positions have entirely different meanings.

Additionally, as can be seen from the list above, subheading B was used for the Galenical code from 1976. Items coded in the Galenical code were eliminated by negation of the control punch for this code (position 11, represented by a hyphen, in column 66).

The searches were carried out in two stages using the following search logic:

SEARCH STATEMENT 1: 013/B1,B2 OR 270/B1,B2

SEARCH STATEMENT 2: 1 LINK NOT 66-

Search Schedule

An initial search, using the logic given in the preceding section, showed that the logic used would retrieve more than 2,500 citations from the database as it was loaded in October, 1979. For budgetary reasons and to some extent for ease of handling the offline citation printouts to be obtained, it was decided to run five identical searches at different dates, printing offline different non-overlapping segments of the total of retrieved citations of each occasion.

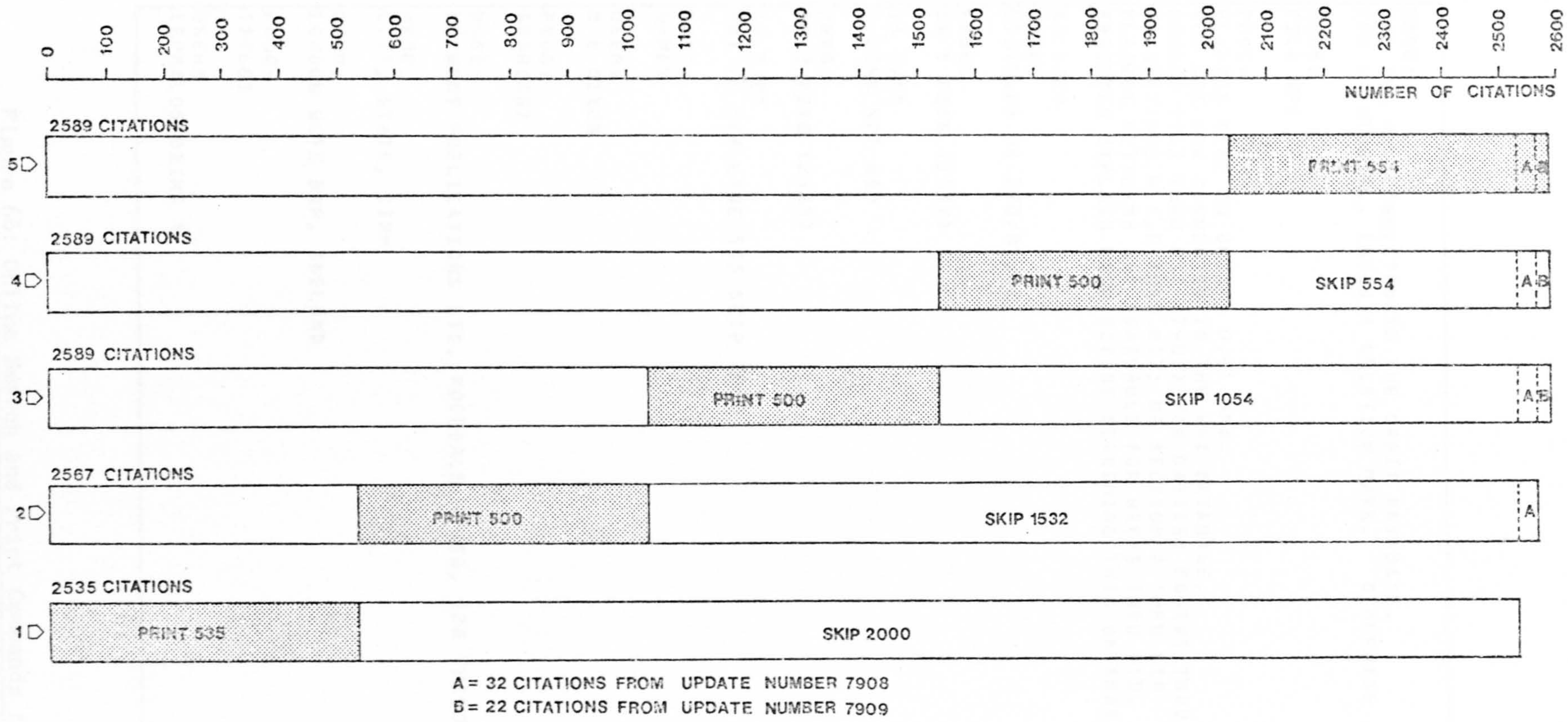
Searches were therefore conducted on 17 October, 30 October, 7 November, 21 November and 30 November, 1979; the citations retrieved and printed offline in "segments" were entitled "Cephalosporins 1", "Cephalosporins 2", etc.

Interim File Updates

It was expected that over the period during which the seaches were carried out there would be at least one file update; in the event there were two, occuring in the intervals between Cephalosporins 1 and 2 and between Cephalosporins 2 and 3 (file updates 7908 and 7909 respectively). File updates for the search file, i.e., the multipunch data, comprise only the addition of newly coded most recent basics. For this reason the oldest data was printed offline for Cephalosporins 1, and the most recent data for Cephalosporins 5. The results of searches and the ranges of citations printed offline are shown schematically in Figure 65; search logic and print commands are shown in Figures 66 to 70.

Cephalosporins 1 retrieved 2,535 citations; update 7908 added 32 citations and update 7909 a further 22 citations. A total of 2,589 citations were thus retrieved. For ease of handling, the citations were filmed onto microfiche, a (partially filled) fiche being created for each of the five searches.

Print file (bibliographic data) updates contain not only data for the most recently added basic patents, but also data concerning specifica-



Cephalosporins 1: Retrieved 17 October, 1979; Latest File Update: 7907
Cephalosporins 2: Retrieved 30 October, 1979; Latest File Update: 7908
Cephalosporins 3: Retrieved 7 November, 1979; Latest File Update: 7909
Cephalosporins 4: Retrieved 21 November, 1979; Latest File Update: 7909
Cephalosporins 1: Retrieved 30 November, 1979; Latest File Update: 7909

Figure 65: Results of Searches and Ranges of Offline Printed Citations for Cephalosporins Report

```
PROG:
YOU ARE NOW CONNECTED TO THE ORBIT DATABASE.
FOR A TUTORIAL, ENTER A QUESTION MARK.   OTHERWISE ENTER A COMMAND.

USER:
FILE WPI

PROG:
ELAPSED TIME ON ORBIT: 0.01 HRS.
YOU ARE NOW CONNECTED TO THE WPI DATABASE.
COVERS 1963 THRU B31 (7907) FOR BASICS; EQUIVS THRU B31; MC THRU B29;
MP SECTIONS B,C,E THRU B17; MP SECTION A THRU B18
PLASDOC KEYTERMS ARE AVAILABLE FOR WEEKS THRU B10.
***ENTER EXPLAIN LINK BEFORE SEARCHING THIS DATABASE***

SS 1/C?
USER:
013/B,B1 OR 270/B1,B2

PROG:
SS 1 PSTG (2537)

SS 2/C?
1 LINK NOT 66-

PROG:
SS 2 PSTG (2535)

SS 3/C?
PRT FU OFF-LINE 535 SKIP 2000

PROG:
NAME?

USER:
M D DIXON

PROG:
ADDRESS?

USER:
DERWENT PUBLICATIONS LTD, ROCHDALE HOUSE, 128 THEOBALDS ROAD

PROG:
CITY, STATE, ZIP-

USER:
LONDON WC1X 8RP, ENGLAND

PROG:
TITLE?

USER:
CEPHALOSPORINS 1
```

Figure 66: Online Search and Print Commands for Offline Citations for Cephalosporins 1

```
PROG:
YOU ARE NOW CONNECTED TO THE ORBIT DATABASE.
FOR A TUTORIAL, ENTER A QUESTION MARK.   OTHERWISE ENTER A COMMAND.

USER:
FILE WPI

PROG:
ELAPSED TIME ON ORBIT: 0.01 HRS.
YOU ARE NOW CONNECTED TO THE WPI DATABASE.
COVERS 1963 THRU B35 (7908) FOR BASICS; EQUIVS THRU B35; MC THRU B33;
MP SECTIONS B,C,E THRU B26; MP SECTION A THRU B22
PLASDOC KEYTERMS ARE AVAILABLE FOR WEEKS THRU 810.
***ENTER EXPLAIN LINK BEFORE SEARCHING THIS DATABASE***

SS 1/C?
USER:
013/D,B1 OR 270/B1,B2

PROG:
SS 1 PSTG (2569)

SS 2/C?
1 LINK NOT 66-

PROG:
SS 2 PSTG (2567)

SS 3/C?
PRT FU OFF-LINE 500 SKIP 1532

PROG:
NAME?

USER:
M D DIXON

PROG:
ADDRESS?

USER:
DERWENT PUBLICATIONS LTD, ROCHDALE HOUSE, 128 THEOBALDS ROAD

PROG:
CITY, STATE, ZIP-

USER:
LONDON WC1X 8RP, ENGLAND

PROG:
TITLE?

USER:
CEPHALOSPORINS 2
```

Figure 67: Online Search and Print Commands for Offline Citations for Cephalosporins 2

```
PROG:
YOU ARE NOW CONNECTED TO THE ORBIT DATABASE.
FOR A TUTORIAL, ENTER A QUESTION MARK.   OTHERWISE ENTER A COMMAND.

USER:
FILE WPI

PROG:
ELAPSED TIME ON ORBIT: 0.01 HRS.
YOU ARE NOW CONNECTED TO THE WPI DATABASE.
COVERS 1963 THRU B39 (7909) FOR BASICS; EQUIVS THRU B39; MC THRU B33;
MP SECTIONS B,C,E THRU B31; MP SECTION A THRU B22
PLASDOC KEYTERMS ARE AVAILABLE FOR WEEKS THRU B10.
***ENTER EXPLAIN LINK BEFORE SEARCHING THIS DATABASE***

SS 1/C?
USER:
013/B,B1 OR 270/B1,B2

PROG:
SS 1 PSTG (2591)

SS 2/C?
1 LINK NOT 66-

PROG:
SS 2 PSTG (2589)

SS 3/C?
PRT FU OFF-LINE 500 SKIP 1054

PROG:
NAME?

USER:
M D DIXON

PROG:
ADDRESS?

USER:
DERWENT PUBLICATIONS LTD, ROCHDALE HOUSE, 128 THEOBALDS ROAD

PROG:
CITY, STATE, ZIP-

USER:
LONDON WC1X 8RP, ENGLAND

PROG:
TITLE?

USER:
CEPHALOSPORINS 3
```

Figure 68: Online Search and Print Commands for Offline Citations for Cephalosporins 3

```
PROG:
YOU ARE NOW CONNECTED TO THE ORBIT DATABASE.
FOR A TUTORIAL, ENTER A QUESTION MARK.   OTHERWISE ENTER A COMMAND.

USER:
FILE WPI

PROG:
ELAPSED TIME ON ORBIT: 0.01 HRS.
YOU ARE NOW CONNECTED TO THE WPI DATABASE.
COVERS 1963 THRU B39 (7909) FOR BASICS; EQUIVS THRU B39; MC THRU B37;
MP SECTIONS B,C,E THRU B31; MP SECTION A THRU B26
PLASDOC KEYTERMS ARE AVAILABLE FOR WEEKS THRU B10.
***ENTER EXPLAIN LINK BEFORE SEARCHING THIS DATABASE***

SS 1/C?
USER:
013/B,B1 OR 270/B1,B2

PROG:
SS 1 PSTG (2591)

SS 2/C?
1 LINK NOT 66-

PROG:
SS 2 PSTG (2589)

SS 3/C?
PRT FU OFF-LINE 500 SKIP 554

PROG:
NAME?

USER:
M D DIXON

PROG:
ADDRESS?

USER:
DERWENT PUBLICATIONS LTD, ROCHDALE HOUSE, 128 THEOBALDS ROAD

PROG:
CITY, STATE, ZIP-

USER:
LONDON WC1X 8RP, ENGLAND

PROG:
TITLE?

USER:
CEPHALOSPORINS 4
```

Figure 69: Online Search and Print Commands for Offline Citations for Cephalosporins 4

```
PROG:
YOU ARE NOW CONNECTED TO THE ORBIT DATABASE.
FOR A TUTORIAL, ENTER A QUESTION MARK.   OTHERWISE ENTER A COMMAND.

USER:
FILE WPI

PROG:
ELAPSED TIME ON ORBIT: 0.01 HRS.
YOU ARE NOW CONNECTED TO THE WPI DATABASE.
COVERS 1963 THRU B39 (7909) FOR BASICS; EQUIVS THRU B39; MC THRU B37;
MP SECTIONS B,C,E THRU B31; MP SECTION A THRU B26
PLASDOC KEYTERMS ARE AVAILABLE FOR WEEKS THRU B10.
***ENTER EXPLAIN LINK BEFORE SEARCHING THIS DATABASE***

SS 1/C?
USER:
013/B,B1 OR 270/B1,B2

PROG:
SS 1 PSTG (2591)

SS 2/C?
1 LINK NOT 66-

PROG:
SS 2 PSTG (2589)

SS 3/C?
PRT FU OFF-LINE 554

PROG:
OFF-LINE PRINT TRUNCATED AT 551 CITATIONS
NAME?

USER:
M D DIXON

PROG:
ADDRESS?

USER:
DERWENT PUBLICATIONS LTD, ROCHDALE HOUSE, 128 THEOBALDS ROAD

PROG:
CITY, STATE, ZIP-

USER:
LONDON WC1X 8RP, ENGLAND

PROG:
TITLE?

USER:
CEPHALOSPORINS 5

SS 3/C?
PRT FU 3 SKIP 551

PROG:

-552-
```

Figure 70: Online Search and Print Commands for Offline Citations for Cephalosporins 5

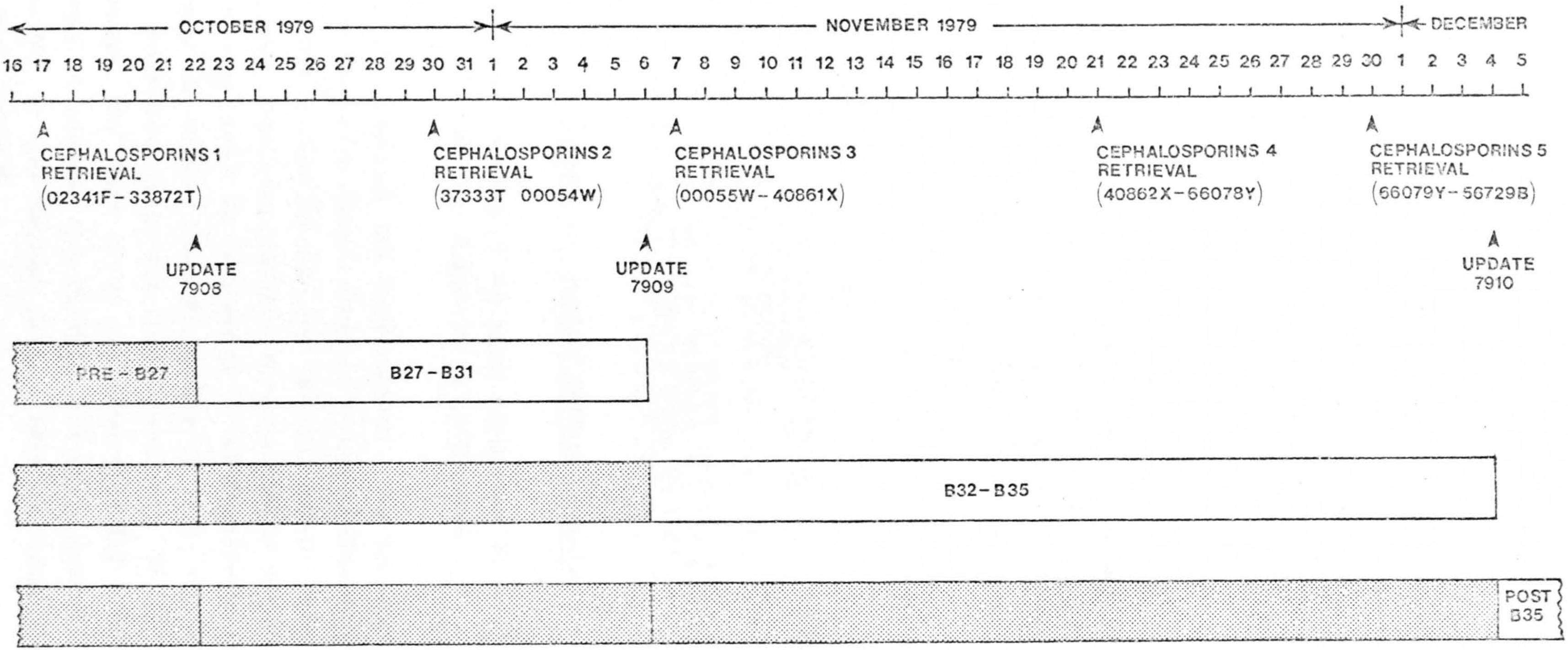


Figure 71: Chronology of Cephalosporin Searches

tions issued in the period since the previous update which are equivalents to earlier processed basic documents. It was therefore necessary to search through the printed (Country Order Alerting Bulletins) abstracts for Section B of CPI to retrieve any added data on equivalents contained in updates 7908 and 7909 for references retrieved in Cephalosporins 1, and in update 7909 for references retrieved in Cephalosporins 2 which had issued in the periods Weeks B32 to B39 and B36 to B39 respectively; this is shown schematically in Figure 71.

Offline Prints of Citations

From the online service several different printout formats are available. The alternatives range from merely printing accession numbers to having the full citation printed out. For the Cephalosporins searched the entire citations were printed; these gave the format illustrated in the typical example shown in Figure 72.

```
-294-
AN  - 38455A/22
CC  - ELI LILLY & CO (ELIL ) B02
IN  - CISE MD, ROY ML
TI  - Stable, crystalline sodium cephalothin prepn.- by freeze-drying
      aq. alkanol or aq. acetone solns.; used for parenteral injection,
      after reconstitution  BE-861135
PI  - 24.05.78 24.11.77-BE-861135 A61K B01J C07D  A61K-31/54
      C07D-501/60 A61K-09
EP  - 21.11.77-NL-012822 24.11.77-DT-752442 24.11.77-JA-141436
      24.11.77-DK-005217 24.11.77-SW-013318 24.11.77-SF-003564
FM  - BE-861135-A22  NL7712822-B23 DT2752442-B23 J54073115-B29
      DK7705217-B28 SW7713318-B28 SF7703564-B35
```

Figure 72: Typical Offline Citation

The explanation of each of the print parameters shown at the left-hand margin (AN, CC, etc.) in Figure 72 is as follows:

AN - The WPI accession and week numbers. For the CPI subset of WPI these accession numbers have the format of five digits followed by a letter indicating the year (R=1970, S=1971, etc.); all pre-CPI Farmdoc accession numbers terminate with the letter F. The accession number is followed by an oblique stroke and a two-digit number to indicate the week, within the year, of the WPI/CPI issue in which the basic was first reported. Thus, in the chosen example, the basic patent was first reported in Week 22 of 1978 (year A) and was the 38,455th CPI basic patent in that year. Non-CPI, or non-chemical patents have accession numbers with the format A1234B/16.

CC - This line carries three units of information: (a) the name of the patentee limited to 24 characters, in this case Eli Lilly & Co., whether the name arises from the basic or from a subsequently issuing equivalent (as was found to be the case in some examples of "joint patentees"); (b) the patentee code in parentheses (ELIL); and (c) the assigned Derwent CPI classification (B02 - corresponding to Section B (Farmdoc), fused ring heterocyclic compounds). For joint patentees all names and relevant codes are given; similarly all Derwent assigned classes were recorded. Prior to 1970 - Derwent Week R01 - no company names were recorded, only the patentee codes are given.

IN - Since CPI Week A04 (early in 1978) up to three inventors' names are recorded in the format of surname (up to ten characters) followed by up to three forename initials.

TI - The title assigned to the basic specification by Derwent; not the title on the specification per se as such titles are often found to be inadequate. The title is followed by the country code and number of the basic specification. In some cases where the first issued document has been delayed and incorporated into WPI/CPI and another member of the family has been artificially made basic, the country code of the first published document and the OPI date are recorded in parentheses between the title and the patent/country number.

PI - The priority line. Contains three data elements: (a) the publication or OPI (Open for Public Inspection) date of the basic patent (24.05.78 in the example); (b) the latest priority, given as date, two-letter country code and number; and (c) IPCs (International Patent Classifications) assigned to the basic document by the issuing Patent Offices together with any additional IPCs assigned to equivalents; the latter are preceded by a "+" sign.

EP - Additional, or multiple, priorities in the same format as in the PI line. These may be multiple priorities given on the basic document, or introduced to the family through the issuance of an equivalent.

FM - The patent family. A list showing the basic patent (country code, number and week number) followed by all documents found to be equivalent to the basic patent.

Medium for Data Analysis

Since it was considered necessary to organise the retrieved data in several different ways, e.g., by patentee, publication date, priority date, etc.,it was thought most appropriate to extract the relevant data from the offline printed citations and transfer this to 80-column punch cards which could be sorted and tabulated according to the desired sequence. Such data as was extracted from the offline prints was supplemented by information obtained by examination of each basic abstract in its printed (Basic Abstracts Journal) form. All data was recorded onto standard IBM keypunching instruction forms. The layout of the cards produced is given schematically on a keypunching instruction form in Figure 73 and is as follows:

Card Column	Data Source	Description
1-5	Print-out	Patentee code. A four or five character mnemonic code used by Derwent for encoding patentee data uniformly. The codes, some of which appear on the microfiche given at the end of this study, are fully explained in the Derwent Instruction Manual No. 1.
7	Print-out and abstract	Multiple patentee indicator. In a number of cases citations carried more than one patentee code; basic patents were examined to see whether such cases were truly joint applications or whether additional patentees had originated from equivalents. True multiple patentees were indicated with an ampersand (&), other cases with an asterisk (*).
9	Abstract	Patent type. Citations were coded for technical content: Synthesis: S; Isolation and/or Purification: P; Intermediates: I; Biological Process: B; Compositions: C; Other Cephalosporin references (e.g. their use in culture media, assay,

		etc.):X. This information was taken from the abstracts as the citation titles were often insufficiently detailed.
11-18	Print-out and abstract	Publication date of the basic, recorded as day.month.year. No publication dates given in online database for basic abstracts prior to January 1974; these dates were obtained from the abstracts.
20	Print-out and abstract	Priority origin indicator. Priorities not given on the basic abstracts but given in the citation, were taken as having been introduced through an equivalent. Such cases were ascertained from the basic abstract and marked with a "+" sign in this column.
21-38	Printout	Priorities. Given as date-country-number Date was given as day.month.year in cols 21-28; priority countries were recorded as ICIREPAT two-character country codes (as modified by Derwent) in cols 30-31; priority (application) numbers were recorded in cols 33-38.
40	Printout	Multiple priority indicator. A card was created for each priority given in the citation. Where only a single priority was given a letter "S" was recorded in this column; where more than one priority was given these were numbered sequentially.
42-50	Printout	Basic patent number. Two character ICIREPAT country code (as modified by Derwent) followed by patent number.
52-57	Printout	Derwent Accession number. Five digits followed by letter to indicate year.

IBM

PUNCHING INSTRUCTIONS

Name MICHAEL D. DIXON

Date OCTOBER 1979

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Application CEPHALOSPORINS PATENTS ANALYSIS

1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80
DIXO-*S	12.Ø1.74+	12.Ø6.72-G	B-123456S	US1234567	12345A15	35Ø6=Ø12	34A=1234
GORE *S	12.Ø1.74+	12.Ø6.72-G	B-123456S	US1234567	12345A15	35Ø6=Ø12	34A=1234
OPPE B	11.Ø1.74	Ø1.Ø4.71-U	S-Ø432151	BE-865432	123Ø7A15	34Ø2	
OPPE B	11.Ø1.74+	3Ø.Ø3.72-U	S-Ø591132	BE-865432	123Ø7A15	34Ø2	

- OFF-LINE PRINT CITATION NUMBER OF CROSS-REFERENCED CITATION
- ACCESSION NUMBER OF CROSS-REFERENCED CITATION
- NUMBER OF COUNTRIES IN FAMILY
- OFF-LINE PRINT CITATION NUMBER
- ACCESSION NUMBER
- BASIC PATENT NUMBER — COUNTRY, NUMBER
- SINGLE/MULTIPLE PRIORITY INDICATOR
- PRIORITY — DATE, COUNTRY, NUMBER
- PRIORITY ORIGEN INDICATOR
- PUBLICATION DATE OF BASIC
- PATENT TYPE
- MULTIPLE PATENTEE
- PATENTEE CODE

Figure 73: Keypunching Form showing Description of Data by Card Columns

59-62	Printout	Citation Number. The offline citation number, 001, 002, 003 .. etc., preceded by "1", "2", etc., for each of the five cephalosporin searches.
64-65	Printout	Cross referenced equivalents. The accession numbers, preceded by an equals symbol (=), of equivalents listed as basics in error within the database but at some time identified by Derwent as being equivalent subsequent to being assigned different accession numbers.
75-79	Printout	Cross referenced citations. The citation number, preceded by an equals symbol (=), of equivalents given in cols 67-73.

Whilst examining the basic abstracts for data needed for card columns 7, 9 and 20, the opportunity was taken to cross check informatiom, such as priority dates, numbers, etc., given in the offline citation printout. An example of a completed keypunching instruction form is given as Figure 74.

Keypunching

Punch cards were created using an IBM 029/Print Key Punch by an experienced operator. This machine has the advantage of interpreting the keyboarded data at the same tine as perforation. The cards so produced were visually checked for accuracy against the Punching Instructions sheets. Corrections were carried out by rekeyboarding entire cards; corrected cards were again checked for accuracy. The entirc data set gave rise to approximately 4200 punch cards; a typical card is illustrated in Figure 75.

Sorting and Printing of Data

The entire set of punched cards were used to generate six lists:

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1 2 3 4 5 6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23 24 25 26 27 28 29 30	31 32 33 34 35 36 37 38 39 40	41 42 43 44 45 46 47 48 49 50	51 52 53 54 55 56 57 58 59 60	61 62 63 64 65 66 67 68 69 70	71 72 73 74 75 76 77 78 79 80
TAKE S	25.06.76	19.04.71-J	A-025184 S	J76020520	571194X 44	33 01	
SANY S	07.06.76	04.12.74-J	A-139185 S	J51065791	566+1X 44	3+ 01	
SANY S	07.06.76	04.12.74-J	A-139184 S	J51065790	566+0X 44	35 01	
NIPK S	07.06.76	04.12.74-J	A-138530 S	J51065788	566394X 44	36 01	
CHEB S	15.07.76	13.01.75-D	T-S01094 S	DT25010944	562204X 44	37 01	
ELIL S	06.07.76	27.03.74-U	S-+55098 1	US39681084	559+84X 44	38 01	
ELIL S	06.07.76	30.06.72-U	S-267795 2	US39681084	559+84X 44	38 01	
BANY B	02.06.76	02.12.74-J	A-137014 S	J51065991	551+4X 44	39 01	
DAIN S	01.06.76	22.11.74-J	A-135292 S	J51063189	549634X 44	+0 01	
SANY S	01.06.76	22.11.74-J	A-134963 S	J51063188	549624X 44	+1 01	
SANY S	01.06.76	22.11.74-J	A-134963 S	J51063187	549614X 44	+2 01	
ELIL S	28.06.76	19.11.75-U	S-632732 1	NL751507+0	544374X 44	43 13	=520886X =4452
ELIL S	28.06.76	24.12.74-U	S-536273 2	NL751507+0	544374X 44	43 13	=520886X =4452
SHIO S	16.06.76	20.03.75-J	A-033880 1	BE-838656	542134X 44	44 15	
SHIO S	16.06.76	17.02.75-J	A-019612 2	BE-838656	542134X 44	44 15	
SHIO S	16.06.76	21.02.75-J	A-022229 3	BE-838656	542134X 44	44 15	
SHIO S	16.06.76	07.03.75-J	A-028452 4	BE-838656	542134X 44	44 15	
BRIM S	30.06.76	02.01.75-U	S-538271 1	BE-837265	542004X 44	45 06	
BRIM S	30.06.76	19.01.77-U	S-760620 2	BE-837265	542004X 44	45 06	
PFIZ S	29.06.76	23.09.74-U	S-508634 1	US39667194	540274X 44	46 01	

Form 25-5915-2 (Revised 1/6/64) (Replaces 25-5915-1, 2-646 and X24-6299)

IBM United Kingdom Limited

Figure 74: Typical Completed Keypunching Form

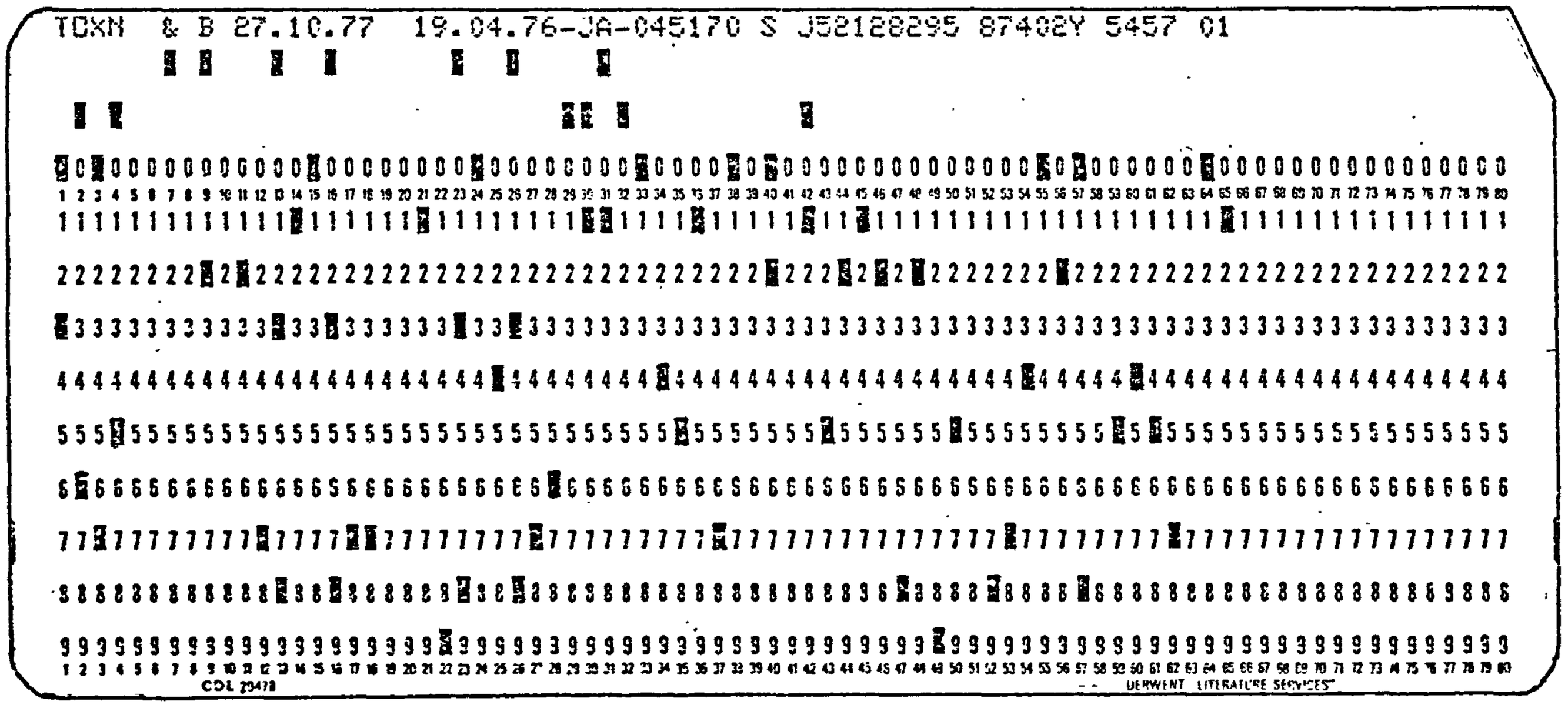


Figure 75: Typical 80-Column Punch Card showing Interpreted Data

(a) Priority date/country/number with patentee — List 1

(b) Publication date within patentee — List 2

(c) Patentee within publication date — List 3

(d) Priority date/country/number within publication date — List 4

(e) Priority country/date/number overall — List 5

(f) Priority date/country/number overall — List 6

To achieve this the cards were processed, through the courtesy of Control Data Corporation, on an IBM 3031 main frame computer to which was coupled an IBM 3211 line printer. A utility program (PROC SORT) was suitably modified to sort the data according to the scheme shown below, whilst a second modified utility program (IEBPTPCH) was used to print the required lists; for each list the entire data contained in each card was printed.

In order to minimise costs, and to avoid excessive manipulation of the programs, the data was not "rotated" prior to printing, such that the parameter arranged in sequence, e.g., the publication date in List 2, was given as the first data on each line. The data was merely printed out in the same order as it appeared in the input punched cards, i.e., so called "80/80" listings were produced.

Data Sorting Sequences

For List 1

		Data illustrated in Fig. 7
Card columns 59-62	- Citation number	5457
within card columns 33-38	- Priority number	045170
within card columns 30-31	- Priority country	JA
within card columns 21-22	- Priority date day	19
within card columns 24-25	- Priority date month	04
within card columns 27-28	- Priority date year	76
within card columns 1-5	- Patentee code	TOXNB (B = blank)

For List 2

Card columns 59-62	- Citation number	5457
within card columns 11-12	- Publication date day	27
within card columns 14-15	- Publication date month	10
within card columns 17-18	- Publication date year	77
within card columns 1-5	- Patentee code	TOXNB

For List 3

Card columns 59-62	- Citation number	5457
within card columns 1-5	- Patentee code	TOXNB
within card columns 11-12	- Publication date day	27
within card columns 14-15	- Publication date month	10
within card columns 17-18	- Publication date year	77

For List 4

Card columns 59-62	- Citation number	5457
within card columns 33-38	- Priority number	045170
within card columns 30-31	- Priority country	JA
within card columns 21-22	- Priority date day	19
within card columns 24-25	- Priority date month	04
within card columns 27-28	- Priority date year	76
within card columns 11-12	- Publication date month	10
within card columns 17-18	- Publication date year	77

For List 5

Card columns 59-62	- Citation number	5457
within card columns 33-38	- Priority number	045170
within card columns 21-22	- Priority date day	19
within card columns 24-25	- Priority date month	04
within card columns 27-28	- Priority date year	76
within card columns 30-31	- Priority date country	JA

For List 6

Card columns 59-62	- Citation number	5457
within card columns 33-38	- Priority number	045170
within card columns 30-31	- Priority country	JA
within card columns 21-22	- Priority date day	19
within card columns 24-25	- Priority date month	04
within card columns 27-28	- Priority date year	76

Sample pages of Lists 1 to 6 are shown as Figures 76 to 81 respectively; the pages illustrated show the entries for the card which is the subject of Figure 75. In each case the lists comprised 70 pages each of 60 lines, plus a final page of 26 lines, representing the 4226 cards used as input. The lists are presented in microfiche format at the end of this thesis.

TOOH		S	22.01.74	10.04.72-US-242842	1	J49007263	23851V	2173	04		
TOOH		I	07.04.76	10.04.72-US-242842	2	US3948927	30000X	3045	01		
TOOH		S	11.04.75	09.10.73-NL-013896	S	NL7313896	28433W	3386	02		
TOOH		S	15.05.75	14.11.73-DT-356862	S	DT2356862	34499W	3365	01		
TOOH		S	01.12.75	06.08.74-GB-034614	1	BE-832174	00109X	3174	13	=23513Y	=4206
TOOH		S	22.03.77	06.08.74-GB-034614	S	US4013653	23513Y	4206	13	=00109X	=3174
TOOH		S	22.01.74	+12.08.74-US-496620	2	J49007263	23851V	2173	04		
TOOH		I	07.04.76	12.08.74-US-496620	1	US3948927	30000X	3045	01		
TOOH		S	01.12.75	+04.10.77-GB-041215	2	BE-832174	00109X	3174	13	=23513Y	=4206
TORA		S	29.08.76	07.02.77-JA-011628	S	J53098986	71444A	5209	01		
TORA		S	17.05.79	18.10.77-JA-125001	S	J54061191	47626B	5023	01		
TOSH/	*	S	11.10.77	07.04.76-JA-039549	2	NL7703864	77073Y	5496	09		
TOSH/	*	S	11.10.77	15.09.76-JA-111125	1	NL7703864	77073Y	5496	09		
TOSX		S	26.08.75	07.02.74-JA-014895	S	J50108282	04663X	3147	01		
TOSX		S	25.04.77	23.10.75-JA-127666	S	J52051388	40495Y	4142	01		
TOSX		S	21.02.78	02.08.76-JA-092170	S	J53018718	26122A	5322	01		
TOSX		S	29.05.78	09.11.76-JA-134452	S	J53059689	46680A	5267	01		
TOXN		S	17.08.77	19.12.70-JA-114804	S	J77031878	64320Y	4010	01		
TOXN		S	23.10.73	20.04.72-JA-040136	S	NL7305374	68145D	2282	10	=72643D	=2273
TOXN		P	05.02.74	01.06.72-JA-054983	S	J49013195	21698V	2180	01		
TOXN		C	09.05.75	01.08.73-JA-086965	S	J50052219	02547X	3159	01		
TOXN		B	15.05.75	23.01.74-JA-010471	2	BE-824681	39285W	3345	12		
TOXN		B	23.08.75	07.02.74-JA-016547	S	J50107166	06282X	3143	01		
TOXN		B	12.09.75	25.02.74-JA-022579	S	J50116686	84040W	3195	01		
TOXN		B	12.09.75	25.02.74-JA-022580	S	J50116687	84041W	3194	01		
TOXN		S	19.12.75	07.06.74-JA-065227	S	J50157389	23826A	5335	01		
TOXN		B	19.12.75	12.06.74-JA-066665	S	J50157591	23858A	5332	01		
TOXN		B	17.04.76	14.10.74-JA-117205	S	J51044695	41066X	4497	01		
TOXN		B	15.05.75	12.12.74-JA-142761	1	BE-824681	39285W	3345	12		
TOXN		B	03.08.76	03.02.75-JA-014550	S	J51086694	71195X	4380	01		
TOXN		P	02.05.77	26.10.75-JA-130150	S	J52054017	42261Y	4134	01		
TOXN		C	27.05.77	18.11.75-GB-047562	S	J52064432	48083Y	4104	02		
TOXN		P	30.05.77	20.11.75-JA-139438	S	J52065289	49344Y	4101	01		
TOXN	&	S	12.07.77	27.12.75-JA-156573	S	J52083391	60293Y	4055	01		
TOXN		B	11.07.77	27.12.75-JA-159808	S	J52082791	60158Y	4056	01		
TOXN		I	06.09.77	03.03.76-JA-023653	S	NL7702304	67184Y	5544	06		
TOXN	&	S	05.09.77	04.03.76-JA-023522	S	BE-852031	63054Y	4019	09		
TOXN	&	S	21.10.79	09.04.76-JA-040588	S	J52125696	85730Y	5461	01		
TOXN	&	B	27.10.77	19.04.76-JA-045170	S	J52128295	87402Y	5457	01		
TOXN		I	11.01.78	26.06.76-JA-075001	S	J53002491	14867A	5364	01		
TOXN		B	08.04.78	18.09.76-JA-112079	S	J53038692	35986A	5302	01		
TOXN		B	08.04.78	18.09.76-JA-112080	S	J53038693	35987A	5301	01		
TOXN		B	08.04.78	18.09.76-JA-112081	S	J53038694	35988A	5300	01		
TOXN	&	B	27.05.78	05.11.76-JA-132318	S	J53059095	48601A	5268	01		
TOXN		B	17.10.78	28.03.77-JA-034205	S	J53118591	84569A	5157	01		
TOXN		X	13.03.79	23.08.77-JA-100162	S	J54034293	32123B	5059	01		
TOYA		S	22.09.76	17.10.70-JA-090972	S	J76033918	78719X	4349	01		
TOYA	*	S	20.04.72	17.10.70-JA-090973	S	DT2151530	27933T	1013	11		
TOYA		S	14.11.72	31.03.71-JA-018803	S	JA4731993	49200U	2318	01		
TOYA		S	01.12.72	15.04.71-JA-024139	2	FR2133761	10233U	2399	01		
TOYA	*	S	26.10.72	15.04.71-JA-024140	2	DT2218209	71522T	2447	13		
TOYA	*	S	26.10.72	15.04.71-JA-024141	1	DT2218209	71522T	2447	13		
TOYA		S	22.03.73	29.07.71-JA-056411	S	JA4822491	51206U	2312	01		
TOYA		S	26.06.73	14.10.71-JA-081136	S	JA4844296	55336U	2307	01		
TOYA		S	01.12.72	01.11.71-JA-086943	1	FR2133761	10233U	2399	01		
TOYA		S	22.06.73	+08.12.71-GB-057046	3	NL7117455	38997U	2342	06		
TOYA		S	22.06.73	+14.12.71-CA-130125	2	NL7117455	38997U	2342	06		
TOYA		S	22.06.73	20.12.71-NL-017455	1	NL7117455	38997U	2342	06		
TOYA		S	18.09.73	23.12.71-JA-104936	S	JA4868590	76524U	2264	01		
TOYA	*	S	22.06.73	28.12.71-JA-002201	2	BE-793191	39684U	2338	08		

Figure 76: Part of Cephalosporins Patents Data Computer Generated List 1

```
TCCH     S 22.01.74  10.04.72-US-242642 1 J49007263 23651V 2173 04
TCCH     S 22.01.74 +12.08.74-US-496620 2 J49007263 23651V 2173 04
TCCH     S 11.04.75  09.10.73-NL-013896 S NL7313896 28433W 3326 02
TCCH     S 15.05.75  14.11.73-DT-350302 S DT2350002 34499W 3305 01
TCCH     S 01-12.75  00.00.74-GB-034014 1 BE-032174 0.169X 3174 13 =23513Y =4206
TCCH     S 0..12.75 +04.10.77-GB-041215 2 BE-032174 00169X 3174 13 =23513Y =4206
TCCM     I 07.04.76  12.08.74-US-496320 1 US3941927 30000X 3045 01
TCCM     I 07.04.76  10.04.72-US-242642 2 US3948927 30000X 3045 01
TCCH     S 22..3.77  06.06.74-GB-034014 S US4013053 23513Y 4206 13 =00169X =3174
TCRA     S 29.08.78  07.02.77-JA-011626 S J5310959C 71444A 5209 01
TCRA     S 17.05.79  16.11.77-JA-125001 S J5402I191 47J26B 5023 01
TCSH/ *  S 11..6.77  15.09.76-JA-111125 A NL7703864 77073Y 5490 09
TCSH/ *  S 11.10.77  07.04.75-JA-039549 2 NL7703864 77073Y 5496 09
TCSX     S 26.08.75  07.02.74-JA-014053 S J5010.282 04063X 3147 01
TCSX     S 25.04.77  23.10.75-JA-127660 S J5205I366 40495Y 4142 01
TCSX     S 21.02.78  02.06.76-JA-092170 S J5310.718 20122A 5322 01
TCSX     S 25.05.78  09.11.76-JA-134452 S J5305986B 40060A 5207 01
TCXN     S 23.10.73  20.04.72-JA-040136 S NL7305574 001450 2282 10 =72649U =2273
TCXN     P 05.02.74  01.00.72-JA-054963 S J4901319J 21090V 2160 01
TCXN     C 09.05.75  01.08.73-JA-066965 S J5005221J 02547X 3159 01
TCXN     B 15.05.75  12.12.74-JA-142761 1 BE-024001 39285W 3345 12
TCXN     B 15.05.75  23.01.74-JA-020471 2 BE-024001 39203W 3345 12
TCXN     B 23.06.75  07.02.74-JA-016547 S J5010.7186 00282X 3143 01
TCXN     B 12.09.75  25.02.74-JA-022566 S J5011.0667 04041W 3194 01
TCXN     B 12.09.75  25.02.74-JA-022579 S J5011.0666 04040W 3195 01
TCXN     B 19.12.75  12.00.74-JA-000005 S J5015J591 23850A 5332 01
TCXN     S 19.12.75  07.00.74-JA-003227 S J5..157369 23020A 5335 01
TCXN     B 17.04.76  14.10.74-JA-117215 S J5114.095 41000X 4497 01
TCXN     B 03.00.76  03.02.75-JA-014050 S J5100.0094 71195X 4306 01
TCXN     P 02.05.77  20.10.75-JA-130150 S J5200.017 42281Y 4134 01
TCXN     C 27.05.77  18.11.75-00-047562 S J5206.432 40003Y 4104 02
TCXN     P 30.05.77  20..1.75-JA-139436 S J5200.269 49344Y 4101 01
TCXN     B 11.07.77  27.12.75-JA-159.00 S J5200.791 00153Y 4050 01
TCXN  &  S 12.07.77  27.12.75-JA-156073 S J5200.391 00293Y 4055 01
TCXN     S 17.08.77  19.12.76-JA-114004 S J7103.076 04520Y 4010 01
TCXN  &  S 05.09.77  04.03.76-JA-023522 S BE-052031 05034Y 4019 05
TCXN     I 00.09.77  03.03.76-JA-023053 S NL7702304 07104Y 5044 00
TCXN  &  B 27.10.77  19.04.76-JA-045170 S J5212.295 07402Y 5457 01
TCXN     I 11.01.78  26.06.76-JA-075001 S J5300.2491 14007A 5304 01
TCXN     B 00.04.78  10.09.76-JA-112001 S J5303.094 05500A 5300 01
TCXN     B 00.04.78  10.09.76-JA-112000 S J5303.094 05507A 5302 01
TCXN     B 01.04.78  10.09.76-JA-112079 S J5303.092 05900A 5302 01
TCXN  &  B 27.05.78  09.01.76-JA-132310 S J5301.095 40001A 5206 01
TCXN     B 17.10.76  20.03.77-JA-034215 S J5311.091 04209A 5257 01
TCXN     X 13.03.79  23.10.77-JA-100102 S J5401.043 02123B 5159 01
TCXN  &  S 21.10.79  03.04.76-JA-040500 S J5201.2090 05700Y 5401 01
TCYA  *  S 20.04.72  17.10.70-JA-070073 S D1210.030 27933T 1013 11
TCYA  *  S 20..0.72  15.04.71-JA-024140 1 DT2210.09 71522I 2447 13
TCYA  *  S 20.10.72  15.04.71-JA-024140 2 DT2210.09 71522I 2447 13
TCYA     S 14.11.72  31.03.71-JA-010003 S JA4731093 49200U 2316 01
TCYA     S 01.12.72  01.11.71-JA-000943 1 FR2133701 10233U 2399 01
TCYA     S 01.12.72  15.04.71-JA-024139 2 FR2133701 10233U 2395 01
TCYA     S 22.03.73  24.07.71-JA-050411 S JA4002491 51200U 2312 01
TCYA  *  S 22.06.73  28.12.71-JA-000202 1 BE-795191 05004U 2330 00
TCYA  *  S 22.00.73  20.12.71-JA-002201 2 BE-795191 05004U 2330 00
TCYA     S 22.00.73  20.12.71-NL-017455 1 NL7117455 30997U 2342 00
TCYA     S 22.00.73 +14.12.71-CA-130125 2 NL7117455 30997U 2342 00
TCYA     S 22.00.73 +00.12.71-GL-057040 3 NL7117455 30997U 2342 00
TCYA     S 20.00.73  14.10.71-JA-001100 S JA4044090 05000U 2307 01
TCYA     S 10.09.73  23.12.71-JA-104930 S JA4000550 76524U 2204 01
```

Figure 77: Part of Cephalosporins Patents Data Computer Generated List 2

FUJI		S	17.10.77	2d.06.76-GB-626746	2	BE-055953	75973Y	5501	13
FUJI		S	17.10.77	05.01.77-GB-000202	1	BE-055953	75973Y	5501	13
ELIL		B	18.10.77	06.08.09-US-847923	2	US4054564	77361Y	5495	01
ELIL		B	18.10.77	03.08.77-US-060556	3	US4054564	77361Y	5495	01
ELIL		B	18.10.77	08.05.72-US-251019	1	US4054564	77361Y	5495	01
FUJI		S	20.10.77	19.05.75-GB-621355	3	JP2125109	85564Y	5402	02
DAIN		1	20.10.77	06.04.76-JA-040091	5	JP2125165	05561Y	5405	01
TSAN		S	20.10.77	10.04.76-JA-040513	5	JP2125166	05562Y	5404	01
SANY		S	20.10.77	10.04.76-JA-040550	5	JP2125167	05563Y	5403	01
ASAH	&	S	21.10.77	09.04.76-JA-040560	5	JP2125090	05730Y	5401	01
BRIM		S	26.10.77	27.04.76-GB-017020	1	BE-053574	77519Y	5494	12
BRIM		S	26.10.77	+07.04.77-US-785392	1	BE-053574	77519Y	5494	12
BRIM		S	26.10.77	+02.02.78-US-874457	3	BE-053574	77519Y	5494	12
BANY		B	27.10.77	19.04.76-JA-043657	5	JP2128293	87400Y	5459	01
TOKN	&	B	27.10.77	19.04.76-JA-045176	5	JP2128255	87402Y	5457	01
ASAH	&	B	27.10.77	19.04.76-JA-045176	5	JP2128255	87402Y	5457	01
FUJI		P	27.10.77	20.04.76-JA-045131	5	JP2128294	87401Y	5456	03
GLAX		S	27.10.77	20.04.76-GB-017307	5	BE-054012	77534Y	5493	07
SHIO		1	31.10.77	27.04.76-JA-049274	5	NL7704034	82388Y	5464	05
ELIL		S	01.11.77	27.12.71-US-212739	2	US4056670	81174Y	5468	01
ELIL		S	01.11.77	11.09.72-US-288227	3	US4056670	81174Y	5468	01
ELIL		S	01.11.77	14.03.73-US-341211	4	US4056670	81174Y	5466	01
ELIL		S	01.11.77	09.06.75-US-584996	1	US4056670	81174Y	5468	01
ROUS		S	04.11.77	14.01.76-FR-000043	2	FR2342733	50573Y	5443	01
MEIJ		S	04.11.77	24.04.76-JA-046794	5	JP2131595	09174Y	5452	01
ROUS		S	04.11.77	13.05.77-FR-014741	1	FR2342733	50573Y	5443	01
SMIK		S	08.11.77	02.09.76-US-719751	1	US4057831	82867Y	5463	04
SMIK		S	08.11.77	+02.11.77-US-847071	2	US4057831	82867Y	5463	04
FARB		S	10.11.77	30.04.76-DT-019247	5	DT2019247	81993Y	5487	07
TAKE		S	14.11.77	06.05.76-JA-051099	5	JP2136191	00710A	5433	02
YOSH		P	14.11.77	06.05.76-JA-051896	5	JP2136190	00717A	5434	01
COIF		S	14.11.77	08.05.76-JA-052741	5	JP2136192	00719A	5432	01
SANY		S	14.11.77	12.05.76-JA-053966	5	JP2136194	00721A	5431	01
MERI		1	15.11.77	12.06.71-US-149364	2	US4056661	84641Y	5471	01
MERI		1	15.11.77	02.02.72-US-223005	3	US4056661	84641Y	5471	01
MERI		1	15.11.77	03.05.73-US-356073	4	US4056661	84641Y	5471	01
MERI		1	15.11.77	07.04.75-US-565495	1	US4056661	84641Y	5471	01
SMIK		S	15.11.77	28.06.76-US-700290	1	US4056669	84621Y	5472	01
MERI		1	15.11.77	+25.04.77-US-791293	3	US4056661	84641Y	5471	01
SMIK		S	15.11.77	+01.09.77-US-839270	2	US4056669	84621Y	5472	01
MORL	*	C	17.11.77	05.05.76-US-668410	5	DT2716260	83237Y	5461	05
LUKE/	*	C	17.11.77	05.05.76-US-668410	5	DT2716260	83237Y	5461	05
BANY		P	19.11.77	10.05.76-JA-050116	5	JP2139190	82752A	5419	01
BEEC		C	21.11.77	+20.04.74-GB-017416	2	JP2139731	82940A	5416	02
BEEC		C	21.11.77	+21.06.74-GB-027715	3	JP2139731	82940A	5418	02
BEEC		C	21.11.77	+19.10.74-GB-049651	4	JP2139731	82940A	5418	02
BEEC		C	21.11.77	05.05.76-GB-010334	1	JP2139731	82940A	5418	02
FARM		S	21.11.77	21.05.76-GB-021052	5	BE-054045	82597Y	5482	11
MERE		S	24.11.77	08.09.75-DT-049402	2	DT2021011	84927Y	5470	04
MERE		S	24.11.77	12.05.76-DT-021022	1	DT2021011	84927Y	5470	04
ANVR		X	25.11.77	26.03.76-FR-002905	5	FR2349520	04860A	5400	01
ELIL		1	29.11.77	28.11.72-US-316191	2	US4060081	80197Y	5456	01
ELIL		1	29.11.77	00.00.73-US-304540	1	US4060081	80197Y	5456	01
MEIJ		I	01.12.77	24.05.76-JA-059190	5	JP2723403	00955Y	5460	04
FUJI		S	01.12.77	29.11.76-GB-049744	5	BE-057597	80274Y	5455	05
SANY		S	02.12.77	20.05.76-JA-060744	5	JP2144090	05477A	5405	01
ONOY		S	02.12.77	27.05.76-JA-060040	5	JP2144069	05476A	5406	01
ONOY		S	02.12.77	27.05.76-JA-060647	5	JP2144066	05475A	5407	01
CAWI-		C	06.12.77	20.01.71-US-100496	2	US4061734	89392Y	5451	01
SOUI		S	06.12.77	24.08.71-US-174510	2	US4061651	89953Y	5450	01

Figure 78: Part of Cephalosporins Patents Data Computer Generated List 3

FUJI		S	17.10.77	28.Co.76-GB-C26746	2	bE-855953	75973Y	5501	13
FUJI		S	17.10.77	05.C1.77-GB-000262	1	bE-855953	75973Y	5501	13
ELIL		B	18.10.77	C0.C6.69-US-047923	2	US4054504	77361Y	5495	G1
ELIL		B	18.10.77	03.C8.78-US-C66056	3	US4054504	77361Y	5495	J1
ELIL		b	18.10.77	08.C5.72-US-251019	1	US4054504	77361Y	5495	61
FUJI		S	20.10.77	19.05.75-GB-021355	S	JP2125169	05564Y	5462	02
DAIN		1	20.10.77	C6.C4.76-JA-046091	S	JP2125185	05561Y	5465	01
TSAN		S	20.10.77	10.C4.76-JA-C46513	S	JP2125186	05562Y	5464	01
SANY		S	20.10.77	10.C4.76-JA-C46530	S	JP2125187	05563Y	5463	C1
ASAH	&	S	21.10.77	C9.04.76-JA-042508	S	JP2125690	05731Y	5461	C1
BRIM		S	26.10.77	27.C4.76-GB-C17C20	1	bE-853974	77519Y	5494	12
BRIM		S	26.10.77	+07.C4.77-US-705392	1	bE-853974	77519Y	5494	12
BRIM		S	26.10.77	+02.C2.78-US-874457	3	BE-853974	77519Y	5494	12
BANY		B	27.10.77	19.04.76-JA-043057	S	JP2128293	07406Y	5459	01
TOXN	&	B	27.10.77	19.04.76-JA-045170	S	JP2128255	07402Y	5457	01
ASAH	&	B	27.10.77	19.04.76-JA-045170	S	JP2128255	07402Y	5457	01
FUJI		P	27.10.77	20.C4.76-JA-045131	S	JP2128294	07401Y	5456	03
GLAX		S	27.10.77	20.C4.76-GB-017307	S	bE-854012	77534Y	5493	07
SHIO		I	31.10.77	27.C4.76-JA-049274	S	NL7704034	82386Y	5484	05
ELIL		S	01.11.77	27.12.71-US-217359	2	US4056076	81174Y	5488	01
ELIL		S	01.11.77	11.09.72-US-2082C7	3	US4056076	81174Y	5488	01
ELIL		S	01.11.77	14.03.73-US-341210	4	US4056076	81174Y	5488	01
ELIL		S	01.11.77	09.06.75-US-564996	1	US4056076	81174Y	5488	01
ROUS		S	04.11.77	14.01.76-FR-000643	2	FR2342733	90573Y	5443	01
MEIJ		S	04.11.77	24.C4.76-JA-046790	S	JP2131595	09174Y	5452	01
ROUS		S	04.11.77	13.05.77-FR-014711	1	FR2342733	90573Y	5443	01
SMIK		S	08.11.77	C2.05.76-US-719751	1	US4057031	82007Y	5463	04
SMIK		S	08.11.77	+02.11.77-US-847871	2	US4057031	82007Y	5463	04
FARB		S	10.11.77	30.C4.76-DT-C29247	S	DT2819247	81393Y	5487	07
TAKE		S	14.11.77	06.C5.76-JA-051C99	S	JP2136291	00718A	5433	01
YOSH		P	14.11.77	06.05.76-JA-051896	S	JP2136190	00717A	5434	01
COIF		S	14.11.77	C8.05.76-JA-052741	S	JP2136192	00719A	5432	01
SANY		S	14.11.77	12.05.76-JA-053966	S	JP2136194	00721A	5431	01
MERI		I	15.11.77	02.06.71-US-149304	2	US4058661	84041Y	5471	01
MERI		I	15.11.77	02.02.72-US-223C05	3	US4058661	84041Y	5471	01
MERI		I	15.11.77	03.05.73-US-356873	4	US4058661	84041Y	5471	01
MERI		I	15.11.77	07.04.75-US-565495	1	US4058661	84041Y	5471	01
SMIK		S	15.11.77	28.06.76-US-700290	1	US4058009	84021Y	5472	01
MERI		I	15.11.77	+25.04.77-US-796793	5	US4058061	84041Y	5471	01
SMIK		S	15.11.77	+01.09.77-US-838278	2	US4058009	84021Y	5472	01
FORE	*	C	17.11.77	05.05.76-US-683410	S	DT2716260	83237Y	5481	05
LONI	*	C	17.11.77	05.05.76-US-683410	S	DT2716260	83237Y	5481	05
BANY		P	19.11.77	10.05.76-JA-050418	S	JP2139190	02752A	5419	01
BEEC		C	21.11.77	+20.04.74-GB-017410	2	JP2139731	02540A	5418	02
BEEC		C	21.11.77	+21.06.74-GB-027715	3	JP2139731	02540A	5418	02
BEEC		C	21.11.77	+09.10.74-GB-043021	4	JP2139731	02540A	5418	02
BEEC		C	21.11.77	05.05.76-GB-018334	1	JP2139731	02540A	5418	02
FARM		S	21.11.77	21.05.76-GB-021052	S	BE-854045	82597Y	5402	11
MERE		S	24.11.77	06.09.73-DT-345402	2	DT2621041	84927Y	5470	04
MERE		S	24.11.77	12.05.76-DT-021011	1	DT2621011	84927Y	5470	04
ANVR		X	25.11.77	26.03.76-FR-006563	S	FR2345516	04162A	5468	01
ELIL		I	29.11.77	28.11.72-US-310191	2	US4060066	80197Y	5456	01
ELIL		I	29.11.77	06.06.75-US-564548	1	US4060066	80197Y	5456	01
MEIJ		I	01.12.77	24.05.76-JA-055156	S	DT2723463	80595Y	5460	04
FUJI		S	01.12.77	29.11.76-GB-049746	S	BE-857397	86274Y	5455	05
SANY		S	02.12.77	20.05.76-JA-060744	S	JP2144090	05477A	5465	01
ONOY		S	02.12.77	27.05.76-JA-060648	S	JP2144069	05476A	5466	01
ONOY		S	02.12.77	27.05.76-JA-060647	S	JP2144068	05475A	5467	01
CANI-		C	06.12.77	20.01.71-US-108196	2	US4061734	84892Y	5451	01
SQUI		a	06.12.77	24.06.71-US-174510	2	US4061851	85953Y	5453	01

Figure 79: Part of Cephalosporins Patents Data Computer Generated List 4

ASAH		S	04.10.77	31.03.76-JA-034379	S	J52118488	81963Y	5485	01
FUJI		J	14.10.77	01.04.76-JA-036997	S	J52122388	83196Y	5474	01
SANY		S	14.10.77	02.04.76-JA-036977	S	J52122387	83695Y	5475	01
TAKE		S	30.09.77	02.04.76-JA-037374	S	BE-853073	70716Y	5525	13
SANY		J	07.10.77	05.04.76-JA-037958	S	NL7703745	75411Y	5504	06
SANG	*	S	11.10.77	07.04.76-JA-039549	2	NL7703884	77073Y	5496	09
TOSH/	*	S	11.10.77	07.04.76-JA-039549	2	NL7703884	77073Y	5496	09
DAIN		J	20.10.77	08.04.76-JA-040091	S	J52125165	85561Y	5465	01
TOXN	&	S	21.10.77	09.04.76-JA-040588	S	J52125696	85730Y	5461	01
ASAH	&	S	21.10.77	09.04.76-JA-040586	S	J52125696	85730Y	5461	01
TSAN		S	20.10.77	10.04.76-JA-040513	S	J52125188	85562Y	5464	01
SANY		S	20.10.77	10.04.76-JA-040530	S	J52125187	85563Y	5463	01
TAKE		S	13.10.77	14.04.76-JA-042885	2	BE-853545	74147Y	5509	12
BANY		B	27.10.77	19.04.76-JA-043657	S	J52128293	87400Y	5459	01
TOXN	&	B	27.10.77	19.04.76-JA-045170	S	J52128295	87402Y	5457	01
ASAH	&	B	27.10.77	19.04.76-JA-045170	S	J52128295	87402Y	5457	01
FUJI		P	27.10.77	20.04.76-JA-045131	S	J52128294	87401Y	5458	03
MEIJ		S	04.11.77	24.04.76-JA-046790	S	J52131595	89174Y	5452	01
SHIO		I	31.10.77	27.04.76-JA-049274	S	NL7704634	82388Y	5464	05
SHIO		S	25.03.76	30.04.76-JA-050295	1	BE-852912	68870Y	5537	15
TAKE		S	14.11.77	06.05.76-JA-051899	S	J52136191	00716A	5433	01
YOSH		P	14.11.77	06.05.76-JA-051896	S	J52136190	00717A	5434	01
COIF		S	14.11.77	08.05.76-JA-052741	S	J52136192	00719A	5432	01
SANY		S	14.11.77	12.05.76-JA-053960	S	J52136194	00721A	5431	01
SHIO		C	01.09.77	13.05.76-JA-054925	S	BE-854640	65073Y	4005	13
BANY		P	19.11.77	14.05.76-JA-056118	S	J52139090	02752A	5419	01
MEIJ		S	08.12.77	19.05.76-JA-056645	S	DT2721731	86504Y	5453	03
NIPP-	&	C	08.12.77	20.05.76-JA-057298	S	DT2719770	88487Y	5454	04
MEIJ	&	C	08.12.77	20.05.76-JA-057298	S	DT2719770	88487Y	5454	04
MEIJ		I	01.12.77	24.05.76-JA-059198	S	DT2723463	86955Y	5460	04
SANY		S	02.12.77	26.05.76-JA-060744	S	J52144690	05477A	5405	01
ONOY		S	02.12.77	27.05.76-JA-060648	S	J52144689	05476A	5406	01
ONOY		S	02.12.77	27.05.76-JA-060647	S	J52144688	05475A	5407	01
SANG-		I	08.12.77	29.05.76-JA-062573	S	J52148091	07377A	5401	01
SANG-		I	08.12.77	29.05.76-JA-062572	S	J52148090	07376A	5402	02
MITP		S	08.12.77	31.05.76-JA-063110	S	J52148092	07378A	5400	01
FUJI		S	22.12.77	03.06.76-JA-065377	2	DT2724073	00349A	5436	03
EIKE-		X	10.12.77	04.06.76-JA-065330	S	J52148681	07558A	5399	01
TOYA		S	15.12.77	08.06.76-JA-066100	S	J52151187	09161A	5394	01
HOOC		S	21.12.77	11.06.76-JA-067768	S	J52153990	11006A	5389	01
BANY		P	21.12.77	14.06.76-JA-068768	S	J52153991	11007A	5388	01
TOKU-		C	19.12.77	21.06.76-JA-072960	S	BE-855780	90159Y	5445	07
NIPK		S	27.12.77	23.06.76-JA-073311	1	J52156997	11599A	5378	01
NIPK		S	27.12.77	23.06.76-JA-112192	2	J52156997	11599A	5376	01
TEIJ		I	27.12.77	24.06.76-JA-073774	S	J52156866	11550A	5367	01
TOXN		I	11.01.78	28.06.76-JA-075001	S	J53002491	14667A	5364	01
YAMA		S	21.12.77	28.06.76-JA-076209	2	BE-855949	00027A	5440	07
SANY		I	24.01.78	07.07.76-JA-080656	S	J53007694	18400A	5353	01
YAMA		S	21.12.77	07.07.76-JA-080659	2	BE-855949	00027A	5440	07
TEIJ		I	24.01.78	09.07.76-JA-080025	S	J53007696	18401A	5352	01
YAMA		S	26.01.78	16.07.76-JA-084614	S	J53009787	18546A	5351	01
TEIJ		I	04.02.76	21.07.76-JA-085929	S	J53012886	20793A	5349	01
TOYA		S	13.02.78	24.07.76-JA-087744	S	J53015394	24017A	5331	01
YAMA		B	15.04.77	26.07.76-JA-088770	1	BE-849763	29215Y	4174	11
TOBI-	&	S	13.02.78	26.07.76-JA-088933	S	J53015407	24023A	5329	01
TOHP	&	S	13.02.78	26.07.76-JA-088933	S	J53015407	24023A	5329	01
SANY		S	20.02.78	26.07.76-JA-089932	S	J53018593	26045A	5325	01
TAKE		S	13.02.78	29.07.76-JA-090942	S	J53015295	24018A	5330	01
NISO-		S	20.02.78	30.07.76-JA-090141	S	J53018594	26046A	5324	01
TOYA		S	20.02.78	02.08.76-JA-091286	S	J53018595	26047A	5323	01

Figure 80: Part of Cephalosporins Patents Data Computer Generated List 5

YAMA		S	29.09.77	26.03.76-JA-033328	S	J52116490	80381Y	5489	01
FARB		S	29.09.77	27.03.76-DT-613172	S	NL7703206	72663Y	5519	06
TAKE		S	14.07.77	29.03.76-JA-034971	1	DT2706271	56712Y	4096	05
MERI		S	04.07.78	30.03.76-US-671784	S	US4099000	65237A	5232	01
MERI		S	14.03.78	30.03.76-US-671785	S	US4769179	26716A	5315	02
CHEB	*	S	13.10.77	30.03.76-US-671788	S	DT2714214	74413Y	5508	04
SQUI	*	S	13.10.77	30.03.76-US-671788	S	DT2714214	74413Y	5508	04
ASAH		S	04.10.77	31.03.76-JA-034379	S	J52116466	81963Y	5485	01
FUJI		I	14.10.77	01.04.76-JA-036997	S	J52122386	83696Y	5474	01
SANY		S	14.10.77	02.04.76-JA-036977	S	J52122367	83695Y	5475	01
TAKE		S	30.09.77	02.04.76-JA-037374	S	DE-653073	70716Y	5525	13
ELIL		I	28.03.78	02.04.76-US-673017	1	US4681440	36474A	5299	01
ELIL		I	23.06.76	+02.04.76-US-673036	3	DE-837041	52069X	4451	14
ELIL		I	04.10.77	02.04.76-US-673036	1	US4052587	74634Y	5511	01
SANY		I	07.10.77	05.04.76-JA-037958	S	NL7703745	75411Y	5504	08
SQUI		S	28.06.78	05.04.76-US-673222	S	US4097070	63382A	5237	01
PROT-		S	06.11.78	06.04.76-GB-013946	S	GB1531284	80565A	5173	01
ERBA		S	16.06.76	07.04.76-IT-022016	1	BE-840350	68777X	4389	12
SANG	*	S	11.10.77	07.04.76-JA-039549	2	NL7703664	77073Y	5496	09
TOSH/	*	S	11.10.77	07.04.76-JA-039549	2	NL7703884	77073Y	5496	09
AMCY	*	X	05.10.77	07.04.76-US-674473	S	BE-853253	72453Y	5526	13
FISH-	*	X	05.10.77	07.04.76-US-674473	S	BE-853253	72453Y	5526	13
DAIN		I	20.10.77	08.04.76-JA-040091	S	J52125165	85561Y	5465	01
TOXN	&	S	21.10.79	09.04.76-JA-040586	S	J52125096	85736Y	5461	01
ASAH	&	S	21.10.77	09.04.76-JA-040586	S	J52125096	85736Y	5461	01
SQUI		S	30.05.78	09.04.76-US-675355	S	US4092475	53361A	5258	01
TSAN		S	20.10.77	10.04.76-JA-040513	S	J52125166	85562Y	5464	01
SANY		S	20.10.77	10.04.76-JA-040530	S	J52125167	85563Y	5463	01
FUJI		S	14.09.77	12.04.76-GB-014916	2	BE-852427	66053Y	5551	09
ELIL		S	16.06.77	12.04.76-US-676183	S	US4042472	60981Y	4037	02
BEEC		S	24.05.77	13.04.76-GB-014952	1	BE-840711	38084Y	4149	10
TAKE		S	13.10.77	14.04.76-JA-042885	2	BE-853545	74147Y	5509	12
MERI		I	10.06.76	+14.04.76-US-676771	2	US3974151	64699X	4410	01
MERI		I	20.12.77	14.04.76-US-676771	1	US4064344	61964A	5428	01
BANY		B	27.10.77	19.04.76-JA-043657	S	J52126293	87400Y	5459	01
TOXN	&	B	27.10.77	19.04.76-JA-045170	S	J52128295	87402Y	5457	01
ASAH	&	B	27.10.77	19.04.76-JA-045170	S	J52126295	87402Y	5457	01
SQUI		S	20.09.77	19.04.76-US-678001	S	US4049651	76539Y	5527	01
ELIL		S	26.07.77	19.04.76-US-678086	S	US4038275	55701Y	4079	06
FUJI		P	27.10.77	20.04.76-JA-045131	S	J52126294	87401Y	5458	03
MEIJ		S	04.11.77	24.04.76-JA-046790	S	J52131595	89174Y	5452	01
BRIM		S	26.10.77	27.04.76-GB-017026	1	BE-853974	77519Y	5494	12
SHIO		I	31.10.77	27.04.76-JA-049274	S	NL7704634	82386Y	5484	05
GLAX		S	27.10.77	28.04.76-GB-017307	S	BE-854012	77534Y	5493	07
FARB		S	10.11.77	30.04.76-DT-619247	S	DT2619247	81594Y	5487	07
SHIO		S	25.03.76	30.04.76-JA-050295	1	BE-852912	66870Y	5537	15
SHIK		S	05.07.77	03.05.76-US-682948	1	US4034092	50323Y	4100	01
BEEC		C	21.11.77	05.05.76-GB-018334	1	J52139731	02940A	5418	02
FORE	*	C	17.11.77	05.05.76-US-683410	S	DT2718260	83237Y	5481	05
LOWE/	*	C	17.11.77	05.05.76-US-683410	S	DT2718260	83237Y	5481	05
TAKE		S	14.11.77	06.05.76-JA-051894	S	J52136191	00718A	5433	01
YOSH		P	14.11.77	06.05.76-JA-051896	S	J52136190	00717A	5434	01
ELIL		S	20.03.79	06.05.76-US-683984	4	US4145538	27801B	5069	01
BEEC		C	07.04.77	08.05.76-GB-019000	1	BE-847145	25280Y	4193	15
COIF		S	14.11.77	06.05.76-JA-052741	S	J52136192	00719A	5432	01
MERE		S	24.11.77	12.05.76-DT-621011	1	DT2621011	84927Y	5476	04
SANY		S	14.11.77	12.05.76-JA-053966	S	J52136194	00721A	5431	01
SHIO		C	01.09.77	13.05.76-JA-054525	S	BE-854640	05073Y	4005	13
BANY		P	19.11.77	18.05.76-JA-056116	S	J52139090	02752A	5419	01
MEIJ		S	08.12.77	19.05.76-JA-056645	S	DT2721731	88504Y	5453	03

Figure 81: Part of Cephalosporins Patents Data Computer Generated List 6

Problem of Computer Listing Errors

The computer was utilised to produce only List 1 on the first run in order that the list could be checked for errors before generating the Lists in their entirety. This was done and, as far as could be ascertained the list was found to be correct.

Instructions were therefore given for Lists 2 to 6 to be produced, although the computer bureau was only able to produce Lists 2 to 4 and 6 at the next available session. Examination of List 2 showed that there were 4226 entries (i.e. lines of printout), but that the single entry for ICI Limited (citation number 3108) had the patentee code altered from ICIL to &C&L and had thus printed as the first line since numerals and special characters - such as ampersand - are listed before alphabetic characters.

Examination of List 3 showed that the entry for citation number 3108 had this time listed under &CIL and that only 4225 entries had printed out. It was not possible, without crosschecking every entry either against the Punching Instruction Forms, or the cards generated thereon, to ascertain which entry had been lost.

List 4 had only 4224 entries and, therefore, two entries had been lost; one of these was for the ICIL entry (citation number 3108). List 6 had only 4223 entries; again the ICIL entry was found to be one of those missing.

The lists were therefore produced a second time, together with List 5. This time all lists were found to be correct. No explanation could be given by the computer bureau personnel as to how th errors could have originated. The alteration of the ICIL patentee code, and the loss of entries, was considered to be a mystifying problem since the computer had obviously read all the input cards correctly and the sort and output systems appeared to be working satisfactorily to produce List 1 on the earlier occasion. The data had been stored on discs between the session when Lists 2, 3, 4 and 6 were produced, i.e., the cards had been used as input only once. It was suspected, but not confirmed, that the errors originated during the program phase following sorting of data and listing the data in the desired sequence prior to printing.

Supplemental Data Retrieved from the Database

(a) Total number of pre-1980 patent for each patentee

The online system was used to search for each patentee, other than inventors who were listed as joint patentees with an organisation or as independant inventors. The searches were restricted to pre-1980 data since they were carried out in July, 1980, whilst the main patent bibliography had been produced in late 1979. This was achieved for companies with standard patentee codes by using the search strategy:

XXXX/PC AND NOT 80/AY

where: XXXX = four character patentee code
/PC = patentee code qualifier
80 = accession year 1980
/AY = accession year qualifier

For non-standard company codes a similar strategy was employed:

XXXX-/PC AND NOT 80/AY

where: XXXX- = non-standardised company code which may have been applied to more than one organisation

The answers so retrieved were stringsearched (see note below) in the line containing the patentee code for the most significant word in the patentee name. Thus, for example, references to Lumac International NV were retrieved as follows:

Step 1: LUMA-/PC AND NOT 80/AY
Step 2: STRS /CC :LUMAC:

In Step 2: STRS = command for stringsearching
/CC = command for the line (company code) to be so searched
:LUMAC:= term to be stringsearched allowing either for left or right hand truncation (indicated by colons, :) in case the word had been coupled with another term such as by hyphenation.

In several instances the total number of citations retrieved using patentee codes of either the type XXXX or XXXX- were relatively low; in such cases where there were less than 25 citations an abbreviated

citation, comprising accession number, classification and title (i.e., AN, CC and TI lines), were printed online since this data was also required for determining the number of patents classified into Central Patents Index Section B (Farmdoc).

Note on Stringsearching

The STRINGSEARCH command, or its abbreviation STRS, is used to perform a text search online on the unit records retrieved by a search statement. It is used to narrow search results by searching for terms in context not possible through direct searching of the inverted files of search fields. The entry format for the STRINGSEARCH command is:

STRS n/field(s) :character string:

where n is the number of the search statement to be searched

If the search statement number is not specified the search is done on the last entered search statement. If the fields are not designated, the search is on the title (/TI) field. The character string is normally enclosed in colons.

(b) Total number of pre-1980 patents in CPI Section B for each patentee

For the majority of searches carried out in (a) above the answers retrieved were searched to see if they had been classified in CPI Section B by stringsearching the CC line (containing patentee code, name and Derwent CPI classification) using the strategy:

STRS /CC :B##:

where:
- STRS = stringsearch command
- /CC = qualifier for the CC line of citations
- B = classification for CPI Section B
- # = "dummy" character permitting retrieval of any character from 0 - 9 and A - Z
- : = left and right hand truncation so that B could be retrieved from amongst a series classification, e.g., from A13 A61 B01 C02 E12

It was necessary to adopt the search parameter B## since this overcame the necessity of searching all the Section B classifications (B01, B02, B03, B04, B05, B06 and B07) in an "OR" relationship.

Where the number of citations retrieved in (a) above was relatively low, i.e., less that 25, the abbreviated citations printed out online were visually scanned to determine how many had been classified into Section B.

The validity of the searches carried out in (a) and (b) above was checked on several occasions by printing of more citations and carrying out visual scanning. For example, the retrieval:

ASAH/PC AND NOT 80/AY

retrieved 8910 citations, and stringsearching of these with:

STRS/CC :B##:

retrieved 498 citations. The first five of these citations were printed online and had Derwent CPI accession numbers:

92168B/51
92023B/51
91909B/51
91800B/51
and 91708B/51

A retrieval for all ASAH patents ("ASAH/PC") retrieved 9185 citations; AN and CC lines were printed for groups of these. The first 275 citations had accession numbers ranging from 000193C/01 to 39249C/22, i.e., they had been added to the file in 1980 (accession number series C). The next thirteen citations and their classifications were:

92705B/51 M13 M24 P73
92169B/51 A31 B05 D13 J04
92090B/51 A85 E19 L03 R47
92088B/51 A82 G02 A21
92051B/51 A02 E14 G02 A11 A14 E12
92023B/51 B03
91951B/51 M21 M23 P51 P55
91909B/51 B07 D22
91885B/51 A89 G06 R23
91868B/51 D15
91847B/51 A32 A13 A23
91800B/15 B02
91798B/51 B02

Thus it was confirmed that only citations with accession numbers in the accession number B-series (1979) and earlier had been retrieved in the first search phase, and of these only those classified into CPI Section B were retrieved in the second phase.

Stringsearching is a somewhat time consuming searching technique and, in the majority of searches conducted as in (a) and (b) above, several "time overflow" conditions were experienced. For example, the retrieval of the 8154 pre-1980 ICIL patentee coded citations took 0.54 hours during which period there were 137 time overflow conditions. The total retrieval of all the data necessary for (a) and (b) consumed 17.45 hours of online usage.

Time overflow conditions arise under the following circumstances: each simultaneous user of the ORBIT program is allotted a certain amount of processing time; most searches are easily accomplished within this time. Some search functions require more processing time than others (e.g., stringsearching), however to maintain an "equal-attention-to-all-users" concept, a capability called time-slicing has been introduced. When such a situation does occur, the user is sent an online message which requires him to respond if he requires searching to continue.

Updated Data Set

In early August, 1981, a further retrieval of Cephalosporins patents was conducted on the WPI and WPIL online files. The same search logic was used as described earlier. This search resulted in 2874 and 33 hits from the WPI and WPIL files respectively. Again, allowing for "missed" equivalents on the one hand, and multiple patentees on the other, this resulted in a data set containing 2944 references with 216 patentees, i.e., a further 345 patents and 24 patentees than the original Cephalosporins data set.

In the interval between running the original retrieval and the update, improvements had been made to SDC's ORBIT program suite which, *inter alia*, allowed for the sorting of retrieved data prior to offline citation printing. The additional data retrieved in the update was therefore sorted by (a) patentee codes, and (b) priority date prior to printing thereby giving no need to go through the lengthy routine for analysis required for the original data set.

APPENDIX II: AIR CUSHION VEHICLES

Sometimes also referred to as ground effect machines or hovercraft, the air cushion vehicle essentially "traps" a volume of air between itself and the ground or water beneath it. Depending upon the design, the vehicle can be lifted from a fraction of an inch up to several feet above the underlying surface, with sustaining pressures, or the equivalent in lifting force, of some 36 psi or more. Normally, operational economy requires that the machine be kept as close to the surface over which it is to travel as may be possible.

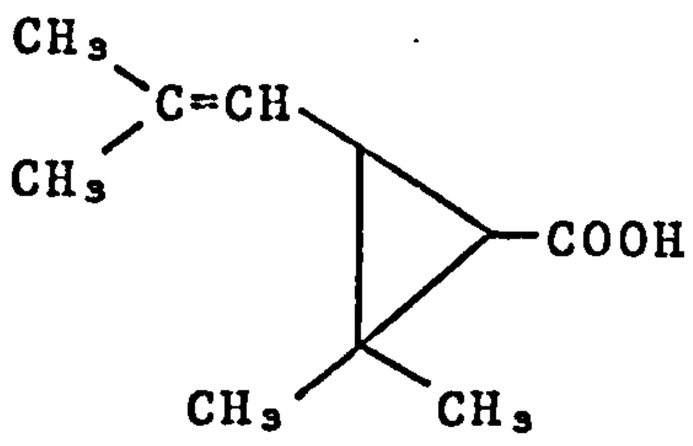
Although methods have been suggested for supporting a vehicle on a cushion of air for a long time, only in the present century have workable machines been built. Three basic types have appeared: the fully amphibious, which use a flexible rubber skirt around the periphery of the craft to retain the air cushion that is produced by fans blowing air underneath it; the purely sea-going, which has side-walls extending into the water to retain the similarly produced cushion, plus flexible skirts at the bow and stern; and the ram wing, which rides on a cushion produced by its own movement.

Machines of these types created much interest in the late 1950s and early 1960s and they aroused great expectations. As of the early 1980s, however, air cushion vehicles enjoy only limited and very specialised applications. The ground-effect principle has been employed in vehicles of the types mentioned and for conveyors and industrial towing vehicles, but numerous practical problems remain to be worked out prior to a widespread application of this principle. These problems continue to receive the attention of industry, with a resultant steady flow of patents; for this reason such documents were included in this study.

The retrieval of Air Cushion Vehicle patents from the WPI online database was conducted on 22 June, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D12. The retrieval was carried out using the IPC B60V (Air Cushion Vehicles) as the only search parameter. This gave a total of 460 citations which, on analysis showed a total of 233 patentees.

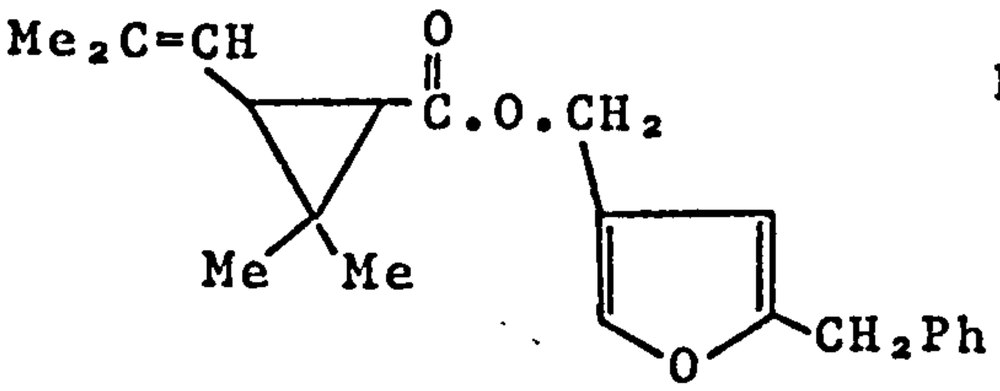
APPENDIX III: CYCLOPROPANE DERIVATIVE INSECTICIDES

Around 1820 the dried heads of Pyrethrum flower were introduced into Europe from Asia for use in dust or liquid extract form as an insecticide especially for horticultural purposes. Pyrethrum flower owes its insecticidal properties to two groups of esters. One group consists of pyrethrin I and cinerin I, both of which have chrysanthemic acid (chrysanthemum monocarboxylic acid) as their acid component. The second group of esters consists of pyrethrin II and cinerin II, both of which have pyrethric acid (monomethyl ester of chrysanthemum dicarboxylic acid) as the acid component.

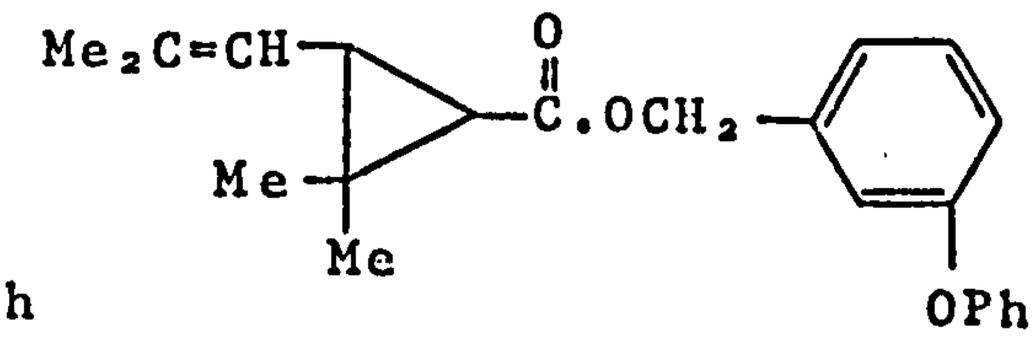


Chrysanthemic Acid

The recognition of the fact that the activity resided in a cyclopropane derivative led to the search for synthetic analogues which would be both more efficacious and more selective in action. Such synthetic compounds include Bioresmethrin and Phenothrin, both of which are commercially available.



Biosresmethrin



Phenothrin

The search for further cyclopropane derivatives with insecticidal properties continues, with a resultant steady flow of patent applications; for this reason these compounds were considered to represent a suitable technology in the present study.

The retrieval for Cyclopropane Derivative Insecticides from the WPI online database was conducted on 6 July, 1981; at that time the files had been updated with data on basics and equivalents as to Derwent Week D12. The retrieval was carried out using the single search statement:

in which /C,C1 are the qualifiers for the fragmentation codes applied to CPI Section C (Agdoc), and 406 the fragmentation code for the cyclopropane ring system. /MC is the qualifier for Manual Codes, and C12-N02 the Section C Manual Code for insecticides.

The search gave 1106 answers which, on analysis, showed that there were 168 patentees.

APPENDIX IV: VIDEODISCS

Recent advances in the mass storage of graphic and textual material have centred upon the development of videodiscs. Videodiscs and optical discs are basically a thin plastic or, in some cases, glass layer which carry data either impressed into the disc or recorded on a coating laid on the disc. There are two fundamental types: the disc which is used to play through a television monitor which is referred to as a videodisc; and the disc which is used to store data for computer systems, which is often referred to as an optical disc; however, it should be noted that often the two terms are confused and used synonymously. Generally speaking, the former record analogue data and the latter digital data, although neither are intrinsic properties.

Videodiscs utilise a laser with an extremely fine beam (about one thousandth of a millimetre in diameter) flashing on and off for one ten-millionth of a second or less. The intense light "burns" microscopic marks along a spiral track on the disc's sensitive recording medium, and the pattern of marks stores the information.

The storage capacity of videodiscs has been estimated to be 10^{11} bits, which is a substantial order of magnitude greater than more conventional magnetic tape.

Because videodiscs show great promise both as a medium for home entertainment programmes and as a mass information storage device, they have attracted the interest of a large number of research teams in industry. It was therefore considered appropriate to include patents on videodisc technology in this study.

The retrieval for Videodisc patents from the WPI online database was carried out on 22 June, 1981; at that time the database had been updated with data on basics and equivalents to Derwent Week D12. The retrieval was carried out using the following four-step search logic:

Search statement 1:

G11B-007/24/IC OR G11B-007/26 OR ALL G11B-009:/IC

Search statement 2:

W04-C01/MC

Search statement 3:

G11B-003/68/IC OR G11B-003/80/IC

Search statement 4:

SEARCH STATEMENTS 1 OR 2 OR 3

In these searches /IC and /MC are the qualifiers for IPCs and Manual Codes respectively. The search parameters utilised are:-

G11B-007/24 = IPC for optical record carriers characterised by the selection of the material or by the structure.

G11B-007/26 = IPC for apparatus or processes especially adapted for the manufacture of optical record carriers.

G11B-009 = IPC for recording information otherwise than by cutting grooves, by magnetisation, or by optical means; record carriers therefor, reproducing by using means other than styli, magnetic means or optical means.

G11B-003/68 = IPC for recording information by cutting, deforming, or pressing grooves, e.g., by stylus, etc., onto record carriers.

G11B-003/80 = IPC for record carriers incorporating subsidiary guide means for heads other than modulated grooves; part-formed unmodulated grooves for conversion into transducing grooves.

W04-C01 = Derwent Manual Code for record carriers using optical methods.

The search gave 548 citations which, on analysis, showed a total of 162 patentees.

APPENDIX V: GENETIC ENGINEERING

The term "genetic engineering" refers to the relatively new laboratory techniques used to change the hereditary endowment of living cells. It is popularly associated with the transfer into and multiplication (cloning) of "foreign" genes in single cell micro-organisms, and includes the synthesis of the foreign gene product by the resulting organisms. It should be noted, however, that the technology is also used to modify higher plant and animal cells genetically.

Present day genetic engineering techniques owe their origin to the results of basic research into genetics and biochemistry carried out over the past 35 years. The laboratory manipulations employed are revolutionary: they permit the production of hybrid organisms with a genetic make-up composed of a mixture of genes of species as diverse as bacteria and man. In such organisms the genetic material (DNA) of each species is covalently linked - hence the term "recombinant DNA". It will be appreciated that such techniques have provided a means to overcome the well known natural morphological and physiological barriers evolved to prevent hybridisation between different species. However, the possibility should be borne in mind that the genetic engineer could be mimicking natural processes which occur, albeit probably rarely. For example, it is conceivable that the DNA of a lysed bacterium in the gut of man could become integrated into his DNA, or that a virus particle could carry a piece of host DNA from one infected individual to another.

This new technology has captured the imagination of industrial managers and entrepreneurs; without doubt it is a technology holding much promise for the future and one in which there is a great deal of industrial activity which is growing in impetus. It was therefore considered appropriate to include genetic engineering patents as one of the data sets for this study.

The retrieval of Genetic Engineering patents from the WPI online database was conducted on 22 June, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D12. The retrieval was carried out using the following multi-step search logic:

Search statement 1:

C12K-001/02/IC OR C12N-015/00/IC OR A01H/IC OR D05-H03/MC

Search statement 2:

PLASMID/IT,TI OR GENETIC/IT,TI OR CHROMOSOME/IT,TI OR RIBOSOME/IT,TI OR MUTANT/IT,TI OR MUTAGEN/IT,TI

Search statement 3:

TRANSMUTATION/IT,TI OR DNA/IT,TI OR RNA/IT,TI OR GENE/IT,TI OR GENOTYPE/IT,TI OR BIOGENIC/IT,TI OR CLONE/IT,TI

Search statement 4:

C12K/IC OR C12N/IC OR D05-H/MC OR D05-H08/MC OR 540/B,B1,B2,C,C1,C2,E3

Search statement 5:

HYBRID/IT,TI OR DOMINANT/IT,TI OR TRANSFORM/IT,TI

Search statement 6:

SEARCH STATEMENTS 1 OR 2 OR 3 OR 4 AND 5

In these searches /IC, /MC, /IT and /TI are the qualifiers for IPCs, Manual Codes, Index Terms and Title Terms respectively; /B, B1, B2, C, C1, C2 and E3 are the qualifiers for the relevant CPI sectional fragmentation codes. The search parameters utilised are:

C12K-001/02 = IPC^2 for mutation or genetic engineering

C12N-015/00 = IPC^3 for mutation or genetic engineering

A01H = IPC for new plants

C12K = IPC^2 for methods and apparatus for microbiological research; isolation, identification and preparation of micro-organisms, including viruses; cell or tissue culture; microbiological materials and apparatus

C12N = IPC^3 for micro-organsims or enzymes; compositions thereof

D05-H = Derwent Manual Code for microbiology

D05-H03 = Derwent Manual Code for formation of microbial mutants

D05-H08 = Derwent Manual Code for cell or tissue culture

540 = Derwent fragmentation code for fermentation, attenuation, use of enzymes and culture

The search gave 1308 citations which, on analysis, showed a total of 665 patentees.

APPENDIX VI: PRESSURE SENSITIVE ADHESIVES

Pressure sensitive adhesives are viscoelastic materials which in solvent-free form remain permanently tacky. They adhere instantaneously to most solid surfaces with the application of very slight pressure.

The important requirements for these adhesives are: thorough and rapid wetting, tackiness, adhesive and cohesive strength and creep resistance. These properties are dependent upon the adhesive formulation which may include the polymer, modifier, tackifying agent, plasticiser, filler, antioxidant and UV stabiliser.

The earlier solution based pressure sensitive adhesives were largely replaced by acrylic emulsions, which were followed by the more recent, commercially available, hot melt pressure sensitive adhesives. The latter products include Kratom G which is a block copolymer elastomer of styrene with butadiene or isoprene, and Hytrel which is a polyether-ester elastomer containing blocks of aromatic esters with short and long glycol segments. Significant developments are taking place in this art, e.g., UV-curable liquid adhesives especially acrylics based, and chemically cured systems especially liquid polyurethanes. The number of patent filings shows continued interest of the plastics industry in this area. Thus, it was considered appropriate to include patents on Pressure Sensitive Adhesives from mono-olefinic polymers in the data sets used in this study.

The retrieval for these patents from the WPI online database was carried out on 1 July, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D12. The retrieval was conducted using the following four-step search logic:

Search statement 1:

/A 35& LINK 074

Search statement 2:

/A 609 LINK 074 LINK 01&

Search statement 3:

SEARCH STATEMENT 2 AND ALL PRESSURE:/IT,TI

Search statement 4:

SEARCH STATEMENTS 1 OR 3

In these searches /A is the qualifier for CPI Section A (Plasdoc) multipunch code; /IT,TI are the qualifiers for Index Terms and Title Terms respectively. LINK is the hierarchical operator which retrieves terms in the same subfield or subrecord, or between the main record and one subrecord. The search parameters are as follows:

35& = Fragmentation code for pressure sensitive adhesives (from Accession Number 60,001Q)
609 = Fragmentation code for adhesives
074 = Fragmentation code for mono-olefinic acrylics
01& = Fragmentation code control for Accession Numbers 60,001P to 60,000Q

The search gave 1126 citations which, on analysis, showed a total of 427 patentees.

APPENDIX VII: PRODUCTION OF TEREPHTHALIC ACID

Terephthalic Acid (TPA) is a high tonnage chemical useful in the manufacture of synthetic polymers especially polyethylene terephthalate polyester (PET) whose consumption world-wide amounts to billions of pounds. Although PET can be produced using dimethyl terephthalate or TPA, the trend is towards the use of TPA, as a result of technological advances which permit both better purification of TPA and its use in polymer production.

Many processes are available for making TPA on a commercial scale. These include: (1) Solid phase disproportionation of the alkali metal salts of benzoic acid, phthalic acid and other benzene carboxylic acids, especially of potassium benzoate in the presence of carbon dioxide at approximately 400°C using cadmium or zinc compounds as catalysts; the TPA is obtained by mineral acid treatment and the by-product salt is recycled. (2) Oxidation of paraxylene using air or oxygen using suitable catalysts in acetic acid reaction solvent.

Because of the continued popularity of PET fibre, the production technology for TPA remains an important subject to be included in the data sets used for this study.

The retrieval of patents relating to Terephthalic Acid Production from the WPI online database was conducted on 16 July, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D13 and Week D17 respectively. The retrieval was carried out using the following multi-step search logic after having instructed the system to search only in the relevant Section E (Chemdoc) fragmentation codes and instructing the computer to recognise "+" for "AND" and "<" for "NOT":

Search statement 1:(pre-1972 search logic)

373+378+473+715+659

Search statement 2: (restriction by essential groups absent)

1+<01&+<01-+<010+<012+<013+<014+<015+<016+<017+<018+<019

Search statement 3: (total 1970-1971 references)

SEARCH STATEMENT 2 + 70/AY OR SEARCH STATEMENT 2 + 71/AY

Search statement 4: (post-1971 logic)

SEARCH STATEMENT 2 + 058+059+616+<595

Search statement 5: (total references 1970 to search date)

SEARCH STATEMENTS 3 OR 4

The complexity of the search was necessary because of changes in the code introduced in 1972. In these searches /AY is the qualifier for accession number years. The fragmentation codes searched are as follows:

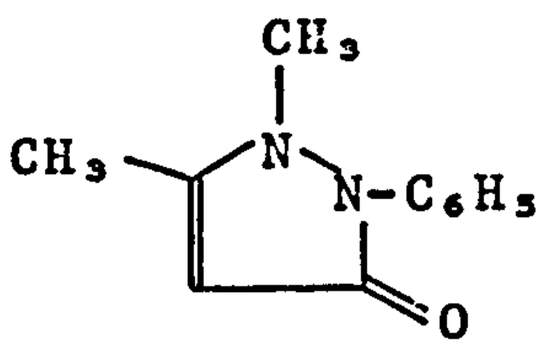
373+378	= One benzene ring present
473	= -COOH groups
715	= Basic Group (carbocyclic aromatic compound)
659	= Production of known compound
01& to 019	= Codes for essential groups (which are negated in this search as they should be absent)
058+059	= Absence of carbon chains
616	= Two -COOH groups present
595	= -OH or ether (which are negated in the logic used)

The retrieval gave 722 references which, on examination, showed 159 patentees.

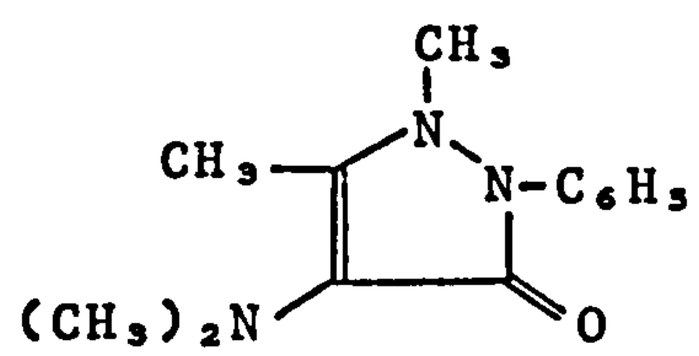
APPENDIX VIII - PHARMACOLOGICALLY ACTIVE PYRAZOLONES

Antipyretics are drugs which set the "thermostat" in the hypothalamus back to normal in a feverish organism. They do not lower normal body temperatures and differ in this respect from hypothermic agents, such as clorpromazine, which aid in maintaining physiological conditions at subnormal level if the body has been artificially chilled several degrees below normal.

The use of pyrazolones in this field was opened by the discovery in the 1880s of Knorr[261] that a compound to which he had attributed faultily a quinine-like structure was actually a pyrazolone derivitive. He called it antipyrine and found it to have a strong febrifuge action even before its correct chemical structure had been ascertained. Subsequent to this finding many other derivatives of pyrazolone were prepared and tested, primarily for antipyretic activity but incidentally also for analgesic and other effects. In this group of compounds, antipyrine and aminopyrine have been most successful.



Antipyrene



Aminopyrene

The pharmaceutical industry continues to patent new pyrazolone derivatives in large numbers and it was therefore decided that such patents should be included in the data sets used for this study.

Pharmacologically Active Pyrazolone patents were retrieved from the WPI online database on 13 July, 1981. At that time the files had been updated with data on basics and equivalents to Derwent Week D12. The retrieval was carried out using CPI Section B (Farmdoc) multipunch data with the following two step search logic:

Search Statement 1:

321/B,B2

Search Statement 2:

1 AND 619/B,B2 OR 1 AND 617/B,B2 OR 1 AND 611/B,B2

In this logic B and B2 are the qualifiers for the relevant fragmentation code; the search parameters utilised are:

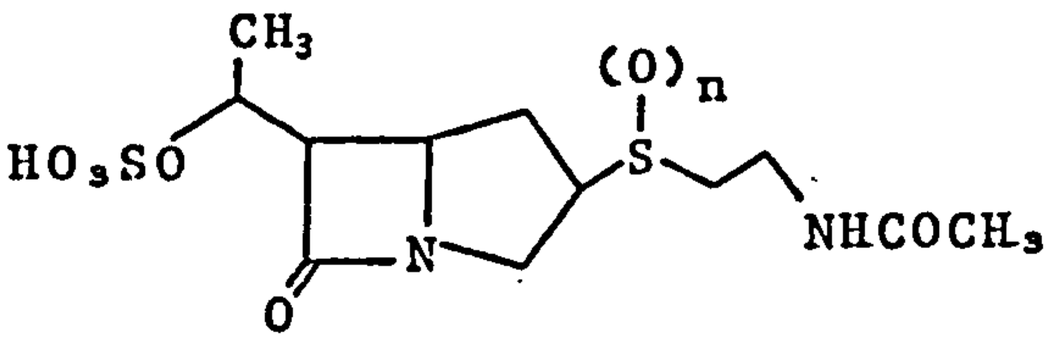
321 = Fragmentation code for five membered ring
with two nitrogen atoms in 1,2-positions
611 = Fragmentation code for analgesic
617 = Fragmentation code for anti-inflammatory activity
619 = Fragmentation code for antirheumatic activity

This search gave 243 citations which, on analysis, showed 130 patentees.

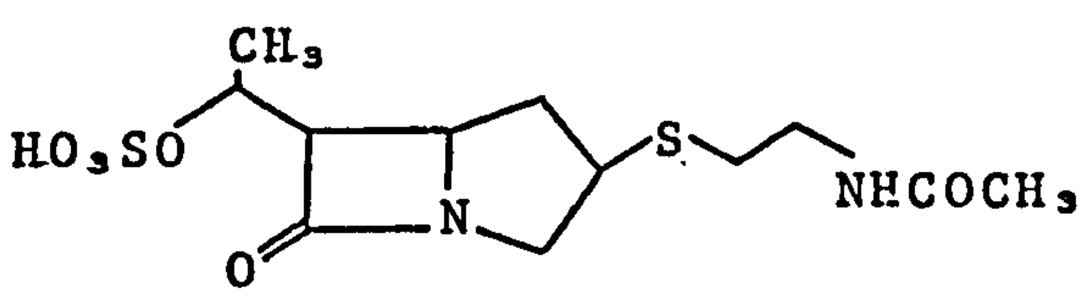
APPENDIX IX - OLIVANIC ACID

Just as the search for further β-lactam antibiotic substances led to research programmes for cephalosporin analogues and to the isolation of Clavulanic Acid (See Appendix X), studies by Hood, Box and Verral[262] led to the isolation of the olivanic acids, a family of β-lactam antibiotics with β-lactamase inhibitory properties, from Streptomyces olivaceus.

Before any structures had been established, three components were identified, these being known as MM13902, MM4550 and MM17880. Despite early difficulties in handling these substances owing to their high chemical lability, the structures were established early in 1976 to be the novel bicyclic derivatives (1), (2) and (3) respectively[263,264].



(1) n = 0, MM13902
(2) n = 1, MM4550



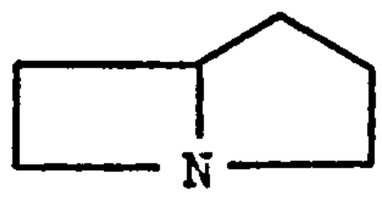
(3) MM17880

Here again, the discovery of this group of antibiotic substances has initiated research programmes leading to patent applications. Such applications were therefore thought to be appropriate for the bibliometric investigations in this study.

Olivanic acid patents were retrieved from the WPI online database on 30 July, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D18. The retrieval was carried out using the search statement:

41252/RR OR OLIVANIC/IT,TI

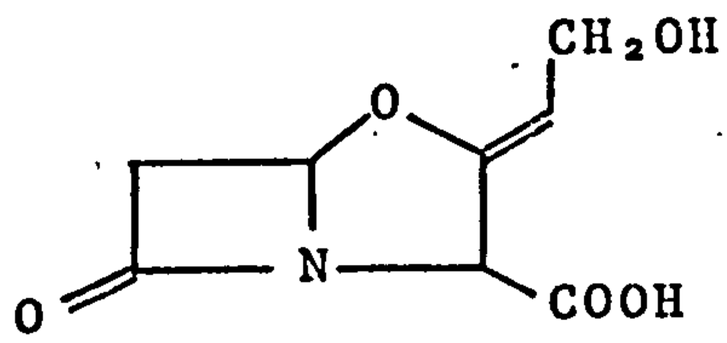
In this statement, /RR represents the search qualifier for CPI Section B Ring Index Numbers; 4152 is the Ring Index Number for the structure:



/IT,TI are the search qualifiers for Index Terms and Title Terms respectively, these being the fields in which the term OLIVANIC might occur. The search gave 118 citations which, on analysis, showed 13 patentees.

APPENDIX X - CLAVULANIC ACID

In addition to the considerable effort exerted by industry to develop new β-lactam antibiotics related to cephalosporins, the possibility that new and more effective β-lactamase inhibitors might occur in nature initiated further programmes of screening micro-organisms for such compounds. This resulted in the detection and isolation from Streptomyces clavuligeus, of a potent, irreversible β-lactamase inhibitor named clavulanic acid by Brown et al[265] in 1976. These workers showed that the structure of clavulanic acid was:



Clavulanic Acid

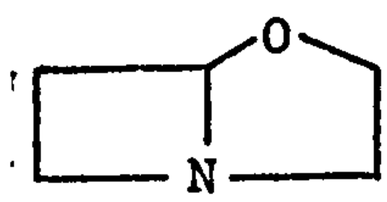
Brown et al reported that this compound was effective as a β-lactamase inhibitor in combination with ampicillin against a number of organisms, e.g., Serratia marescens, normally resistant to ampicillin, but in the presence of 1 $\mu g\ ml^{-1}$ of sodium clavulate the minimum inhibitory concentration of ampicillin was considerably reduced.

As a result of this work, further research has been carried out on clavulanic acid and its derivatives which has led to patent applications. As patents relating to this compound could be considered to be a "new technology", and as the compound is related to the cephalosporins, they were considered to be appropriate for inclusion in this study.

Clavulanic acid patents were retrieved from the WPI online database on 30 July, 1981; at that time the files had been updated with data on basics and equivalents to Derwent Week D18. The retrieval was carried out using the search statement:

41250/RR OR CLAVULANIC/IT,TI

In this statement /RR represents the search qualifier for the CPI Section B Ring Index Numbers; 41250 in the Ring Index Number for the structure:



/IT,TT are the search qualifiers for Index Terms and Title Terms respectively, these being the fields in which the term CLAVULANIC might occur.

The search gave 133 citations which, on analysis, showed 16 patentees.

APPENDIX XI: LOTKA'S LAW

A review of Lotka's Law, its theory and application, has recently been given by Potter[266].

The generalised expression for Lotka's Law is:

$$y = A\,x^{-B}$$

Writing the expression as: $\ln y = \ln A - B \ln(x)$, one can calculate A and B from a graph of ln y against ln x, when ln A = intercept and -B = gradient.

An alternative treatment of Lotka's Law is to calculate the value of A from the value of B (i.e. - gradient) and total number of authors. In this case total authors expected is equal to total authors observed, and:-

$$\text{total authors} = \sum Ax^{-B}$$

$$= A \sum \frac{1}{x^B}$$

$$A = \frac{\text{total authors}}{\sum \frac{1}{x^B}}$$

Programs to calculate A have been developed by Brand[267] in FORTRAN IV and Coile[171] in BASIC. These programs perform the calculation of A for values of x_i from 1 to i such that:-

$$\left(\sum_{x=1}^{x=i-1} \frac{1}{x^B}\right)\text{total authors} - \left(\sum_{x=1}^{x=i} \frac{1}{x^B}\right)\text{total authors} < (0.000005 \times \text{total authors})$$

After x_i iterations the value of constant A converges to at least three significant figures.

For the present study, the Coile program has been modified for the EG 3003 microcomputer; the program developed is given in Figure 82 and a typical run for the original Cephalosporins data set in Figure 83.

The program requires that the slope (B) is input before running. Values of B have been calculated by regression analysis using a programmable Sharp EL-5100 calculator; an illustrative calculation for the original Cephalosporins is given in Table 58. Note that the program run was aborted (by depressing the "BREAK" key on the computer) when convergence was observed; in the sample run this was after 222 iterations.

Lotka's Law plots, on log-log graph paper, have been prepared and, using the calculated value of B, lines of best fit passing through the mean point have been constructed. Such plots are illustrated in Figure 84 using the original Cephalosporins data set.

A second BASIC program, again modified from Coile[171], was then used to calculate the expected frequency distributions of the y patentees making x contributions. This program, shown in Figure 85, and a typical run, again using the original Cephalosporins data, is shown in Figure 86.

```
10 REM DETERMINATION OF LOTKA'S CONSTANT
20 REM COILE'S PROGRAM A-3 MODIFIED BY MDD
30 REM B=LOTKA'S SLOPE EXPONENT
40 REM A=LOTKA'S CONSTANT
50 REM
60 REM CLEAR DISPLAY
70 CLS:PRINT:PRINT:PRINT
80 LET Z=0
90 INPUT"INPUT VALUE FOR SLOPE";B
100 REM CHANGE X(MAX) IN LINE 120 IF X>200
110 REM X=NUMBER OF ITERATIVE CALCULATIONS
120 FORX=1TO200
130 LET Q=1/X[B:REM [=EXPONENTIATION SYMBOL
140 LET Z=Z+Q
150 LET A=1/Z
160 REM CLEAR DISPLAY
170 CLS
180 REM ARRANGE DISPLAY AT BOTTOM OF SCREEN
190 PRINT@840,"X";:PRINT@850,"A"
200 PRINT@968,X;:PRINT@978,A
210 REM TIME DELAY TO MANUALLY RECORD RESULTS
220 FOR T=1T050 STEP .01:NEXT T
230 NEXT X
999 END
```

Figure 82: Program in BASIC to calculate Lotka's Constant

```
INPUT VALUE FOR SLOPE? 1.197925

          X             A
          1             1
          2             .696429
          3             .586822
          4             .527954
          5             .490306
          6             .463725
          7             .443726
          8             .427996
          9             .415214
          10            .404565
          11            .395515
          12            .387701
          13            .380864
          14            .374816
          15            .369415
          16            .364553
          17            .360145
          18            .356124
          19            .352435
          20            .349036
          ▽             ▽
          ▽             ▽
          ▽             ▽
          ▽             ▽
          205           .257536
          206           .257424
          207           .257313
          208           .257202
          209           .257092
          210           .256983
          211           .256875
          212           .256767
          213           .25666
          214           .256553
          215           .256448
          216           .256343
          217           .256238
          218           .256134
          219           .256031
          220           .255929
          221           .255827
          222           .255726
          223           .255626
          224           .255526
          225           .255426
          226           .255328

BREAK IN 220
```

Figure 83: Computer run to determine Lotka's Constant for Original Cephalosporins Data Set (note run aborted after 226 iterations, convergence having been noted at iteration 222)

X	N(X)	%N(X)	log X	log N(X)
1	83	43.23	0.000000	1.919078
2	24	12.50	0.301030	1.380211
3	16	8.33	0.477121	1.204120
4	8	4.17	0.602060	0.903090
5	5	2.60	0.698970	0.698970
6	6	3.13	0.778151	0.778151
7	2	1.04	0.845098	0.301030
8	5	2.60	0.903090	0.698970
9	1	0.52	0.954243	0.000000
10	1	0.52	1.000000	0.000000
11	1	0.52	1.041393	0.000000
12	1	0.52	1.079181	0.000000
13	3	1.56	1.113943	0.477121
14	2	1.04	1.146128	0.301030
15	1	0.52	1.176091	0.000000
16	1	0.52	1.204120	0.000000
17	3	1.56	1.230449	0.477121
21	2	1.04	1.322219	0.301030
25	2	1.04	1.397940	0.301030
28	2	1.04	1.447158	0.301030

LOTKA'S EXPONENT (FIRST 20 DATA POINTS) = -1.197925

Mean log X = 0.935919 = 8.628182

Mean log N(X) = 0.502099 = 3.177599

Table 58: Determination of Lotka's Exponent and Mean Points for Lotka plot using EL-5100 programmable calculator for Original Cephalosporins Data Set

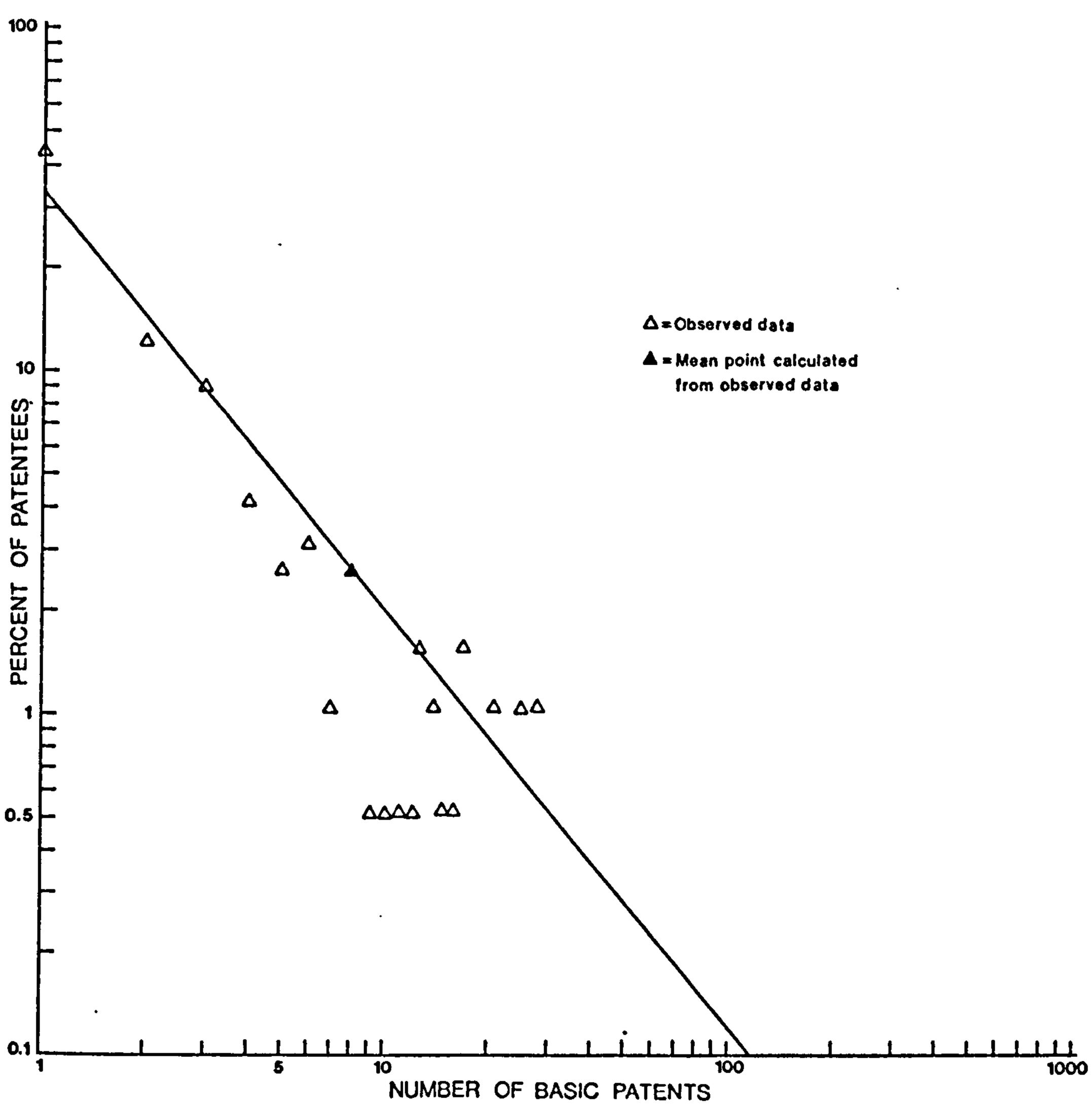


Figure 84: Lotka's Law Graph for Original Cephalosporins Data Set showing line of Slope -1.198 passing through Mean Point

```
10 REM LOTKA'S DISTRIBUTION OF SCIENTIFIC PRODUCTIVITY
20 REM COILE'S PROGRAM A-3 MODIFIED BY MDD
30 REM Y DISTRIBUTION OF AUTHORS MAKING X CONTRIBUTIONS
40 REM T=TOTAL PATENTEES, A=LOTKA'S CONSTANT,
50 REM B=LOTKA'S SLOPE EXPONENT
60 REM
70 REM CLEAR DISPLAY
80 CLS:PRINT:PRINT:PRINT
90 INPUT "TOTAL PATENTEES";T
100 INPUT "LOTKA'S CONSTANT";A
110 INPUT "LOTKA'S SLOPE EXPONENT";B
120 REM CHANGE X(MAX) IN LINE 130 IF X>25
130 FOR X=1TO25
140 LET Y=T*A/X[B:REM [= EXPONENTIATION SYMBOL
150 LET P=Y*100/T
160 REM CLEAR DISPLAY
170 CLS
180 REM ARRANGE DISPLAY AT BOTTOM OF SCREEN
190 PRINT@832,"X";:PRINT@840,"Y";:PRINT@850,"PER CENT"
200 PRINT@960,X;:PRINT@968,Y;:PRINT@978,P
210 REM TIME DELAY TO MANUALLY RECORD RESULTS
220 FOR Q=1TO50 STEP .01:NEXT Q
230 NEXT X
999 END
```

Figure 85: Program in BASIC to calculate Lotka's Distribution of Scientific Productivity

```
TOTAL PATENTEES?192
LOTKA'S CONSTANT?.255726
LOTKA'S SLOPE EXPONENT?-1.197925

X           Y           PER CENT
1           49.0994     25.5726
2           21.4025     11.1471
3           13.168      6.85833
4           9.32939     4.85906
5           7.14106     3.7193
6           5.73997     2.98957
7           4.77213     2.48548
8           4.0667      2.11807
9           3.53155     1.83935
10          3.1128      1.62125
11          2.77693     1.44632
12          2.50206     1.30316
13          2.27329     1.18401
14          2.08018     1.08343
15          1.91517     .997484
16          1.77268     .923271
17          1.64851     .858599
18          1.53941     .801776
19          1.44286     .75149
20          1.35687     .706703
```

Figure 86: Computer run to calculate Lotka's Distribution for Original Cephalosporins Data Set

APPENDIX XII: THE SIMON-YULE DISTRIBUTION

From observation and analysis of the frequency of different words in long sequences of text, the approximate formula:

$$n_r \alpha r^{-(\rho+1)} \qquad (r = 1,2,\ldots;\rho > 0)$$

for n_r the number of words appearing r times, was found to give a usefully accurate fit. In order to define a probability distribution appropriate to such a situation, one may define

$$P(x) = cr^{-(\rho+1)} \qquad (r = 1,2,\ldots)$$

$$\text{with} \qquad c = \left[\sum_{r=1}^{\infty} r^{-(\rho+1)}\right] = [\xi(\rho+1)]^{-1}$$

where $\xi(\cdot)$ denotes the Riemann zeta function. This distribution is called the zeta distribution. When used in linguistic studies, it is often called the Zipf-Estoup Law (Estoup[268], Zipf[143]). The use of the distribution in this connection has also been studied by Good[269]. It is found that ρ very often has values slightly in excess of 1. Seal[270] has applied the distribution to the number of insurance policies held by individuals.

The distribution is analagous to the continuous Pareto distribution; it is sometimes called the discrete Pareto distribution.

Simon[159] noted that, for many distributions of word frequencies, a very good fit of this distribution could be obtained for the larger (>3) values of r, with $\rho = 1$. For r = 1,2, however, this was not the case. If $\rho = 1$, the ratio of relative frequencies of 1's and 2's should be $1:2^{-2} = 4:1$. Observed values of this ratio (in the data studied by Simon) were nearer to 3:1, sometimes even less. Simon suggested consideration be given to distributions of form.

$$P(x) = A_\rho B(r,\rho + 1) \qquad (r = 1,2)$$

where A and ρ are constants and $B(r,\rho + 1)$ is the Beta function of i, $\rho+1$:

$$B(i,\rho+1) = \int_0^1 \lambda^{x-1}(1-\lambda^{\rho})d\lambda$$

$$= \frac{\Gamma(x)\,\Gamma(\rho+1)}{(x+\rho+1)} \qquad (o<x, o<\rho, <\infty)$$

Simon derived estimated frequencies from:

$$\beta(x) = \frac{(1-\alpha)\,(x-1)}{1+(1-\alpha)x} = \frac{P^*(x)}{P^*(x-1)}$$

and $$P^*(x) = \frac{k\alpha}{2-\alpha} = \frac{n_k}{2-\alpha}$$

where n_k = total authors
k = total papers
α = $n_{k/k}$

and $$\rho = \frac{1}{1-\alpha}$$

Simon gave the name Yule Distribution to this function because it was obtained by Yule[170] in 1923 as the limiting case of a distribution in mathematical genetics. Some examples of applications of the Yule distribution have been given by Kendall[271].

The BASIC program given in Figure 87 adapated from Coile[171], allows computation of the Simon-Yule function; in the program

$N = n_k$
$K = k$
$A = \alpha$
$I = x$
$R = p$
and $F = P^*(x)$

A sample run is given for the Cephalosporin data in Figure 88.

```
10 REM SIMON-YULE DISTRIBUTION FUNCTION PROGRAM
20 REM COILE'S PROGRAM G-1 MODIFIED BY MDD
30 REM A=N/K WHERE N=TOTAL PATENTEES, A=TOTAL BASICS
40 REM R=1/(1-A)
50 REM
60 REM CLEAR DISPLAY
70 CLS:PRINT:PRINT:PRINT
80 INPUT "TOTAL NUMBER OF PATENTEES = ";N
90 INPUT "TOTAL NUMBER OF BASIC PATENTS = ";A
100 LET A=N/K
110 LET R=1/(1-A)
120 LET F=N/(2-A)
130 REM CLEAR DISPLAY
140 CLS
150 REM ARRANGE DISPLAY AT BOTTOM OF SCREEN
160 PRINT@832,"I";:PRINT@840,"F";:PRINT@850,"PER CENT"
170 PRINT@960,"1";:PRINT@968,F;:PRINT@978,100*F/N
180 REM TIME DELAY TO MANUALLY RECORD RESULTS
190 FORQ=1TO50STEP.01:NEXTQ
200 LET I=2
210 LET F=F*(1-A)*(I-1)/(1+(1-A)*I)
220 LET X=100*F/N
230 REM CLEAR DISPLAY
240 CLS
250 REM ARRANGE DISPLAY AT BOTTTOM OF SCREEN
260 PRINT@832,"I";:PRINT@840,"F";:PRINT@850,"PER CENT"
270 PRINT@960,I;:PRINT@968,F;:PRINT@978,X
280 REM TIME DELAY TO MANUALLY RECORD RESULTS
290 FORZ=1TO50STEP.01:NEXTZ
300 LET I=I+1
310 REM CHANGE I(MAX) IN LINE 320 IF I>20
320 IF I=21 THEN 999
330 GOTO210
999 END
```

Figure 87: Program in Basic to Calculate the Simon-Yule Distribution

```
INPUT TOTAL NUMBER PATENTEES?192
INPUT TOTAL NUMBER BASIC PATENTS?2599

I           F           PER CENT
1           99.682      51.9177
2           32.3667     16.8577
3           15.8669     8.26403
4           9.37067     4.88056
5           6.16515     3.21102
6           4.35406     2.26774
7           3.23331     1.68401
8           2.4927      1.29828
9           1.97838     1.03041
10          1.60702     .836991
11          1.33034     .692886
12          1.11881     .582713
13          .953546     .496639
14          .822035     .428143
15          .715713     .372767
16          .628562     .327376
17          .556257     .289717
18          .495622     .258137
19          .444288     .2314
20          .400454     .20857

READY
>_
```

Figure 88: Computer run to calculate the Simon-Yule Distribution for Original Cephalosporins Data Set

APPENDIX XIII: PRICE'S PARETO-TYPE DISTRIBUTION

In 1962 Professor Derek J. de Solla Price, of Yale University, gave a series of lectures at the Brookhaven National Laboratory dealing with the sociology of science. These lectures have been printed in a book, Little Science, Big Science[272]. In his lecture entitled "Galton Revisited", Price examined and compared the scientific productivity of the authors listed in the first index volume of the abridged Philosophical Transactions of the Royal Society of London (17th and early 18th centuries) with the authors listed in the 1907-1916 decennial index of Chemical Abstracts, which had been studied by Lotka.

Price expressed the opinion that Lotka's crude, simple inverse-square law of scientific productivity needed modification to reduce the proportion of high scorers since, otherwise, the maximum number of published papers in a lifetime would be in the thousands rather than in the hundreds that were observed with even the most prolific scientists. He therefore derived a distribution law of the Pareto type:-

$$N = k \frac{1}{p} - \frac{1}{a + p} = \frac{ak}{p(a + p)}$$

where N is the number of authors publishing "at least" p scientific papers within a given interval of time (which Price took as a lifetime). The parameter, a, was estimated by Price as 15 papers per lifetime (this being his estimate of the boundary between high and low productivity). The arbitary constant of proportionality, k, can be calculated from the above equation by rearranging as follows:

$$k = \frac{Np(a + p)}{a}$$

Since Price preferred to reduce all data to a basis of 100 authors publishing but a single paper, one can set N = 100 for p = 1. Then for a = 15:

$$k = \frac{100(1)\ (15 + 1)}{15} = 106.667$$

For patenting activity studied in the present work, rather than use a = 15, it was considered appropriate to equate a, Price's "boundary", with the average number of patents per patentee. A program in BASIC to calculate Price's Pareto-type distribution has been written based upon a similar program given by Coile[171]. The program is given in Figure 89; in the computer nomenclature used a is represented by A, p by P and k by K. A typical run, using the original Cephalosporin data as the example is given in Figure 90.

Price preferred to discuss productivity in the sense of "at least" p papers in the Pareto fashion rather than in the Lotka sense of publishing "exactly" so many papers. In order to compare Price's distribution with other theoretical approaches, it is necessary to convert Price's "at least" data into "exactly" as many papers data; this is shown (for the example run) in Table 59.

```
10 REM PRICE'S PARETO-TYPE DISTRIBUTION
20 REM MODIFIED FROM COILE'S PHD THESIS, PAGE 160
30 REM TOTAL PATENTS=S
40 REM TOTAL PATENTEES=M
50 REM PRICE'S 'BOUNDARY' FOR HIGH/LOW PRODUCTIVITY =A=S/M
60 REM PRICE'S CONSTANT=K=100*(A+1)/A
70 REM N=A*K/P*(A+P)
80 REM N PATENTEES PUBLISHING AT LEAST P PATENTS
90 CLS:INPUT"TOTAL NUMBER OF PATENTS =";S
100 INPUT "TOTAL NUMBER OF PATENTEES =";M
110 LET A=S/M
120 LET K=100*(A+1)/A
130 PRINT:PRINT"PRICE'S BOUNDARY (A) = ";A
140 PRINT"PRICE'S CONSTANT (K) = ";K
150 FOR B=1TO25STEP.01:NEXTB
160 CLS:LET X=A*K
170 FOR P=1TO25
180 LET Y=X/P
190 LET N=Y/(A+P)
200 PRINT@841,"P";:PRINT@846,"N"
210 PRINT@968,P;:PRINT@973,N
220 FOR C=1TO50STEP.01:NEXTC
230 NEXTP
999 END
```

Figure 89: Program in BASIC to calculate Price's Pareto-type Distribution

```
TOTAL NO. OF PATENTS = ?2599
TOTAL NO. OF PATENTEES = ?192

PRICE'S BOUNDARY (A) = 13.5365
PRICE'S CONSTANT (K) = 107.387

          P      N
          1      100
          2      46.7818
          3      29.3018
          4      20.7232
          5      15.6842
          6      12.4011
          7      10.112
          8      8.43712
          9      7.16688
          10     6.17615
          11     5.38585
          12     4.74369
          13     4.21378
          14     3.7707
          15     3.396
          16     3.07596
          17     2.80021
          18     2.56079
          19     2.35144
          20     2.16726
          21     2.00429
```

Figure 90: Computer run to calculate Price's Pareto-type Distribution for Original Cephalosporins Data Set

P	N [not less than]	ACTUAL %	FREQUENCY
1	100.0000	53.2182	102.1789
2	46.7818	17.4800	33.5616
3	29.3018	8.5786	16.4709
4	20.7232	5.0390	9.6749
5	15.6842	3.2831	6.3036
6	12.4011	2.2891	4.3951
7	10,1120	1.6749	3.2158
8	8.4371	1.2702	2.4388
9	7.1669	0.9907	1.9021
10	6.1762	0.7903	1.5174
11	5.3859	0.6422	1.2330
12	4.7437	0.5299	1.0174
13	4.2138	0.4431	0.8508
14	3.7707	0.3747	0.7194
15	3.3960	0.3200	0.6144
16	3.0760	0.2758	0.5295
17	2.8002	0.2394	0.4596
18	2.5608	0.2094	0.4020
19	2.3514	0.1841	0.3525
20	2.1673	0.1630	0.3130
21	2.0043	-	-

Table 59: Conversion of Price's "Not-less-than" data to Theoretical Frequency Distribution for Original Cephalosporins Data Set

APPENDIX XIV: WILLIAMS' GEOMETRIC SERIES

J. Dufrenoy[273] has discussed the number of papers published by different authors which were reviewed in single years in the Review of Applied Mycology, particularly for the years 1932, 1934 and 1935.

Dufrenoy suggested that if the probability of an author to produce 1 paper was p_1, then the probability to produce 2, 3 or 4 papers would be $(p_1)^2$, $(p_1)^3$, $(p_1)^4$, etc., and so the frequency of publication of papers should be on a geometric series. Williams[167] expressed this geometric series as

$$n_1,\ n_1x,\ n_1x^2,\ \ldots\ \text{etc.}$$

If N is the total number of papers (patents in this study) and S the total number of authors (patentees in this study), then it can be shown that

$$n_1 = \frac{S^2}{N}$$

and

$$x = \frac{(N-S)}{N}$$

Williams applied the geometric series to Dufrenoy's data and to data of the number of papers published by authors in the Review of Applied Entomology. Williams found that the geometric series tended to underestimate the number of authors with a single publication and those with 5 or more, but to overestimate authors with 2 to 4 papers.

A program in BASIC to calculate the geometric series has been described by Coile[171]. For the present study this program has been modified and is shown in Figure 91; in the program nomenclature M, S and X are used respectively for n_1, S and X. A typical run, using the original Cephalosporins data set, is given in Figure 92.

```
10 REM WILLIAMS' GEOMETRIC SERIES
20 REM COILE'S PROGRAM (P.121, TABLE E-4) MODIFIED
30 REM SERIES IS: N, N*X, N*X↑2, N*X↑3, ETC. ETC.
40 REM S=TOTAL PATENTEES, M=TOTAL PATENTS
50 REM N=S↑2/M
60 REM X=(M-S)/M
65 CLS
70 INPUT "TOTAL PATENTEES = ";S
80 INPUT "TOTAL PATENTS   = ";M
90 LET N=S↑2/M
100 LET X=(M-S)/M
110 PRINT:PRINT "CALCULATED VALUE OF N = ";N
120 PRINT "CALCULATED VALUE OF X = ";X
130 FOR R=1TO25STEP.01:NEXTR
140 FORQ=1TO25
150 LET Z=N*X↑Q
160 LET P=100*Z/S
170 PRINT@832,"NO.";
175 PRINT@840,"SERIES";:PRINT@854,"PER CENT"
180 PRINT@967,Z;:PRINT@980,P
190 PRINT@960,Q+1;
200 IFQ=25THEN999
210 FORA=1TO50STEP.01:NEXTA
220 CLS:NEXTQ
999 STOP
```

Figure 91: Program in BASIC to calculate Williams' Geometric Series Distribution

```
TOTAL PATENTEES = ?192
TOTAL PATENTS   = ?2599

CALCULATED VALUE OF N = 14.1839
CALCULATED VALUE OF X = .926125
NO.       SERIES          PERCENT
1         14.1839         7.38746
2         13.1361         6.84171
3         12.1657         6.33629
4         11.2669         5.8682
5         10.4346         5.43469
6         9.66375         5.0332
7         8.94984         4.66138
8         8.28868         4.31702
9         7.67636         3.9981
10        7.10927         3.70275
11        6.58408         3.42921
12        6.09769         3.17588
13        5.64722         2.94126
14        5.23004         2.72398
15        4.84367         2.52275
16        4.48585         2.33638
17        4.15446         2.16378
18        3.84755         2.00393
19        3.56331         1.85589
20        3.30008         1.71879
```

Figure 92: Computer run to calculate Williams' Geometric Series Distribution for Original Cephalosporins Data Set

APPENDIX XV: FISHER'S LOGARITHMIC SERIES

Fisher, Corbett and Williams[168] first suggested in 1943 that a logarithmic series could be applicable in biological problems of sampling, such as the frequency of species with different numbers of individuals, or genera with different numbers of species. These authors demonstrated that there was a relationship between the logarithmic and the Negative Binomial distribution. In 1944, Williams[167] tested whether the logarithmic series could be applicable to data on the numbers of publications written by biologists and found that this fitted the observed frequencies better than the geometric series.

In 1947, Williams[274] reported that the logarithmic series could be applied to a wide range of biological applications such as the numbers of individuals classified into species, species identified in a geographic area, the numbers of parasites on hosts, etc.

The logarithmic series is:-

$$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4}...., \quad \text{etc.}$$

As negative terms have little meaning in biology, this can be written as:

$$x + \frac{x^2}{2} + \frac{x^3}{3} + \frac{x^4}{4} + ... = -\ln(1-x)$$

or as a more general frequency it can be written:

$$n_1, \quad \frac{n_1 x}{2}, \quad \frac{n_1 x^2}{3}, \quad \frac{n_1 x^3}{4}$$

where n_1 is the number of groups with 1 unit, and the successive terms those with 2, 3, 4, etc., units. The series is discontinuous and has an infinite number of terms.

The sum of all terms to infinity, which is the total number of groups, is given by:

$$S = \frac{n_1}{x}(-\ln(1-x)) \qquad \text{(L1)}$$

This is finite if $x < 1$; that is to say, the series is then convergent. The total number of units, N, is given by:

$$N = \frac{n_1}{(1-x)} \qquad (L2)$$

If S and N are known, n_1 and x, and hence the whole series, can be calculated.

For equations L1 and L2 it follows that the average number of units per group (N/S) is given by:

$$\frac{N}{S} = \frac{x}{(1-x)(-\ln(1-x))} \qquad (L3)$$

Thus for any average number of units per group there is only one possible value of x; when this has been calculated, n_1 can be obtained by multiplying N by (1-x).

Equation L3 may be solved for x using methods described by Herdan[275a] and Chatfield et al[276]. The method relies upon solving the equation with trial values of x to make the right hand expression equal to the observed value of N/S. Coile[171] has developed a BASIC program to achieve this; for the present study this program has been modified for the EG3003 system and is given in Figure 93. An example run to determine x (Fisher's Constant) for the original Cephalosporins data set is given in Figure 94.

Figure 95 gives a BASIC program, modified from that given by Coile, to calculate Fisher's logarithmic series distribution. The program uses the terminology P for total patents instead of N, A for total patentees instead of S, and X for Fisher's Constant determined as above. An example run, using the original Cephalosporins data set is given in Figure 96.

```
10 REM DETERMINATION OF FISHER'S CONSTANT, X
20 REM TOTAL NUMBER OF PAPERS = N (I.E. BASIC PATENTS)
30 REM TOTAL NUMBER OF PATENTEES = S
40 REM DETERMINE X BY TRIAL, USING VALUES UNTIL CALCULATED
50 REM VALUE OF N/S APPROXIMATES OBSERVED VALUE
60 CLS:CLEAR 1000
70 INPUT "TOTAL NUMBER OF PATENTS = ";N
80 INPUT "TOTAL NUMBER OF PATENTEES = ";S
90 LET Q=N/S:PRINT:PRINT
100 PRINT "OBSERVED VALUE OF N/S = ";Q
110 PRINT:PRINT
120 INPUT "TRIAL VALUE OF X = ";X
130 LET Z=(1-X):LET T=(-LOG(Z))
140 LET R=Z*T:LET W=X/R
150 PRINT:PRINT"CALCULATED VALUE OF S/N = ";W;
    "(OBS. S/N = ";Q;")"
160 PRINT:PRINT "FOR ANOTHER ITERATION ENTER"
170 PRINT"'0'; FOR ANOTHER SERIES OF TRIALS"
180 INPUT "ENTER "1"; TO STOP ENTER '2'";Y
190 IF Y=0GOTO110
200 IF Y=1GOTO60
210 IF Y=2GOTO999
999 PRINT "NORMAL END OF JOB":END
```

Figure 93: Program in BASIC to determine Fisher's Constant

```
TOTAL NUMBER OF PATENTS? 2599
TOTAL NUMBER OF PATENTEES? 192

OBSERVED VALUE OF N/S = 13.5365

TRIAL VALUE OF X = ? .98
CALCULATED VALUE OF N/S = 12.5255 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?0

TRIAL VAULE OF X = ? .982
CALCULATED VALUE OF N/S = 13.5799 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?0

TRIAL VALUE OF X = ? .9818
CALCULATED VALUE OF N/S = 13.4619 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?0

TRIAL VALUE OF X = ? .9819
CALCULATED VALUE OF N/S = 13.5221 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'? 0

TRIAL VALUE OF X = .98192
CALCULATED VALUE OF N/S = 13.5337 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?0

TRIAL VALUE OF X = ?.98193
CALCULATED VALUE OF N/S = 13.5394 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?0

TRIAL VALUE OF X = ?.981925
CALCULATED VALUE OF N/S = 13.5365 (OBS. N/S = 13.5365)

FOR ANOTHER ITERATION ENTER
'0'; FOR ANOTHER SERIES OF TRIALS
ENTER '1'; TO STOP ENTER '2'?2

END OF JOB
```

Figure 94: Computer run to determine Fisher's Constant for Original Cephalosporins Data Set

```
10 REM FISHER'S LOGARITHMIC SERIES DISTRIBUTION
20 REM COILE'S PROGRAM (P.128, TABLE F-5) MODIFIED
30 REM FOR EG3003 BY M D DIXON
31 REM P = TOTAL NUMBER OF PATENTS
32 REM A = TOTAL NUMBER OF PATENTEES
33 REM X = CONSTANT DETERMINED TO MAKE W=Q
34 REM Q = P/A
40 CLS: INPUT "TOTAL NUMBER OF PATENTS = ";P
41 INPUT "TOTAL NUMBER OF PATENTEES = ";A
42 INPUT "FISHER'S CONSTANT (X) = ";X
60 LET W = (-1)*X/(1-X)/LOG(1-X)
70 LET Q=P/A
80 PRINT:PRINT
90 PRINT "CALCULATED VALUE (W) FOR P/A = ";W
91 PRINT "OBSERVED VALUE (Q) FOR P/A = ";Q
92 PRINT:PRINT "ARE W AND Q SUFFICIENTLY CLOSE"
93 PRINT "TO PROCEED WITH THE CALCULATION"
94 INPUT "TYPE IN 'YES' OR 'NO'";A$
95 IF LEFT$(A$,1) = "Y" GOTO 105
96 IF LEFT$(A$,1) = "y" GOTO 105
97 IF LEFT$(A$,1) = "N" GOTO 999
98 IF LEFT$(A$,1) = "n" GOTO 999
105 CLS:LET B=P*(1-X)
106 PRINT "FISHER'S DISTRIBUTION IS :- ":PRINT
108 LET C = B*X/2
110 LET D = B*X^2/3
120 LET E = B*X^3/4
130 LET F = B*X^4/5
140 LET G = B*X^5/6
150 LET H = B*X^6/7
160 LET I = B*X^7/8
170 LET J = B*X^8/9
180 LET K = B*X^9/10
190 LET L = B*X^10/11
200 LET M = B*X^11/12
210 LET N = B*X^12/13
220 LET O = B*X^13/14
230 LET R = B*X^14/15
240 LET S = B*X^15/16
250 LET T = B*X^16/17
260 LET U = B*X^17/18
270 LET V = B*X^18/19
280 LET W = B*X^19/20
290 LET Y = B*X^20/21
300 PRINT B,C,D,E
310 PRINT F,G,H,I
320 PRINT J,K,L,M
330 PRINT N,O,R,S
340 PRINT T,U,V,W
350 PRINT Y
360 PRINT:PRINT "TO RE-RUN PROGRAM ENTER 0"
370 INPUT "TO STOP PROGRAM ENTER 1";Z
380 IF Z=0 THEN 10 ELSE 999
999 PRINT "END OF JOB":END
```

Figure 95: Program in BASIC to calculate Fisher's Logarithmic Series Distribution

```
TOTAL NUMBER OF PATENTS = ?2599
TOTAL NUMBER OF PATENTEES = ?192
FISHER'S CONSTANT (X) = ?.981925

CALCULATED VALUE (W) FOR P/A =113.5365
OBSERVED VALUE (Q) FOR P/A = 13.5365
ARE W AND Q SUFFICIENTLY CLOSE
TO PROCEED WITH THE CALCULATION
TYPE IN 'YES' OR 'NO'?YES

FISHER'S DISTRIBUTION IS :-

46.9769      23.0639      15.098       11.1188
8.7343       7.14702      6.01529      5.16825
4.51096      3.98648      3.55857      3.20306
2.90323      2.64713      2.426        2.23327
2.06391      1.91401      1.7805       1.6609
1.55231

TO RE-RUN PROGRAM ENTER 0
TO STOP PROGRAM ENTER 1?1
END OF JOB
```

Figure 96: Computer run to calculate Fisher's Logarithmic Series Distribution for Original Cephalosporins Data Set

APPENDIX XVI: SHOCKLEY'S LOGNORMAL DISTRIBUTION

In 1957, Shockley[166] reported on a study of the scientific productivity of physicists in several research institutes. Using graphic techniques he showed that the cumulative distribution of the number of journal publications on a logarithmic scale (to the base 10) versus cumulative number of authors on a linear scale indicated a more or less normal distribition of the logarithm of rate of publication, i.e., a "log-normal" distribution. However, Shockley described some of these lognormal fits as "very jumpy". Shockley was able to demonstrate similar lognormal distributions for patent applications filed during five and ten year periods respectively by physicists at two large industrial laboratories.

Following procedures outlined by Bliss[277], Coile[171] developed a computer program in BASIC to calculate lognormal estimates of the numbers of authors publishing papers. In this program the lognormal distribution is fitted to discrete data by placing class boundaries such as 0.5, 1.5, 2.5, 3.5, etc., midway between successive integers, transforming these boundaries to logarithms, and assuming that the frequency, F, in each interval is concentrated halfway between the transformed boundaries. Above 5, grouping is introduced with class boundries that increase by an approximately uniform percentage of about 40%, and the pooled frequencies in each interval assigned a value halfway between class boundaries in logarithms; class boundaries of 5.5, 7.5, 10.5, 14.5, 20.5, 28.5, 39.5, 55.5, 77.5 and 108.5 are used.

The mean $\bar{y}$ (M in computer notation) and variance σ^2 (S^2 in computer notation) are computed from the log-midpoints, Y, of the grouped distribution. The point of truncation is at K_o = log 0.5 = -0.301031, and the logs of the mid points of the smaller classes are -0.0624695, 0.287016, 0.471005, etc. The mean is

$$M = \frac{\Sigma(FY)}{\Sigma F}$$

where F is frequency

and Y is midpoint of logs of class boundaries

The variance S^2 is

$$S^2 = \frac{\Sigma(FY^2) - \frac{(\Sigma FY)^2}{F}}{\Sigma F - 1}$$

Bliss stated that proposed improvements to this rather arbitrary procedure seem to be second order corrections and did not adopt them.

Bliss estimated the parameters of the complete normal population in units of the variate Y from the first and second moments of the truncated sample. With the point of truncation K_o equal to -0.301031, Cohen's[278] ratio γ (N in computer notation)

$$N = \frac{S^2}{(M - K_o)}$$

is entered in a table given by Cohen (and reproduced by Coile[171]), to obtain by interpolation Cohen's auxiliary estimation function Θ (H in computer notation). The population mean $\bar{\mu}$ (D in computer notation) is then estimated as

$$D = M - H\,(M - K_o)$$

and its variance $\hat{\sigma}^2$ (V in computer notation) as

$$V = S^2 + H\,(M - K_o)$$

with standard deviation $\hat{\sigma} = \sqrt{\sigma^2}$

To obtain the expected frequencies, first the class limits Y_L are converted to standard measure

$$X_L = -\left(\frac{\hat{\mu}}{\hat{\sigma}}\right) + \frac{Y_L}{\hat{\sigma}}$$

or in computer notation

$$X_L = \frac{K_{(z)} - D}{\sqrt{V}}$$

The program thus generates a table of Y(L) and X(L). This program has been modified to run on the EG 3003 microcomputer, the program listing is given in Figure 97. Before running the program the observed frequency distribution is entered as a series of DATA elements in lines 650 to, if necessary, 890.

In Coile's studies, the proportionate areas for each X_L was then interpolated from a table of the normal probablity integral such as F(t) of Table 1 in Bennett and Franklin[279], however in the present study, the proportionate area was calculated using the NORMAL program written in BASIC by van Tassel[280]. The proportionate area was then multiplied by the total number of authors to obtain the cumulative expected frequencies in the truncated sample. Finally, the differences between successive terms are the expected frequencies for comparison with the observed frequencies.

A sample run using the modified Coile program with the original Cephalosporins data is given in Figure 98 and interpolation of the results obtained to give the expected frequency in Table 60.

```
10 REM SHOCKLEY'S LOGNORMAL DISTRIBUTION
20 REM COILE'S PROGRAM (P.152, TABLE H-3) MODIFIED FOR ANY
25 REM DATA SET AND FOR EG3003 SYSTEM BY M D DIXON
30 CLS:PRINT "***** IMPORTANT *****":PRINT:PRINT
40 PRINT "IF DATA NOT YET ENTERED PRESS <BREAK>"
50 PRINT "KEY AND LIST PROGRAM LINES 560-640."
60 FORC=1TO50STEP.01:NEXTC:CLS
70 INPUT "NO. OF SETS OF DATA";Q
80 DIM I(Q+1), K(Q+1), Y(Q+1)
90 REM COMPUTATION OF MID-POINTS OF LOGS
100 LET I1=0
110 FOR X=.5TO(Q+.5)
120 LETI1=I1+1
130 LETK(I1)=LOG(X)/2.30258
140 LETJ=LOG(X+1)/2.30258
150 REM I IS INTERVAL BETWEEN LOGS
160 LETI(I1)=J-K(I1)
170 REM Y IS MID-POINT OF LOGS OF X
180 LET Y(I1)=K(I1)+I(I1)/2
190 NEXTX
200 LET S1=S2=S3=S4=S5=S6=S7=S8=A1=A2=A3=A4=A5=T=0
210 FOR Z=1TOQ
```

Figure 97: Program in BASIC to calculate Shockley's Lognormal Series Distribution

```
220 REM F=FREQUENCY (OBSERVED AND INPUT AS DATA STATEMENTS
230 REM IN LINES 650 ONWARDS BEFORE RUNNING PROGRAM!!!!)
240 READF
250 LET S1=F*Y(Z)
260 LET S2=F*(Y(Z)[2)
270 LET S3=F*I(Z)
280 LET S4=F*(I(Z)[2)
290 REM A1=N=SUM OF F
300 LET A1=A1+F
310 LET A2=A2+S1
320 LET A3=A3+S2
330 LET A4=A4+S3
340 LET A5=A5+S4
350 NEXTZ
360 REM MEAN (M) IS SUM OF F*Y/N
370 LET M=A2/A1
380 LET S5=(A3-(A2[2)/(A1-1))
390 REM S6 IS VARIANCE S SQUARED
400 LET S6=S5/(A1-1)
410 REM S7 IS STANDARD DEVIATION
420 LET S7=SQR(S6)
430 REM E IS STANDARD ERROR
440 LET E=S7/SQR(A1)
450 PRINT "SUM OF FREQUENCIES N = ";A1
460 PRINT "MEAN Y                = ";M
470 PRINT "VARIANCE S SQUARED    = ";S6
480 PRINT "STANDARD DEVIATION    = ";S7
490 PRINT "STANDARD ERROR        = ";E:PRINT:PRINT
500 LET S8=S6-(A5)/12/A1
510 LET T=SQR(S8)
520 PRINT "ADJUSTED VARIANCE      = ";S8
530 PRINT "ADJUSTED STANDARD"
540 PRINT "          DEVIATION    = ";T
550 FOR W=1TO100STEP.01:NEXTW:CLS
560 REM ##########################################################
570 REM # BEFORE RUNNING THE OBSERVED FREQUENCIES, F,            #
580 REM # INCLUDING ZERO VALUES, MUST BE ENTERED AS DATA         #
590 REM # STATEMENTS COMMENCING IN LINE 650. FOR EXAMPLE         #
600 REM #              650 DATA 325                              #
610 REM #              660 DATA  155                             #
620 REM #              670 DATA 75                               #
630 REM #              680 DATA 0                                #
640 REM ##########################################################
900 CLS:LET N=S6/(M+.301031)[2
910 PRINT:PRINT"COHEN'S RATIO N = ";N:PRINT
920 PRINT "PLEASE INPUT COHEN'S AUXILLIARY"
930 INPUT "ESTIMATION FUNCTION THETA";H
940 FOR  Z=1TO(Q+1)
950 LET D=M-H*(M+.301031)
960 LET V=S6+H*(M+.301031)
970 LET R=(K(Z)-D)/SQR(V)
980 PRINT@842,"Y(L)";:PRINT@857,"X(L)"
990 PRINT@964,K(Z);:PRINT@979,R
1000 FORG=1TO50STEP.01:NEXTG
1010 NEXTZ
1020 END
```

Figure 97: Program in BASIC to calculate Shockley's Lognormal Series Distribution (continued)

```
***** IMPORTANT *****
IF DATA NOT YET ENTERED PRESS <BREAK>
KEY AND LIST PROGRAM LINES 560-640.

NO. OF SETS OF DATA?20

SUM OF FREQUENCIES N = 163
MEAN Y                = .270844
VARIANCE S SQUARED    = .161128
STANDARD DEVIATION    = .401408
STANDARD ERROR        = .0314407


ADJUSTED VARIANCE     =.150586
ADJUSTED STANDARD
       DEVIATION      =.388054

COHEN'S RATION N = .492685
ESTIMATION FUNCTION THETA?.566846

          Y(L)              X(L)
          1                 -.355583
          2                 .329318
          3                 .647779
          4                 .857543
          5                 1.01422
          6                 1.13932
          7                 1.24347
          8                 1.33268
          9                 1.41071
          10                1.48005
          11                1.54244
          12                1.59916
          13                1.65114
          14                1.69912
          15                1.74367
          16                1.78525
          17                1.82422
          18                1.86091
          19                1.89555
          20                1.92837
          21                1.95955

READY
>_
```

Figure 98: Computer run to calculate Shockley's Lognormal Series Distribution for Original Cephalosporins Data Set

X(L)	F(t)	PROPORTIONATE FREQUENCY	EXPECTED FREQUENCY
-0.355583	0.361076	0.267967	51.449664
0.329318	0.629043	0.112393	21.579456
0.647779	0.741436	0.062992	12.094464
0.857543	0.804428	0.040333	7.743936
1.01422	0.844761	0.027955	5.367360
1.13932	0.872716	0.020437	3.923904
1.24347	0.893153	0.015528	2.981376
1.33268	0.908681	0.012153	2.333376
1.41071	0.920834	0.009736	1.869312
1.48005	0.930570	0.007947	1.525824
1.54244	0.938517	0.006591	1.265472
1.59916	0.945108	0.005537	1.063104
1.65114	0.950645	0.004707	0.903744
1.69912	0.955352	0.004039	0.775488
1.74367	0.959391	0.003498	0.671616
1.78525	0.962889	0.003052	0.585984
1.82422	0.965941	0.002681	0.514752
1.86091	0.968622	0.002369	0.454848
1.89555	0.970991	0.002105	0.404160
1.92837	0.973096	0.001880	0.360960
1.95955	0.974976		

Table 60: Conversion of Shockley's Lognormal Series Program Output to Theoretical Frequency Distribution for Original Cephalosporins Data Set

APPENDIX XVII: THE BOREL-TANNER DISTRIBUTION

The Borel-Tanner Distribution describes the distribution of the total number of customers served before a queue vanishes under condition of a single queue with random arrival times (at constant rate λ), of customers and a constant time (β) occupied in serving each customer. It supposes that the probablity of arrival of a customer during the period $(t,t + (\Delta t))$ is $\lambda(\Delta t) + o(\Delta t)$ and that the probability of arrival of two, or more, customers in the period is $o(\Delta t)$. If there are initially M customers in the queue, then the probablity that the total number (x) of customers before the queue vanishes is equal to k is:

$$P(x=k) = \frac{M}{(k-M)!} k^{k-M-1} (\lambda\beta)^{k-M} e^{-\lambda\beta k}$$

$$k = M, M+1, M+2....; M \text{ is an integer}$$

For this equation to represent a proper distribution it is necessary that $\lambda\beta$ be less than 1. If $\lambda\beta>1$, then $\sum_{k=m}^{\infty} (x=k)<1$.

The parameters λ and β appear only as their product,$\lambda\beta$; it is convenient to use a single symbol, say α , for this product ($\alpha<1$). The distribution was obtained in 1943 by Borel[281] for the case M=1 in a consideration of the delay to pedestrians crossing a road, and for general values of M by Tanner[282] in 1953 in consideration of delays that occur when two opposing streams of vehicles are trying to pass along a length of road only wide enough for one vehicle at a time.

Haight and Breuer[176] have studied the Borel-Tanner distribution and have published tables of the cumulative distribution function $P(x\leqslant k)$ to five decimal places for M=1; α =0.01(0.01)0.62. Owen[283] has published similar tables whilst Haight[284] has described an analogous distribution. Rao[285] has written a program in FORTRAN for the Borel-Tanner distribution, however this was not suitable for the EG3003.

For this distribution:

$$\text{Mean} = M(1-\alpha)^{-1}$$
$$\text{Variance} = M(1-\alpha)^{-3}$$

The distribution can be calculated by equating α to the sample mean[172], since if M=1, $\alpha = \frac{\bar{x}-1}{\bar{x}}$

The EG 3003 program written to calculate the Borel-Tanner distribution is given in Figure 99; a computer run using the original Cephalosporins data as an example is given in Figure 100. In the program the sample mean is represented by M, the Borel-Tanner constant α by A, the number of patents per patentee as F and the frequency by R.

```
10 CLEAR 1000:CLS
20 REM BASIC PROGRAM TO CALCULATE BOREL-TANNER FREQUENCY
30 REM DISTRIBUTION FROM OBSERVED DISTRIBUTION
40 REM BY MICHAEL D DIXON, APRIL 1982
50 REM PROGRAM SECTOR FOR CALCULATING MEAN TAKEN FROM 'CLASS'
60 REM PROGRAM BY DENNIE VAN TASSEL.   SECTOR FOR CALCULATING
70 REM FACTORIALS FROM 'N!' PROGRAM ON P.199 IN
80 REM 'BASIC BASIC' BY COAN
110 DIM X(100),F(100),R(100)
120 REM INITIALISE
130 S=0:F=0:N=0:A=0:E=2.718282
140 PRINT:PRINT
150 PRINT "##########################"
160 PRINT "  DETERMINATION OF THE"
170 PRINT "       BOREL-TANNER"
180 PRINT " FREQUENCY DISTRIBUTION"
190 PRINT "##########################"
200 PRINT:PRINT
210 INPUT "HOW MANY DATA CLASSES";C
220 PRINT:INPUT "TOTAL NO. PATENTEES ";T
230 PRINT "FOR EACH CLASS GIVE:-"
240 PRINT "  THE VALUE      = X"
250 PRINT "  THE FREQUENCY = F"
260 FORH=1TO20STEP.01:NEXTH:CLS
270 FORI=1TOC:PRINT "FOR CLASS NO. ";I
280 INPUT " X = ";X(I)
290 INPUT " F = ";F(I)
300 N=N+F(I)
310 S=S+X(I)*F(I)
320 NEXTI
330 REM CALCULATE AND DISPLAY MEAN (M)
340 M=S/N
350 PRINT "CALCULATED VALUE OF MEAN = ";M
360 REM CALCULATE AND DISPLAY BOREL-TANNER CONSTANT (A)
370 A=(M-1)/M
380 PRINT "CALCULATED VALUE BOREL-TANNER"
390 PRINT "                  CONSTANT (A) = ";A
400 REM CALCULATE THEORETICAL DISTRIBUTION INITIAL CLASS
410 R(1)=T*(E[-A)
420 REM CALCULATE DISTRIBUTION FOR REMAINING CLASSES
430 FORI=2TOC
440 REM CALCULATE (X-M)!
450 LET F=1:FORX=(I-1)TO1STEP-1:LETF=F*X:NEXTX
460 REM SUBSTITUTE VALUES IN EQUATION
470 R(I)=T*(1/F)*I[(I-2)*A[(I-1)*E[(-A*I)
480 NEXTI
490 REM DISPLAY RESULTS
500 PRINT TAB(3) "CLASS";:PRINT TAB(13) "FREQUENCY"
510 FORI=1TOC
520 PRINT TAB(5) I;
530 PRINT USING "####.####" TAB(13) R(I)
540 FORH=1TO25STEP.01:NEXTH
550 NEXTI
560 PRINT:PRINT "DO YOU WANT TO DO ANOTHER"
570 INPUT "CALCULATION (YES/NO)";V$
580 IF LEFT$(V$,1)="Y"THEN10ELSE590
590 CLS:PRINT:PRINT  "NORMAL END OF JOB"
999 END
```

Figure 99: Program in BASIC to calculate the Borel-Tanner Frequency Distribution

```
##########################
  DETERMINATION OF THE
       BOREL-TANNER
 FREQUENCY DISTRIBUTION
##########################

HOW MANY DATA CLASSES?20

TOTAL NUMBER OF PATENTEES ?192

FOR EACH CLASS GIVE:-
  THE VALUE      = X
  THE FREQUENCY = F

FOR CLASS NO. 1
 X = ?1
 F = ?83
FOR CLASS NO. 2
 X = ?2
 F = ?24
FOR CLASS NO. 3
 X = ?3
 F = ?16
FOR CLASS NO. 4
 X = ?4
 F = ?8
FOR CLASS NO. 5
 X = ?5
 F = ?5
FOR CLASS NO. 6
 X = ?6
 F = ?6
FOR CLASS NO. 7
 X = ?7
 F = ?2
FOR CLASS NO. 8
 X = ?8
 F = ?5
FOR CLASS NO. 9
 X = ?9
 F = ?1
FOR CLASS NO. 10
 X = ?10
 F = ?1
FOR CLASS NO. 11
 X = ?11
 F = ?1
FOR CLASS NO. 12
 X = ?12
 F = ?1
FOR CLASS NO. 13
 X = ?13
 F = ?3
FOR CLASS NO. 14
 X = ?14
 F = ?2
FOR CLASS NO. 15
 X = ?15
 F = ?1
FOR CLASS NO. 16
 X = ?16
 F = ?1
FOR CLASS NO. 17
 X = ?17
 F = ?3
FOR CLASS NO. 18
 X = ?18
 F = ?0
FOR CLASS NO. 19
 X = ?19
 F = ?0
FOR CLASS NO. 20
 X = ?20
 F = ?0

CALCULATED VALUE OF
MEAN = 3.17178

CALCULATED VALUE
BOREL-TANNER
CONSTANT (A) = .68472

 CLASS        FREQUENCY
   1           96.8125
   2           33.4252
   3           17.3105
   4           10.6250
   5            7.1648
   6            5.1294
   7            3.8278
   8            2.9447
   9            2.3187
  10            1.8597
  11            1.5140
  12            1.2478
  13            1.0392
  14            0.8731
  15            0.7391
  16            0.6299
  17-           0.5399
  18            0.4652
  19            0.4027
  20            0.3500

DO YOU WANT TO DO ANOTHER
CALCULATION (YES/NO)? NO

NORMAL END OF JOB
```

Figure 100: Computer run to calculate the Borel-Tanner Distribution for Original Cephalosporin Data Set

APPENDIX XVIII: THE NEGATIVE BINOMIAL DISTRIBUTION

Special forms of the Negative Binomial distribution were discussed by Pascal[286] in 1679. There is a derivation by Montmort[287], published in 1714. 'Student'[288] in 1907, used the distribution as an alternative to the Poisson distribution in describing counts in the plates of a haemacytometer.

Greenwood and Yule[289] in 1920 obtained the distribution as a consequence of certain simple assumptions in accident proneness models, while Eggenberger and Polya[290], in 1923, obtained the distribution as a limiting case of an 'urn-scheme'.

Since this time, there has been an increasing number of applications of the Negative Binomial, and an associated development of statistical techniques based on this distribution.

The expression for the Negative Binomial distribution is:

$$P(x) = \frac{\Gamma(c+x-1)}{\Gamma(c)\ \Gamma(x)} \times \frac{c}{w+c}^{c} \times \frac{w}{w+c}^{(x-1)}$$

where P(x) is the probablity of an author producing x articles, Γ is a gamma function, and c, w >0.

The number of authors expected producing x articles is given by:

P(x) x total authors

The mean of the Negative Binomial distribution is w, and the variance is given by $\frac{w\ (w+c)}{c}$. Now, since the Negative Binomial distribution starts at x = 0, while the author productivity distribution starts at x = 1, sample mean = w + 1. Hence:

$$\bar{x} = w + 1$$

and $$S^2 = \frac{(\bar{x} - 1)\ ((\bar{x} - 1) + c)}{c}$$ where $\bar{x}$ is sample mean and S^2 is sample variance

Thus w and c can be calculated from:

$$w = \bar{x} - 1 \qquad \text{(NB1)}$$

$$c = \frac{(\bar{x} - 1)^2}{s^2 - (\bar{x} - 1)} \qquad \text{(NB2)}$$

The Negative Binomial distribution is frequently used as a substitute for the Poisson distribution when it is doubtful whether the strict requirements, particularly independance, for a Poisson distribution will be satisfied. The occurrence of Negative Binomial distributions as mixtures of Poisson distributions has already been noted.

Among specific fields where Negative Binomial distributions have been found to provide useful representations may be mentioned accident statistics (Arbous and Kerrich[291], Greenwood and Yule[289]), in birth-and-death processes (Furry[292], Kendall[293]), in psychological data (Sichel[294]), in demand (by households) for 'frequently bought products', observed distributions of consumer expenditure (Chatfield et al.[276]), and as weights (lag distributions) for times series in economics (Solow[295]). Medical and military applications have been described by Chew[296] and by Bennett and Birch[297].

O'Neill[298] found that the Negative Binomial distribution fitted the number of interlibrary loan requests for journals which could not be filled in Western New York; Altman and Lazorick[299] have proposed the use of this distribution to describe interlibrary loan journal photocopying; and Lazorick[300] has applied it to the frequencies with which groups of books with defined characteristics are likely to be used in a research library. Tague and Farradane[301] have successfully used the Negative Binomial in a study of literature retrieval effectiveness measures.

Bird[302] has examined five different indexing systems and found that a reasonable statistical fit could be made to the Negative Binomial distribution. Brand[267] has found that the Negative Binomial distribution did not fit author productivity data from Geo Abstracts for the 1966-75 period.

It may be noted that the Negative Binomial distribution is a mathematical representation of the "success-breeds-success" phenomenon; Rao has derived the Negative Binomial distribution by assuming that the probability that an author of x papers will publish one more between time t and t + dt, is a linear funtion of x. Rao also shows that the Negative Binomial distribution describes a pattern of scientific productivity under a wide range of social conditions.

Davies[303], Brand[267], Wyshak[304] and Rao[285] have each derived programs, written in FORTRAN IV, to determine Negative Binomial distributions. However, because of the limitations of the microcomputer available for this study, a further program in BASIC has been written. The program is listed in Figure 101; the basis of the calculations is as follows: the required values of sample mean and sample variance may be found as follows: Patentee productivity data of number of patentees observed contributing x basic patents is a frequency distribution, such that number of basic patents x_1 x_2 ... have respective frequencies f_1 f_2 ..., (where f_1 f_2 ... are numbers of patentees observed). The mean of the frequency distribution is $\frac{\Sigma fx}{\Sigma f}$ and the variance is: $\frac{\Sigma fx^2 - \bar{x}^2}{\Sigma f}$

Therefore $\bar{x} = \frac{\Sigma(\text{patentees observed x patents})}{\text{total patentees}}$

and $S^2 = \frac{\Sigma\ (\text{patentees observed x (patents)}^2)}{\text{total patentees}} - \bar{x}^2$

The values of x and S^2 are then substituted in the equations NB1 and NB2 given above.

A computer run using the original Cephalosporins data as an example is given in Figure 102.

```
10 CLEAR10000
20 REM BASIC PROGRAM TO CALCULATE NEGATIVE BINOMIAL FREQUENCY
30 REM DISTRIBUTION FROM OBSERVED FREQUENCY DISTRIBUTION.   BY
40 REM MICHAEL D. DIXON, MARCH/APRIL, 1982.
50 REM PROGRAM SECTOR FOR CALCULATING MEAN AND VARIANCE (LINES
60 REM 250-400) ADAPTED FROM 'CLASS' PROGRAM BY VAN TASSEL
70 REM CALCULATION OF 'W' AND 'K' AS PER S. BRAND MSC THESIS
80 REM CITY UNIVERSITY, 1980.   CALCULATION OF THEORETICAL
90 REM DISTRIBUTION ADAPTED FROM FORTRAN IV PROGRAM, PP366-375
100 REM IN 'COMPUTER PROGRAMMING IN QUANTITATIVE BIOLOGY' BY
105 REM R. G. DAVIES, ACADEMIC PRESS, LONDON 1971.
108 CLS
110  DIM X(100),F(100),W(100)
120 S=0:Q=0:N=0:K=0:P=0:R=0:G=0:U=0
```

Figure 101: Program in BASIC to calculate the Negative Binomial Frequency Distribution

```
130 PRINT:PRINT
140 PRINT "##########################"
150 PRINT " DETERMINATION OF THE"
160 PRINT "  NEGATIVE BINOMIAL"
170 PRINT "FREQUENCY DISTRIBUTION"
180 PRINT "##########################"
190 PRINT:PRINT
200 INPUT "HOW MANY CLASSES";C:INPUT "TOTAL PATENTEES";T
210 PRINT:PRINT
220 PRINT " FOR EACH CLASS GIVE:-"
230 PRINT"    THE VALUE      = X"
240 PRINT"      THE FREQUENCY = F"
250 FOR H=1TO20STEP.01:NEXTH:CLS
260 FORI=1TOC
270 PRINT "FOR CLASS NO. ";I
280 INPUT " X = ";X(I)
290 INPUT " F = ";F(I)
300 N=N+F(I)
310 S=S+X(I)*F(I)
320 Q=Q+F(I)*X(I)[2
330 NEXT I
340 REM CALCULATE MEAN
350 M=S/N
360 REM CALCULATE VARIANCE
370 V=(Q-S[2/N)/N
380 REM DISPLAY MEAN AND VARIANCE
390 PRINT "MEAN      = ";M
400 PRINT "VARIANCE = ";V
480 P=M-1
490 PRINT "CALCULATED VALUE OF W = ";P
500 K=(P[2)/(V-(M-1))
1060 REM CALCULATE THEORETICAL DISTRIBUTION
1080 PRINT "CALCULATED VALUE OF K = ";K
1090 W(1)=N/((1+(M-1)/K)[K)
1100 SW=W(1)
1110 FOR I=2TOC
1120 U=(I-1)
1130 W(I)=W(I-1)*(K+(U-1))*(M-1)/(K+(M-1))/U
1140 SW=SW+W(I)
1150 W(C+1)=T-SW
1160 NEXT I
1170 REM DISPLAY THEORETICAL DISTRIBUTION
1180 PRINT TAB(5) "CLASS";
1190 PRINT TAB(15) "FREQUENCY"
1195 FOR I=1TO(C+1)
1200 PRINT TAB(7) I;
1210 PRINT  TAB(16) USING "####.####";W(I)
1212 FORJ=1TO20STEP.01:NEXTJ
1215 NEXT I
1220 PRINT
1230 PRINT "DO YOU WISH TO CALCULATE"
1240 INPUT "ANOTHER DISTRIBUTION";W$
1250 IF LEFT$(W$,1)="Y"THEN1260ELSE1270
1260 CLS:GOTO10
1270 PRINT "NORMAL END OF JOB"
1280 FOR D=1TO25STEP.01:NEXTD:CLS
9999 END
```

Figure 101: Program in BASIC to calculate the Negative Binomial Frequency Distribution (continued)

```
##########################
 DETERMINATION OF THE
   NEGATIVE BINOMTAL
FREQUENCY DISTRIBUTION
##########################


HOW MANY CLASSES?20
TOTAL PATENTEES?192

FOR EACH CLASS GIVE:-
   THE VALUE      = X
   THE FREQUENCY = F

FOR CLASS NO. 1
 X = ?1
 F = ?83
FOR CLASS NO. 2
 X = ?2
 F = ?24
FOR CLASS NO. 3
 X = ?3
 F = ?16
FOR CLASS NO. 4
 X = ?4
 F = ?8
FOR CLASS NO. 5
 X = ?5
 F = ?5
FOR CLASS NO. 6
 X = ?6
 F = ?6
FOR CLASS NO. 7
 X = .?7
 F = ?2
FOR CLASS NO. 8
 X = ?8
 F = ?5
FOR CLASS NO. 9
 X = ?9
 F = ?1
FOR CLASS NO. 10
 X = ?10
 F = ?1
FOR CLASS NO. 11
 X = ?11
 F = ?1
FOR CLASS NO. 12
 X = ?12
 F = ?1
FOR CLASS NO. 13
 X = ?13
 F = ?3
FOR CLASS NO. 14
 X = ?14
 F = ?2
FOR CLASS NO. 15
 X = ?15
 F = ?1
FOR CLASS NO. 16
 X = ?16
 F = ?1
FOR CLASS NO. 17
 X = ?17
 F = ?3
FOR CLASS NO. 18
 X = ?18
 F = ?0
FOR CLASS NO. 19
 X = ?19
 F = ?0
FOR CLASS NO. 20
 X = ?20
 F = ?0
MEAN      = 3.17178
VARIANCE = 13.8846
CALCULATED VALUE OF W = 2.17178
CALCULATED VALUE OF K = .402689

      CLASS      FREQUENCY
        1          77.2208
        2          26.2320
        3          15.5200
        4          10.4857
        5           7.5246
        6           5.5894
        7           4.2457
        8           3.2760
        9           2.5572
       10           2.0141
       11           1.5975
       12           1.2745
       13           1.0216
       14           0.8222
       15           0.6640
       16           0.5379
       17           0.4368
       18           0.3555
       19           0.2900
       20           0.2369

DO YOU WISH TO CALCULATE
ANOTHER DISTRIBUTION?NO
NORMAL END OF JOB
```

Figure 102: Computer run to calculate the Negative Binomial Distribution for Original Cephalosporins Data Set

APPENDIX XIX: THE KOLMOGOROV-SMIRNOV ONE-SAMPLE TEST

The Kolmogorov-Smirnov test has been described by Birnbaum[205,206], Birnbaum and Tingey[307], Goodman[308], Massey[309], and Siegel[173]. Also, Robertson[253] has confirmed Coile's view that the test is more suitable than the χ^2 test for goodness of fit in studies of frequency distributions on scientific productivity.

The test is concerned with the degree of agreement between the distribution of a set of sample values (observed scores) and a specified theoretical distribution. It determines whether the scores in the sample can reasonably be considered to have come from a population having the theoretical distribution.

To achieve this, the test involves specifying the cumulative freqency distribution which would occur under the theoretical distribution and comparing that with the observed cumulative frequency distribution. The point at which these distributions show the greatest divergence is determined. Reference to the sampling distribution indicates whether a divergence of the magnitude calculated is likely on the basis of chance.

Let $F_o(X)$ represent the theoretical cumulative frequency distributions. For any value of X, the number of patents, the value of $F_o(X)$ is the fraction of total patentees predicted to have X or fewer patents. $S_N(X)$ represents the observed cumulative frequency distrubution of the total of N patentees.

Under the null hypothesis that the sample has been drawn from the theoretical distribution, it is expected that for every value of X, $S_N(X)$ should be fairly close to $F_o(X)$; that is to say the differences between $S_N(X)$ and $F_o(X)$ are expected to be small and within the limits of random errors. The Kolmogorov-Smirnov tests these absolute value differences; the largest value of $F_o(X) - S_N(X)$ is called the maximum deviation, D, which is:

$$D = \text{maximum} \left| F_o(X) - S_N(X) \right|$$

Massey[309] gives critical values of D which are reproduced in Table 62.

Sample Size (N)	Level of Significance for D = maximum $\lvert F_o(X) - S_n(X) \rvert$		
	.10	.05	.01
1	.950	.975	.995
2	.776	.842	.929
3	.642	.708	.828
4	.564	.624	.733
5	.510	.565	.669
6	.470	.521	.618
7	.438	.486	.577
8	.411	.457	.543
9	.388	.432	.514
10	.368	.410	.490
11	.352	.391	.468
12	.338	.375	.450
13	.325	.361	.433
14	.314	.349	.418
15	.304	.338	.404
16	.295	.328	.392
17	.286	.318	.381
18	.278	.309	.371
19	.272	.301	.363
20	.264	.294	.356
25	.24	.27	.32
30	.22	.24	.29
35	.21	.23	.27

Table 61: Critical Values of D in the Kolmogorov-Smirnov One-Sample Test (Adapted from Massey[309])

If N, the sample size, is greater than 35, critical values of D are calculated as follows:

$$\text{At 0.10 Level of Significance, } D = 1.22/\sqrt{N}$$
$$\text{At 0.05 Level of Significance, } D = 1.36/\sqrt{N}$$
$$\text{At 0.01 Level of Significance, } D = 1.63/\sqrt{N}$$

Using the observed Cephalosporins (original set) data and the theoretical distribution determined by the Negative Binomial frequency distribution, Table 63 illustrates how D may be calculated.

Brand[267] has described a computer program, written in FORTRAN IV, to perform the Kolmogorov-Smirnov Test. For the present study a program, given in Figure 103, has been written in BASIC which will calculate D and the corresponding critical values, for up to 100 pairs of theoretical and observed data. The program places the observed and theore-

PATENTS PER PATENTEE	THEORETICAL %	$F_o(X)$	OBSERVED %	$S_N(X)$	$F_o(X)-S_N(X)$
1	40.22	0.4022	43.23	0.4323	-0.0301
2	13.66	0.5388	12.50	0.5573	-0.0185
3	8.08	0.6196	8.33	0.6406	-0.0210
4	5.46	0.6742	4.17	0.6823	-0.0081
5	3.92	0.7134	2.60	0.7083	0.0051
6	2.91	0.7425	3.13	0.7396	0.0029
7	2.21	0.7646	1.04	0.7500	0.0146
8	1.71	0.7817	2.60	0.7760	0.0057
9	1.33	0.7950	0.52	0.7812	0.0138
10	1.05	0.8055	0.52	0.7864	0.0191
11	0.83	0.8138	0.52	0.7916	0.0222
12	0.66	0.8204	0.52	0.7968	0.0236
13	0.53	0.8257	1.56	0.8124	0.0133
14	0.43	0.8300	1.04	0.8228	0.0072
15	0.35	0.8335	0.52	0.8280	0.0055
16	0.28	0.8363	0.52	0.8332	0.0031
17	0.23	0.8386	1.56	0.8488	-0.0102
18	0.19	0.8405	0.00	0.8488	-0.0083
19	0.15	0.8420	0.00	0.8488	-0.0068
20	0.12	0.8432	0.00	0.8488	-0.0056

$D_{max} = 0.0301$ N = 192

0.10 Level of significance = 1.22 / $\sqrt{192}$ = 0.0880
0.05 Level of significance = 1.36 / $\sqrt{192}$ = 0.0981
0.01 Level of significance = 1.63 / $\sqrt{192}$ = 0.1176

Table 62: Determination of Kolomogorov-Smirnov D_{max} for Cephalosporins Original Data set observed Frequency Distribution and Negative Binomial Theoretical Frequency Distribution

tical distributions in arrays and, having calculated $F_o(X) - S_N(X)$, sorts these values in ascending order. The highest values, i.e., D_{max}, is selected and printed together with the critical values at 0.1, 0.05 and 0.01 levels of significance. The validity of the program was checked by comparing results with selected mathematical calculations of D. The computer determination of D_{max} for the original set of Cephalosporin data and the calculated Negative Binomial distribution is given in Figure 104.

```
10 CLEAR 10000
20 CLS
30 REM SET ARRAYS
40 DIM O(100),E(100),D(100),T(100),Z(100)
50 PRINT "  **************************"
60 PRINT"   CALCULATION OF D(MAX) FOR"
70 PRINT "       KOLMOGOROV-SMIRNOV"
80 PRINT "          ONE SAMPLE TEST"
90 PRINT "  **************************"
100 PRINT:PRINT:PRINT
110 PRINT "ARE YOU READY TO"
120 INPUT"  INPUT YOUR DATA (YES/NO)";A$
130 IF LEFT$(A$,1)="Y" THEN 140 ELSE 110
140 CLS
150 INPUT"TOTAL NUMBER PATENTEES";N
160 PRINT:INPUT"NUMBER OF PAIRS OF DATA";Q
170 PRINT:PRINT"PLEASE INPUT YOUR DATA"
180 FOR I=1TOQ
190 PRINT:PRINT "PAIR";I
200 INPUT "OBSERVED FREQUENCY = ";O
210 O(I)=O/N
220 INPUT "EXPECTED FREQUENCY = ";E
230 E(I)=E/N
240 NEXT I
250 REM CALCULATE FO(X), SET IN ARRAY D
260 FOR I=1TOQ
270 D(I)=0
280 D(I)=O(I)+D(I-1)
290 NEXT I
300 REM CALCULATE SN(X), SET IN ARRAY T
310 T(I)=0
320 T(I)=E(I)+T(I-1)
330 NEXT I
340 REM CALCULATE ABSOLUTE VALUE OF
350 REM (FO(X)-SN(X)),SET IN ARRAY Z
360 FOR I=1TOQ
370 LET Z(I)=ABS(D(I)-T(I))
380 NEXT I
390 REM SORT Z(I) VALUES INTO ASCENDING ORDER
400 FOR I=1TO(Q-1)
410 FOR J=QTO(I+1)STEP-1
420 IF Z(J)<=Z(J-1) THEN 460
430 LET F=Z(J-1)
440 LET Z(J-1)=Z(J)
450 LET Z(J)=F
460 NEXT J
470 NEXT I
480 REM SELECT HIGHEST VALUE OF Z(I), I.E., D(MAX)
490 FOR I=1TOQSTEP-Q
500 CLS
510 PRINT:PRINT "D(MAX) = ";
515 PRINT USING "#.####";Z(I)
516 PRINT "================"
520 REM CALCULATE AND DISPLAY CRITICAL VALUES OF D(MAX)
530 PRINT "CRITICAL VALUES OF D (WHEN"
```

Figure 103: Program in BASIC to determine D_{max} for Kolmogorov-Smironov One Sample Test

```
540 PRINT"N IS >=35 - ELSE REFER TO"
550 PRINT "TABLES) ARE :-"
560 PRINT
570 PRINT "AT 0.10 SIGNIFICANCE"
580 PRINT "                LEVEL = ";
585 PRINT USING "#.####";1.22/SQR(N)
590 PRINT "AT 0.05 SIGNIFICANCE"
600 PRINT "                LEVEL = ";
605 PRINT USING "#.####";1.36/SQR(N)
610 PRINT "AT 0.01 SIGNIFICANCE"
620 PRINT "                LEVEL = ";
625 PRINT USING "#.####";1.63/SQR(N)
630 PRINT
640 PRINT "DO YOU WANT TO RUN ANOTHER"
650 INPUT "TEST? TYPE 'YES' OR 'NO'";B$
660 IF LEFT$(B$,1)="Y" THEN 140 ELSE 670
670 PRINT "END OF JOB"
680 FOR P=1TO10STEP.01:NEXTP:CLS
999 END
```

Figure 103: Program in BASIC to determine D_{max} for Kolmogorov-Smironov One Sample Test (continued)

```
**************************
 CALCULATION OF D(MAX) FOR
    KOLMOGOROV-SMIRNOV
      ONE SAMPLE TEST
**************************

ARE YOU READY TO
INPUT YOUR DATA (YES/NO)? YES

TOTAL NUMBER OF PATENTEES? 192

NUMBER OF PAIRS OF DATA? 20

PLEASE INPUT YOUR DATA

PAIR 1
OBSERVED FREQUENCY = ?83
EXPECTED FREQUENCY = ?77.2208

PAIR 2
OBSERVED FREQUENCY = ?24
EXPECTED FREQUENCY = ?26.232

PAIR 3
OBSERVED FREQUENCY = ?16
EXPECTED FREQUENCY = ?15.52

PAIR 4
OBSERVED FREQUENCY = ?8
EXPECTED FREQUENCY = ?10.4857

PAIR 5
OBSERVED FREQUENCY = ?5
EXPECTED FREQUENCY = ?7.5246

PAIR 6
OBSERVED FREQUENCY = ?6
EXPECTED FREQUENCY = ?5.5894

PAIR 7
OBSERVED FREQUENCY = ?2
EXPECTED FREQUENCY = ?4.2457

PAIR 8
OBSERVED FREQUENCY = ?5
EXPECTED FREQUENCY = ?3.276

PAIR 9
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?2.5572

PAIR 10
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?2.0141

PAIR 11
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?1.5975

PAIR 12
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?1.2745

PAIR 13
OBSERVED FREQUENCY = ?3
EXPECTED FREQUENCY = ?1.0216

PAIR 14
OBSERVED FREQUENCY = ?2
EXPECTED FREQUENCY = ?.8222

PAIR 15
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?.664

PAIR 16
OBSERVED FREQUENCY = ?1
EXPECTED FREQUENCY = ?.5379

PAIR 17
OBSERVED FREQUENCY = ?3
EXPECTED FREQUENCY = ?.4368

PAIR 18
OBSERVED FREQUENCY = ?0
EXPECTED FREQUENCY = ?.3555

PAIR 19
OBSERVED FREQUENCY = ?0
EXPECTED FREQUENCY = ?.29

PAIR 20
OBSERVED FREQUENCY = ?0
EXPECTED FREQUENCY = ?.2369

D(MAX) = 0.0301
==========
CRITICAL VALUES OF D (WHEN
N IS >=35 - ELSE REFER TO
TABLES) ARE :-

AT 0.10 SIGNIFICANCE
                LEVEL = 0.0880
AT 0.05 SIGNIFICANCE
                LEVEL = 0.0981
AT 0.01 SIGNIFICANCE
                LEVEL = 0.1176

DO YOU WANT TO RUN ANOTHER
TEST? TYPE 'YES' OR 'NO'? NO
END OF JOB
```

Figure 104: Kolmogorov-Smirnov Test computer run for Observed Distribution Original Cephalosporins Data Set and calculated Negative Binomial Distribution

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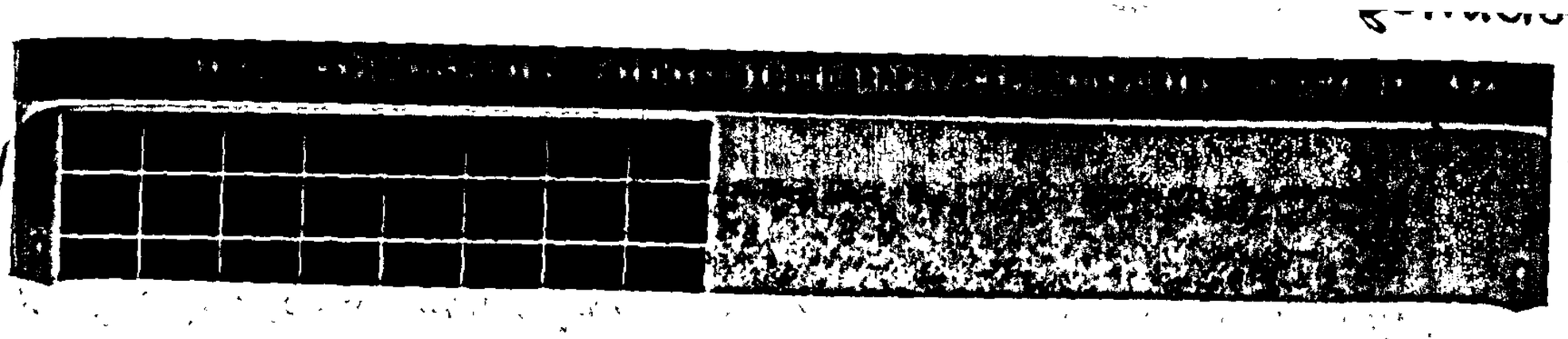
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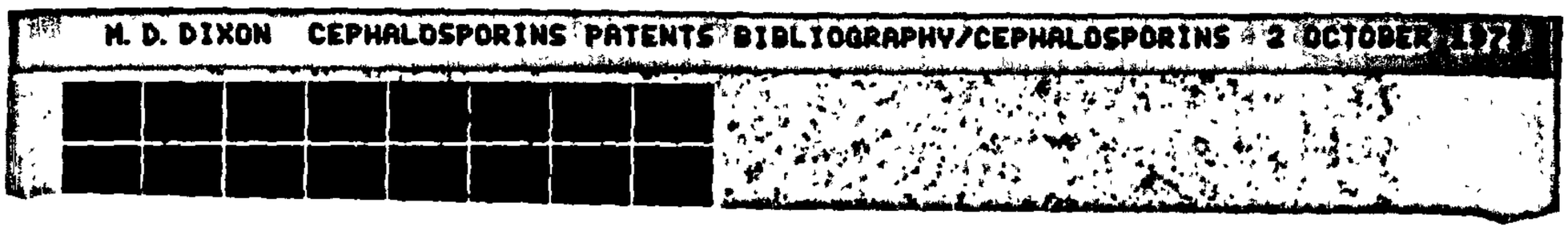
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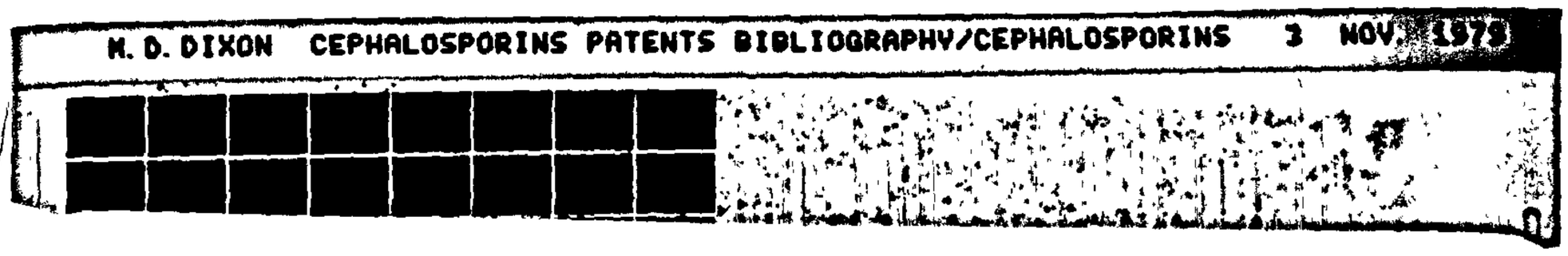
NOTE: The following references are to papers presented at the OECD seminar entitled "Workshop on Patent and Innovation Statistics" held in June, 1982; these unpublished papers have a restricted circulation and are not generally available. The references concerned are numbers 38, 45, 63, 68, 69, 93, 186, 217, 219 and 228.

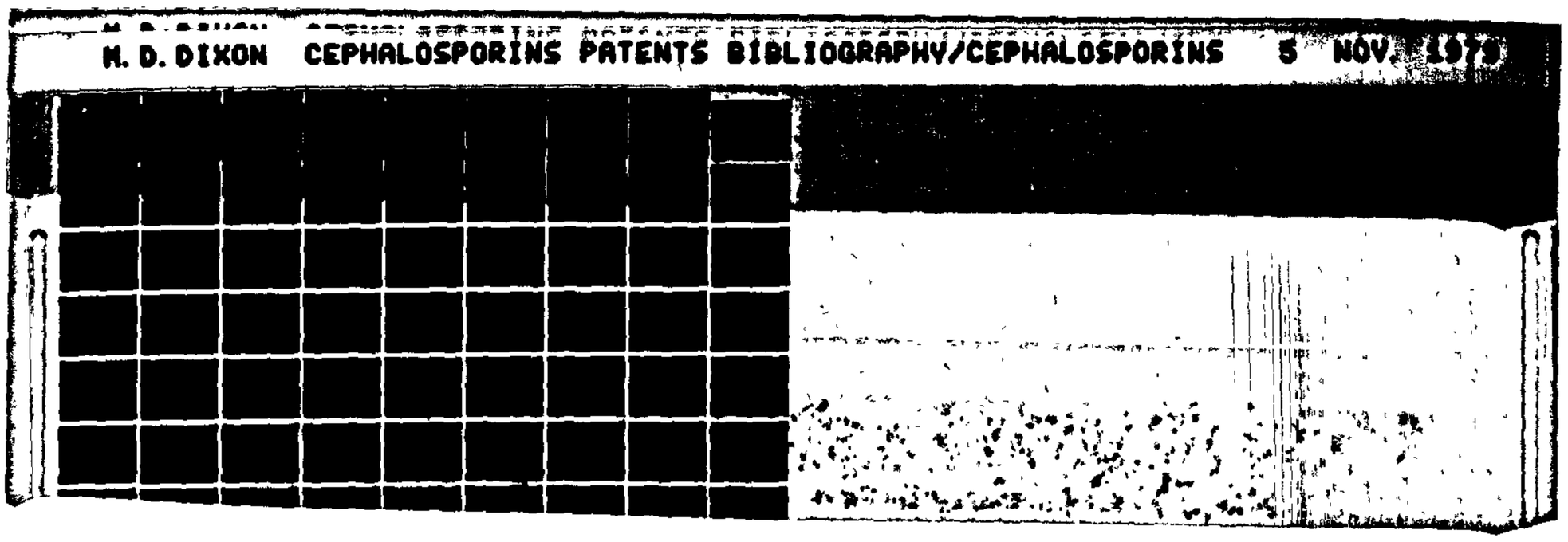
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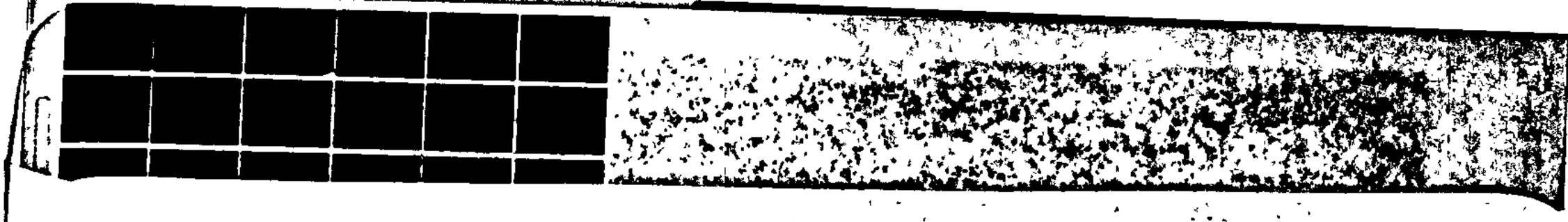


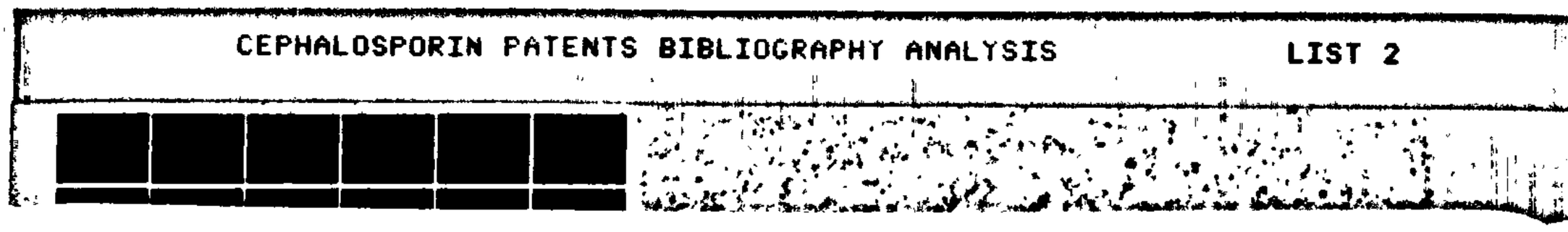


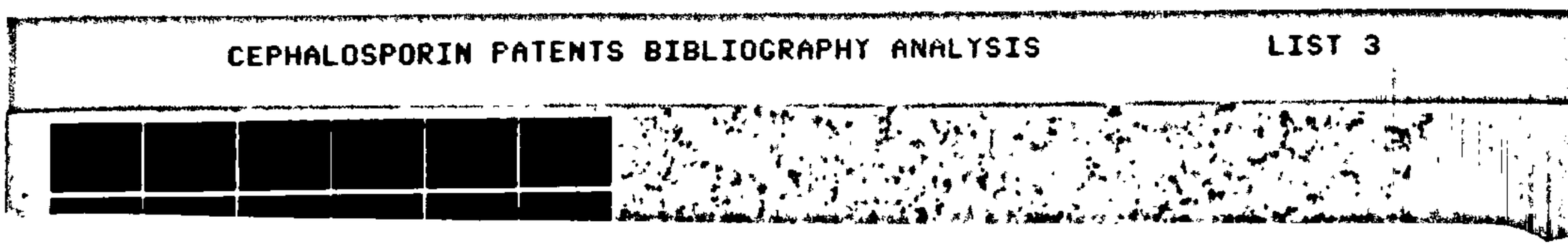


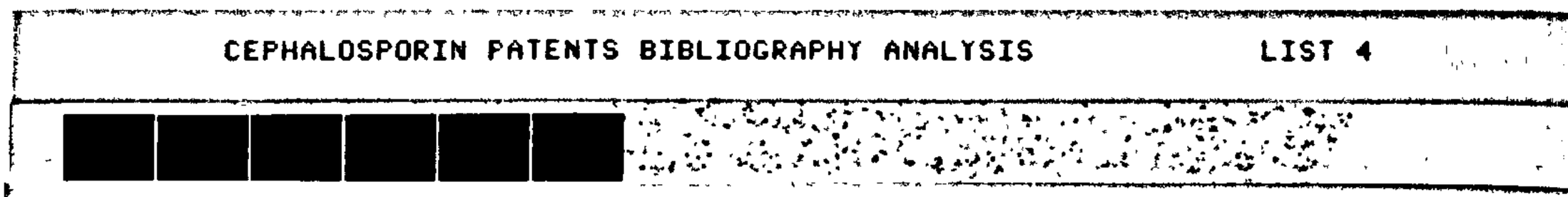
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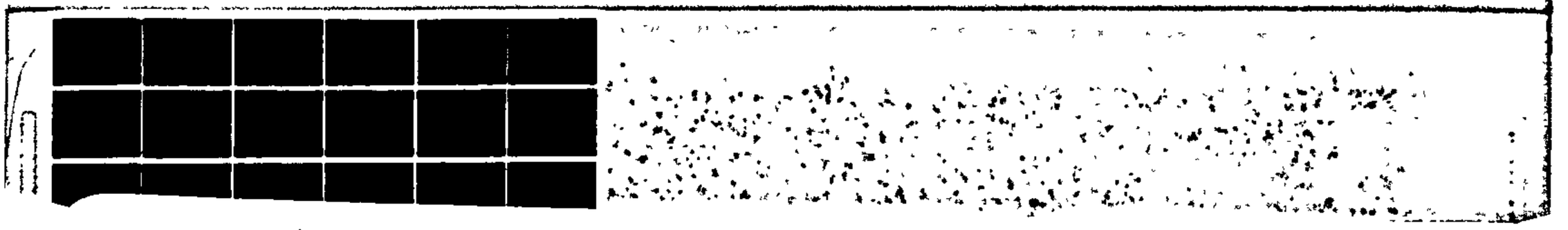












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