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ASLIB

CRANFIELD RESEARCH PROJECT

REPORT ON THE FIRST STAGE OF AN INVESTIGATION INTO THE COMPARATIVE EFFICIENCY OF INDEXING SYSTEMS

by

Cyril W. Cleverdon

An investigation supported by a grant from
The National Science Foundation
Washington

The College of Aeronautics
Cranfield, England

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PREFACE

It was in 1953 that the train of events started which brought about my participation in the investigation which is the subject of this report. R.G.Thorne, of the Royal Aircraft Establishment, and I had been closely associated with the development of the Nationaal Luchtvaart-laboratorium Card Catalogue of Aerodynamic Data (Ref. 1). This was an index designed for the retrieval of information in answer to very specific requests, and was far removed from the systems used in conventional library indexing. In that the average time taken to index each document was $1\frac{1}{2}$ hours, it was comparatively expensive, although the cost was shared out on a subscription basis amongst a number of organisations. Clearly, however, such an index could only be used for a relatively limited range of documents that were of particular significance, and Thorne and I were prepared to accept the possibility that in certain circumstances an organisation might be economically justified in maintaining two different types of indexes covering an overlapping range of documents. The Universal Decimal Classification was widely used in England and, in spite of many criticisms, was on the whole meeting the requirements of its users for a general indexing system. We were looking for another system which would fulfil the same function as the NLL scheme, but which might be less expensive and therefore more attractive economically for a single organisation to operate.

At the meetings of the Documentation Committee of the Advisory Group for Aeronautical Research & Development to N.A.T.O., we had reports from the two American members, Mr.K.Lowry and Mr.E.Jackson, of the developments in the United States. In particular

we heard of the work of Mr. Calvin Mooers and also of Dr. Mortimer Taube, whose Uniterm system appeared to have possibilities of fulfilling our requirements, and we decided to do a small test on this system. This, in the first place, consisted of my indexing 200 reports in the field of aircraft structures, and carrying out tests based on questions compiled by Thorne. The report on this work (Ref. 2) was written mainly with the intention of publicising the uniterm system in England, in the hope that other people would be sufficiently interested to try it. Later we indexed a further 800 reports, but this time the test results were less encouraging and we did not continue our investigations with this system.

Meanwhile we were concerned in devising test procedures, in particular with the NLL card catalogue (Ref. 3), and by this time I had become convinced that the only way to obtain a valid comparison between systems would be to control conditions in such a way that there was an economic basis for the comparison. At the Conference of the Aslib Aeronautical Group in 1955 I read a paper (Ref. 4) in which, for the first time, the necessity for controlled experiments was put forward. This conference was held jointly with the Classification Research Group, a small group of enthusiasts who, with B. C. Vickery as secretary and B. J. Palmer as chairman, met regularly to discuss problems of classification, in particular facet classification. They were the foremost and probably the only group in England who were considering these problems, but in America at this time there were a number of groups actively engaged in proposing new systems and methods. It was clear that claims were being made by proponents which, while possibly correct,

could not be considered proven by results; just as clearly many of the arguments being used by opponents of the systems were equally unproven or trivial. It seemed desirable that a serious investigation should be made so that opposing claims could be evaluated, and by this time we had definite views as to how such an investigation could be carried out.

In June 1955 I was invited to take part in a Symposium on Information Retrieval Systems at a meeting of the Scientific and Technical Division of the Special Libraries Association Convention in Detroit. Shortly before this meeting, there had been an interesting leader in American Documentation (Ref. 5), and, in the SLA paper, taking as a text an extract from this leader, I made a plea that some independent work should be done in the States to evaluate the rival claims. After the meeting, Mrs. Helen Brownson, of the National Science Foundation suggested that, if we would prepare a detailed proposal, it could be submitted to the Foundation with an application for a grant.

This suggestion was considered by the Aslib Aeronautical Group, a sub-committee of which prepared the first draft of the proposal, which was then reviewed by a special committee appointed by the Council of Aslib, and with some minor alterations was sent to the National Science Foundation in 1956. Originally the limit of our hopes was that the Foundation might be willing to make a contribution towards the cost, and it was a pleasant surprise to be told that the Foundation were willing to consider an application for the total sum of 28,000 dollars to cover the expenses involved in preparing the indexes.

Few people can have received so much co-operation and assistance as I have had in the project. First and primarily acknowledgements are due to the National Science Foundation for their generous financial support and to Mrs. Helen Brownson, of the Foundation, whose particular responsibility the project has been, and who has throughout done everything possible to assist the work. Next I must acknowledge my debt to the Principal and the Senate of the College of Aeronautics for permitting me to undertake the project, and also to those members of my library staff who have had to suffer the inconvenience of the project work going on in their midst.

Closely associated with the project from the start have been the members of a special committee appointed by the Council of Aslib, and Mr. B.C.Vickery, Mr. J.Farradane, Mr. K.Lowry, Mr. R.C. Wright and Mr. C.Hanson have all been generous in the time and thought which they have given in helping us with our problems. To my friends in the Aslib Aeronautical Group I am particularly grateful, not only for their general suggestions and criticisms, but also for the work of the Classification sub-committee in revising the aerodynamic sections of the U.D.C. From the start I have at all times had the fullest support and encouragement from Mr. L.Wilson, Director of Aslib, and I am grateful for his assistance which has made the administrative aspects of the project so easy for me.

There are many others whom I should mention and in particular those, many unknown to me personally, who helped us by compiling questions for the test programme or by doing supplementary indexing.

Finally, I would acknowledge the work done by the full-time members of the project staff, Miss Warburton, Mr. J. Sharp and Mr. J. Hadlow, and in the first few months, Mr. T. Opatowski. It was a particularly fiendish form of torture to have to index continuously against a stop-watch, and it demanded the highest personal integrity to work consistently under these conditions. Throughout the whole two years of this stage of the project I received the fullest support from the staff who cheerfully and loyally undertook every task demanded of them. It has been my pleasure and privilege to work with such a team.

This report is basically a factual account of the first stage of the project, but it was felt that every facet of the experience gained should be set down, whether it be a statement of fact or the philosophy of a particular problem as seen by the indexers. Since their experiences are virtually unique, it is reasonable that their observations should be recorded, even though no solution to particular problems can be offered. In the preparation of the report, Mr. Sharp has given much assistance, and most of Chapter 4 in particular is as he wrote it.

C. W. Cleverdon

The College of Aeronautics,
Cranfield.

August, 1960.

CHAPTER 1

INTRODUCTION

In July 1957 the National Science Foundation awarded a grant of £10,000 to Aslib for an investigation to be made into the comparative efficiency of four indexing systems. This work was to be undertaken at the College of Aeronautics, Cranfield, England, under the direction of the Librarian, Mr. Cyril Cleverdon. The grant made was to cover the first stage of the project which involved the indexing by the four systems of 18,000 research reports and periodical articles in the general field of aeronautical engineering, with half of the documents dealing with the specialised subject of high speed aerodynamics. Three indexers were required for the work, and they took up their appointments on the 1st April, 1958.

The staff consisted originally of Mr. J.R.Sharp, Mr. J.F Hadlow and Mr. T. Opatowski. Mr. J.R Sharp is a Fellow of the Library Association, and after serving in the Royal Air Force from 1940-1945, returned to work at Hull Public Library until 1954, when he took the position of Technical Librarian with Short Bros. & Harland Ltd., a large aircraft firm in Northern Ireland. There he had experience in indexing the type of literature covered by the project and he resigned that post to join the project staff.

Mr. J.F.Hadlow spent two years with Northumberland County Library before joining the Royal Air Force for two years as a National Serviceman. He then spent a year at Newcastle School of Librarianship where he passed the Registration examination of the Library Association. For a further year he was again with the County Library before joining the staff, but had had no experience in the type of work involved in the project.

For the third position Mr. T. Opatowski was appointed. He had completed a post-graduate course in aeronautics, and had spent several years in aircraft research work. He showed a real aptitude for the work and was a stimulating and valuable member of the team, particularly in the early stages of the work when a great deal of time had to be spent in evolving satisfactory methods for setting up the various systems and with the revision of the schedules of the Faceted Classification. However, when more time had to be given to the basic work of indexing documents, he found it increasingly onerous, and by October 1958 came to the decision that he would not be able to continue to do for two years the type of work that the project involved, and with reluctance his resignation was accepted.

There is no doubt that this stage of the project imposed a severe mental strain on the indexers, and it is to the credit of the project staff that, in spite of unexpected problems in the early stages the work was completed in the scheduled time. Following the resignation of Mr. Opatowski, I considered it would be inadvisable to take the risk of appointing another technical person, due to the danger of their under-estimating the difficulties involved, and as a result, Miss B. Warburton was appointed and joined the staff on the 1st January, 1959. Miss Warburton, an Associate of the Library Association, started her career in Sheffield Public Libraries, and for five years had been librarian of the United Steel Co. Ltd. in Sheffield.

The Council of Aslib appointed an Advisory Committee consisting of Mr. B. C. Vickery, at that time Librarian of Imperial Chemical Industries, Akers Research Laboratories and now Deputy Director of the Lending Library Unit, Mr. J. Farradane, Information Officer, Tate

& Lyle Ltd., and Mr. R.C. Wright, Librarian, Royal Aircraft Establishment. In addition Mr. W.K. Lowry, Manager, Technical Information Libraries, Bell Telephone Laboratories, agreed to serve as a corresponding member, and, following his appointment as Aslib Research Director, Mr. C.W. Hanson became a committee member in January 1959. This committee met at Cranfield on five occasions.

CHAPTER 2

GENERAL OBJECTIVES OF THE INVESTIGATION

"The vastly increased sums of money which have been devoted to research have brought about two major changes which affect bibliographical work. The volume of papers issued is now vastly greater than in the pre-war years, and also the number of individuals or organisations working in the same field of knowledge has increased considerably. There is no longer the situation where a scientist could keep abreast of developments over a fairly broad field of knowledge and be reasonably certain of knowing, either personally or by reputation, most of the other scientists concerned in similar work. Nowadays it is generally agreed that even the specialist is, in many fields of knowledge, unable to give more than a cursory glance at a large proportion of the papers which are of potential value to him. A result of this is that, whenever a new problem is approached, a scientist is far less likely to have a complete knowledge of the work already done, and therefore must make greater use of bibliographical aids.

"With the increasing complexity of research work, experimental test equipment has become very expensive, and its operating costs are usually high. It is therefore more than every necessary to avoid duplication of work previously done. These facts have, to a certain extent, been recognised by government and industry alike, and the result has been a great increase in the number of special libraries and information bureaux serving research organisations. Many new techniques in librarianship have been evolved to suit the changed functions of these organisations, and prominence has always been given to various methods of retrieving information. In particular the factors discussed in the opening paragraph have, during the past years, resulted in an impetus in this work and many non-conventional systems have been suggested in an effort to overcome the problems created by the vastly greater flow of research papers and the increased need to locate information.

"Apart from new systems, there have been rapid developments in the physical aspects of the work. In the same way as a librarian is no longer faced with the plain alternative of using a dictionary catalogue or classified catalogue, but in addition has to consider the merits of Uniterm or Zato-coding, so instead of the practically automatic choice of 5" x 3" cards, there are the possibilities to be considered of hand or machine sorted punched cards, and various mechanical or electronic devices to assist in retrieval.

"In all the controversies that have raged during the past fifty years on the basic points of a book catalogue or card catalogue, with an alphabetical subject arrangement or a classified arrangement, it is interesting to note that no attempt has been made to carry out any

controlled tests that would enable one to make statements based on fact rather than voice theoretical opinions. The changed attitude that must prevail was admirably stated in the editorial of "American Documentation" for April 1955, which, in part, reads,

> "Cautious and searching evaluation of all experimental results is essential in rating the efficiency of documentation systems. May the age old controversies that arose from the conventional concepts of classification not be reborn in the mechanized searching systems of the future. There is hope for the avoidance of such error if we will but regard documentation systems as useful devices, the benefits of which must be determined, not by polemics, but by the intelligent measurement of such benefits in relation to needs and costs. The machines of the future can make us free but only if we are willing to subject them, and ourselves, to the most rigid intellectual discipline".

"The complication in attempting to evaluate the comparative efficiency of any two retrieval systems is due to the number of various factors which have to be considered. These can be summarized as follows :-

1. The documents which are to be indexed
2. The system of indexing
3. The indexer's subject knowledge of the documents being indexed
4. The indexer's familiarity with the indexing system
5. The size of the index

6. The type of question which is to be put to the index
7. The equipment to be used in recording or retrieving data
8. The overall efficiency, which is made up of :-

   a. The time cost in preparing the index
   b. The time cost in locating required information
   c. The cost of equipment used
   d. The probability of producing the required answer
   e. The absence of irrelevant answers ('noise')
   f. The number of searches made. "

The foregoing is taken from the opening pages of the first draft of the proposal which was prepared in 1956 and in general it contained the basic considerations on which the project was planned. This section of the report will deal with the actions which were taken to enable us to investigate the various factors listed above.

The document collection

There are obviously a number of different requirements when indexing collections of documents in different subjects; it may even be the case with different groups of documents in the same subject field and also possibly for the same group of documents when the index is being compiled for different sets of users. The extent to which these differences are important is a matter for conjecture, but it would be rash to suggest that the results which we obtain will necessarily be valid for every other subject field. We think that it will be possible to investigate this matter without it being necessary to do more than a small fraction of the work involved in the present project.

The choice of aeronautics as the subject for the indexing was mainly

determined by the availability of the documents, but it did have a number of other advantages. As it is a subject which embraces a number of disciplines, we were able to investigate the indexing systems over a broad range of subjects including, amongst others, metallurgy, plastics, electrical engineering, production engineering, mechanical engineering, fuels, mathematics and most branches of physics. Approximately half the documents used were in the specialised field of high speed aerodynamics, and this concentration on one detailed subject area, combined with the general coverage of a wide range of subjects, should show the varying capabilities from the viewpoint of special or universal systems.

Reports and papers vary in their presentation and most practising indexers would agree that this is a factor which can definitely influence the time that is taken to index a document and possibly influences the quality of the indexing. Little general consideration has been given to the form of titles, yet it is obvious that there is a considerable difference in this respect between British and United States practice. With the advent of mechanical indexing of the Key-Word-in-Context type, the importance of the terminology of the titles is more likely to be recognised, but for the human indexer also the titles should be a precise and succinct statement which will immediately tell the indexer the basic subject of the paper. From the abstract or summary, the indexer can reasonably expect that the author will have indicated most if not all the points which have to be brought out in the indexing.

It appeared that the project presented an opportunity to investigate any possible differences that might exist in the indexibility of different types of documents. Half the documents indexed were articles in

scientific and technical journals while the other half were research reports. There was another equal division between papers written in the United States and in other English-speaking countries. Papers were not used if they had been written more than ten years previously, and in fact nearly half of the documents were published during the two years of the indexing.

The breakdown between

a. High speed aerodynamics and general subjects
b. Articles in journals and research reports
c. U.S. papers and papers from other countries

were maintained within each "document group" (see page 20) so that the effect of the various conditions could be evaluated at all stages of the work. A representative group of 100 documents is listed in Appendix A.

The system of indexing

Four systems were chosen for comparison, these being

a. The Universal Decimal Classification
b. Alphabetical subject catalogue
c. A faceted classification scheme
d. The Uniterm system of co-ordinate indexing

The basis for this selection was that the schemes differed as fundamentally as is possible and represented the principal types of retrieval systems which have any significance in the present state of the art.

It should be emphasised that the mechanics of the systems, in the

sense of the equipment and methods which are used for recording and retrieval, were regarded as being outside the scope of the project. The basic principles of the systems are not altered in any way by their method of application and as the purpose of the project is to compare the systems as such, the possible use of machines or special apparatus has not been taken into account. Machines can alter the economics of the operation of the respective methods, and can determine the choice of one system as against another for practical purposes, but such a choice can only be made after the relative efficiencies of the systems as such have been assessed. It is felt that it is a serious error to consider whether a given piece of machinery can work as an information retrieval system merely because it exists as a piece of machinery, and particularly, as is so often the case, when it has been designed for quite a different purpose. The correct approach, rather, is to find what system in principle lends itself best to information retrieval under a given set of circumstances and then look for ways of making it as economic a proposition as possible, by the use of machines, or by any other method of application. To have considered, as some have suggested, the comparison of the selected systems with a 'machine retrieval system' would have been to be guilty of the grossest example of 'cross classification'.

Reasons for the choice of the schemes

The Universal Decimal Classification was chosen as the most widely used system of the 'enumerative' type. Though it is to some extent 'synthetic', it is fundamentally enumerative in that the vast majority of its places are fixed within its respective classes, and the synthetic principle applies generally only to those aspect of subjects which might

be regarded as 'auxiliary' to the basic numbers. A more purely enumerative scheme might have been chosen, but the end result would probably have been so little different that the exclusion of U.D.C. would certainly not have been justified.

U.D.C. is not only enumerative, but it is typical of the classical 'tree of knowledge' classification. Moreover, it uses the decimal principle for supposedly unlimited expansion, a feature which has certain advantages, particularly from the point of view of mechanising alphabetical indexing, but which tends to produce numbers of unacceptable length at the level of indexing used for the project. Unfortunately the principle of decimal notation for the purpose of showing hierarchy has been abused to some extent, and this may or may not affect it adversely. However, the principle remains sufficiently well embodied in the scheme to justify its testing opposed to the Facet scheme, which is not based on the ' tree of knowledge' principle, is not enumerative, and does not use a hierarchical notation.

The alphabetical subject catalogue was an obvious choice as one of the systems to be tested, as it is the one system which lists subjects in a known order, regardless of grouping by classification, and without the necessity of any intermediate step in searching such as is necessary with a classified catalogue. Its comparison with the classified catalogues (U.D.C. and Facet) is expected to show whether anything is lost or gained by the absence of the grouping provided by classification both for specific reference and for generic survey. It is sometimes argued that a subject can be classified though it cannot be adequately expressed in words, but others such as Metcalfe (Ref. 6), argue strongly against this. A comparison between the alphabetical and the classified catalogues

should demonstrate the validity or otherwise of such arguments. The idea that classification permits more specific description of a given subject than does the use of alphabetical subject headings is also prevalent in some quarters. That the degree of specificity is unlimited with a system designed for such exhaustive specification as U.D.C. cannot be denied. The crux of the problem of information retrieval is, however, the need to ensure that the description of a subject by the searcher, in terms used by the system, coincides exactly, or more or less exactly with that assigned by the indexer. If such coincidence is difficult or impossible, then the efficiency of the system will be impaired accordingly. It is possible that the shortcomings of classification systems in this respect reach down to that level of coarseness which alphabetical systems possess, and the testing of the systems should show whether or not this is the case.

The alphabetical subject catalogue has in common with the Uniterm system, the use of terms used to describe subjects in ordinary language. What it does not normally do is to provide headings comprising every possible permutation and combination of the words used. The Uniterm system permits such permutation and combination by the very nature of its mechanics.

Finally, without the analysis of principles, the inclusion of the alphabetical subject catalogue would have been justified solely on the grounds of its almost exclusive use in America, as against the popularity of the classified catalogue in British libraries.

It was felt that any attempt to compare systems of information retrieval would serve no purpose if it did not include a scheme based on the most modern principles. A scheme was therefore prepared by

B.C. Vickery and J.L. Farradane specially for the project. Some modifications to this scheme were made before it was brought into operation, but these were mainly of a technical nature (that is, technical from the point of view of the subject matter, not from the point of view of classification principles), but it should be emphasised that care was taken to preserve the structure of the scheme as the compilers were the best judge of what was required from this point of view.

The purpose of including a faceted scheme was to test the effectiveness of subject analysis and synthesis by facet principles as this technique is obviously a very powerful tool. Implicit in this type of scheme is the principle of 'preferred order' and the use of a chain index for the purpose of entering the classified file at a suitable point, and the collection of 'distributed relatives'. The authors of the scheme considered very seriously the question of preferred order, for the subject matter presented a very difficult problem in this respect, mainly on account of the large number of categories involved. Our experience in indexing by this method showed that their choice of preferred order had, in the main, been the correct one. It may be that modifications would have been made for a more satisfactory arrangement, but this is by no means certain, and such modifications could, in fact, have made the scheme worse rather than better. It is extremely difficult to assess the value of one order against another, but the indexers' experience, in general, supported the authors' choice.

What is more serious is the possibility that no single order can cater for all requirements. As preferred order is a fundamental part of a faceted scheme of this kind, the results of the tests should be

significant in that the principle should be shown to be valid or not. Should the testing of the schemes show the faceted scheme to be wanting, it will not necessarily be concluded that facet analysis as such serves no useful purpose. It could be that the categories properly derived by facet analysis have their value jeopardised by being tied to the principle of preferred order. This feature will be investigated by later tests where we shall use the categories without reference to preferred order. This will be done by free co-ordination of terms, one from each category at a time, by the use of punched cards or a computer. This procedure should significantly advance our knowledge in this matter, as it is extremely unlikely that any preferred order fundamentally different from the one adopted would be any more satisfactory.

The interesting feature about the comparison of the faceted scheme with the other classification scheme (U.D.C.) is that the former is built from the outset on scientific principles of classification, whilst the latter is largely empirically derived.

An investigation of this kind would not have been complete without the inclusion of a system based on co-ordinate principles. The main difference which this type of scheme provides is the facility to combine all or any of the relevant terms in the system by way of permutation or combination. This facility is available only to a more or less limited extent in the other schemes and it was imperative that the efficiency of this feature should be tested. It is difficult, in the present state of the art, to assess what is the best level of sophistication in a scheme of this kind, for on the one hand there is the danger of 'false drops' because of ambiguity in relationships, and on the other the risk of the inclusion of irrelevant terms because of difficulty in definition, and the overlapping

of terms. The former has been catered for in some schemes by the use of 'role indicators' and the latter by the use of the 'thesaurus' approach. There seems to be no conclusive evidence of the efficiency of these devices and it was decided, therefore, that no attempt would be made to incorporate such possible refinements, beyond the provision of references from synonyms to the terms selected for use. It may be that 'literary warrant' is a better basis for the selection of terms than any artificial principles and it was therefore left to the indexers to co-operate in generating suitable terms during the course of indexing. The result, therefore, is that we compiled a Uniterm index as originally proposed by Dr. M. Taube.

These decisions created some surprise, and it may be desirable to explain our reasons. We had originally considered using a more complex form of co-ordinate system than simple uniterms. Examples of what might have been done are shown by the following working schemes :-

1. The thesaurus approach, as used by Whelan (Ref. 9)
2. Zato-coding (Ref. 10)
3. The categorizing of terms, as used by Wildhack in the National Bureau of Standards index on instrumentation (Ref. 11)
4. Concept co-ordination (e.g. Wadington) (Ref. 12)
5. The use of role indicators (e.g. Farradane) (Ref. 13)

The first two methods both have a separate dictionary of unit terms, so that the indexer shall know which particular descriptor (or descriptors) to use and the third system appears to be in the main a list of unit terms sorted alphabetically into the categories. In all cases the intention is to help the searcher to devise a programme which is more likely to match

the indexing.

The true value of these different approaches can, we hope, be ascertained in the project if we take our basic uniterms and regroup them in the appropriate manner. This will be a simple problem clerically, but it would obviously not have been so easy to do the same thing in reverse if we had, for instance, used a thesaurus system. Retesting the regrouped terms will indicate the gains and losses of these different forms of co-ordinate indexing.

The concept co-ordination system devised by Wadington is an illustration of what we wished to avoid doing. In this case the organisation (Titanium Division of National Lead Co.) started their search for an improved indexing system by constructing a classification based on facet principles, but found difficulties in its practical application. Switching next to Uniterms, they found it inadequate due to the many incorrect co-ordinations that could be made. Pre-coordinating many of the terms overcomes this difficulty, and it gradually became evident that the unit concepts thus devised were much the same as the terms used to construct the facet classification. So the structure of the classification, without its coding, was used as a retrieval system in a straight co-ordinate manner. If we had developed a co-ordinate system in this manner, we should probably have finished with something similar to the facet system we are using which is, of course, quite capable of being used as a co-ordinate system. It is, in fact, our intention to test it in this way in addition to the basic method of using a classified catalogue and chain index.

As for role indicators, an analysis of our test results will show the number of occasions when false drops would have been avoided by their

use, this being another occasion where the reverse process would not have been so useful.

In every case it appears that having in the first place used Uniterms, we shall be able to investigate many other forms of co-ordinate indexing without having to repeat the indexing process.

The indexer's subject knowledge and familiarity with the systems

Whereas one school of thought insists that technical indexing can be done only by a person with technical qualifications, there are others who argue that this is not necessarily the case, and that anyhow it would be wasteful to employ technical persons on such work. However, no results are known of tests designed to compare the indexing ability of different types of persons. Potential indexers for the project might be described as being within the following broad groups: (A) technical knowledge of the subject plus indexing experience; (B) technical knowledge of the subject but no indexing experience; (C) indexing experience in the subject field; (D) indexing experience in another subject field; (E) theoretical knowledge of indexing; (F) neither knowledge of the subject nor of indexing.

In deciding the types of persons to recruit, it was considered that, of the very few persons with the qualifications outlined in (A), it would be difficult to persuade any of them to join the project. The significance in certain circumstances of using an individual such as outlined in (F) was appreciated, but it was decided not to use this category in the project. The choice finally was made to recruit three indexers who would be representative of groups (B), (C), (E).

As mentioned earlier Mr. Opatowski, the indexer originally appointed as having technical knowledge, left in the early stages of the indexing, and was replaced by Miss Warburton, who did not have technical knowledge but was representative of group (D).

With some, if not all, of the systems, it was to be expected that the indexers would become more efficient as they had more experience in the use of the systems. In order to ascertain the extent of this improvement, the whole programme was divided into three main sections and the indexing conditions were repeated within each section of the whole programme, so that we shall have comparable results for all stages of the indexing.

Size of the index

The size of the intended index is a matter of considerable importance, and whereas one hopes that it should be possible to assess a system without indexing a million documents, it is impractical to expect valid results from very small scale tests.

In a project of this kind it was necessary to index a sufficient number of documents such as would ensure that retrieval is not made too obvious and simple. On the other hand it was undesirable to waste money by continuing the work beyond the stage where useful and valid information could be gained.

The decision as to the number of documents we should index was based on the fact that we had a possible 60 permutations of the three main variables (see page 20) and that 100 documents was a convenient number to use for each of these sixty groups. This would make up a sub-programme of 6,000 documents, and repeating this three times gave us a total programme of 18,000 documents. We are certain that to have concluded the work of indexing at the completion of the second stage of the programme (i.e. at 12,000 documents) would have adversely affected the results and we feel reasonably confident that to have continued the indexing beyond the ultimate stage would not have been justified.

The fact that approximately half the documents fall within the narrow field of high speed aerodynamics (see page 7) means that we shall be searching indexes with a high concentration of entries in this particular area. It is reasonable to suggest that in a normal index of aeronautical documents, such a concentration of references in one specialised field would only be found in a collection which altogether contained possibly 200,000 documents and we therefore feel justified in assuming that results in this area would remain valid for a document collection several times larger than that used in the project.

The overall efficiency

The assumption on which the investigation is based is that the only valid way to measure the efficiency of any system of indexing is by basing measurements on economic costs and in this there are always three matters to be considered, these being :-

a. The cost of indexing
b. The cost of preparing the physical index
c. The cost of searching

The cost of indexing is made up of salary paid to the indexer (with any overhead costs involved) and the average time spent in indexing a document. We attempted to cover the first point by appointing people of different qualifications who would normally expect to receive different salaries. The time spent in indexing is, in any single organisation, a policy decision and will depend on a number of factors. To assess the result of such a decision, the indexers were given fixed times for indexing each group of 100 documents, these times being an average, for each document in the

group, of sixteen minutes, twelve minutes, eight minutes, four minutes and two minutes.

It was deliberately decided that our investigation would not include any comparison of different methods which can be used for recording indexing decisions, of different equipment which can be used for retrieving information or of methods of printing out retrieved data. The reasons for neglecting these matters is that they have no direct bearing on the efficiency of indexing. Unless the indexer has made an entry under a certain heading, it is useless to search for that heading, whether one is using a card catalogue, peek-a-boo equipment, punched cards or a computer. It is true that different equipment might make a system more attractive economically, but it would not affect the end result and its economic advantages will depend on the circumstances. To take an obvious example, the comparison of lists of numbers (as originally proposed for Uniterm) is normally a slow and cumbrous method, and one which might be done more quickly by a computer, albeit the costs for a single search would be higher. However, if one regularly had up to 100 searches to be made at a time, then the cost per search with the computer might well be economic.

These matters are very important, but, particularly three years ago when the project started, the situation regarding equipment for data retrieval was in a state of flux and new developments might well alter the whole picture. Meanwhile a great deal of experience has been gained particularly in the United States, and if no other report on the subject is issued in the meantime, we intend at the completion of the project to do an analysis of the costs of all types of equipment used in information retrieval.

CHAPTER 3

GENERAL ORGANISATION OF PROGRAMME

There were three main variables to be investigated, namely the system, the indexer, and the indexing time. With four systems, three indexers and five indexing times, the number of permutations is sixty. The documents to be indexed were divided into groups of one hundred (from here on referred to as a "document group"), and therefore 6,000 documents were indexed before the same indexing conditions are repeated.

The procedure was that the first indexer indexed documents 1 - 100 by system A, allowing himself an average time of 16 minutes for each document. Immediately after indexing a document by system A, he allocated the appropriate headings or classification numbers for systems B, C, and D, but this was done without strict time control. Documents 101 - 200 were indexed by system B with the 16 minute allowance for each document, followed by the postings for systems A, C, and D. Items 201 - 300 and 301 - 400 were similarly indexed by systems C and D.

This procedure was repeated for documents 401 - 500, 501 - 600, 601 - 700, and 701 - 800, except that for these document groups the average indexing time was limited to 12 minutes. For documents 801 - 1200, the time was limited to 8 minutes; for 1201 - 1600 it was 4 minutes, and finally for documents 1601 - 2000 the indexing time was limited to 2 minutes per document. Meanwhile the second indexer carried out a similar procedure with documents 2001 - 4000, and the third indexer was doing the same with documents 4001 - 6000. The indexing of documents 6001 - 12,000 repeated the conditions found in the indexing

of 1 - 6000, and the whole stage was repeated for the third time in documents 12,001 - 18,000.

The preparation of these document groups was done in advance; in the earlier stages of the work the procedure was for the documents to be collected together and a list prepared. As described earlier, within each group of 100 documents there were the further sub-groups of having half the documents dealing with high speed aerodynamics while the remainder ranged over the whole subject field. There was the division between periodical articles and research reports, and also between United States publications and those from other countries. To simplify the somewhat complex procedure that this involved, in the later stages of the work we first typed cards giving details of a large number of documents and were able, more effectively, to make our selection of document groups by sorting these cards.

Before being passed to the indexer, each document had a master indexing card inserted. This card, as shown in Fig. 1, contained the project document number, and information concerning the indexer, the main indexing system and the time allowance.

On receiving the group of 100 documents, the indexer had the responsibility of indexing them to the best of his or her ability within the conditions imposed. Presuming that the indexer had received a group of 100 documents to be indexed by the Universal Decimal Classification as the main system with an indexing time of 16 minutes, this meant that the indexer would have to complete the indexing by U.D.C. of this group of documents within a total time of 1600 minutes, and he was given the flexibility to vary the time spent on any individual item. In addition he had to index by the other three systems, and this

question of the subsidiary indexing presented some initial problems. Basically it was not intended that there should be the same strict time controls with the subsidiary indexing as was the case with the main indexing, but it was desirable that the indexing should be approximately the same standard by all systems within any single group.

The difficulty arose in trying to separate the time spent in assessing the subject content of a document as against the time spent in deciding on the most satisfactory notation or headings. The percentage of time spent in these two actions would not remain constant throughout the varying time allowances, and as the time allowance became shorter the ratio of reading time to indexing time decreased sharply. As a result of tests made by the indexers it was decided that the following times should be allowed for the subsidiary systems.

Main system	Subsidiary system
16 mins.	4 mins.
12	3
8	2
4	$1\frac{1}{2}$
2	1

Later experience bore out the correctness of these figures, and it was felt at the end of the whole of the indexing work that the assessment had been about right.

The amount of time required for assessing the subject content of a report as against the time taken for assigning suitable headings naturally varied from one report to another. In general, the times listed above made for consistent indexing and the subject matter of a

document could usually be assimilated quickly enough to leave adequate time for assigning class numbers. In fact, with the majority of reports the indexers found themselves assigning numbers very shortly after first examining the document, and further reading merely served to confirm the original classification, except where later in the report mention was made of a subsidiary subject, (e.g. a special method of testing), which demanded separate indexing.

There were cases where all the time available was needed for reading the document, because of the abstruse nature of the subject, but in general this made little difference to the comparative times spent on the subsidiary systems and nothing should be lost on this account.

The greatest difficulty in this respect was caused by the report whose subject matter was easily assimilated, but which required a large number of class numbers or subject headings because of the many different subjects treated. At the longer times even these could usually be catered for adequately in the times permitted for subsidiary systems. In a few exceptional cases at the shorter times, the indexers used some discretion about using rather longer times for subsidiary systems. It would obviously have been wrong to devote almost the full time of, say, 4 minutes for the main system to assigning class numbers for a document which needed little actual reading, and to restrict the subsidiary systems to the stated $1\frac{1}{2}$ minutes. These cases were rare, and it can hardly be doubted that the course taken in these instances was the correct one.

A point which had to be watched carefully, particularly in the early stages, whilst the indexes were building up quickly, was the time spent

in making decisions about the choice of, say, a new U.D.C. number, or a new alphabetical subject heading. Where such a decision was not just the appropriateness of the heading to the document in question but a question of general policy that required a discussion and a joint decision by all the staff, the time was not included in the indexing time, as this would have affected the quality of the indexing of that document adversely.

The original proposal envisaged the completion of the work within two years from the commencement date, at the same time permitting the indexers a generous allowance of leave to compensate for the arduous nature of the work. This estimate was based on a working week of 38 hours, but it rapidly became clear that this estimate was a very poor one, for one of the greatest difficulties in the early stage was that experienced by the indexers in becoming accustomed to the very stringent conditions which continuous indexing with time controlled by a stop watch brought about. The mental strain of working under these conditions was severe, but perseverance eventually brought about an attitude of mind which made the work bearable. It was felt that two years was as much as the average human being could reasonably be expected to index under such controlled conditions, even though the number of hours actually logged as indexing time was a comparatively low proportion of what would be regarded as normal working hours.

Taken as an average in the later stages of the work, it was the experience of the indexers that five hours recorded indexing time represented a good day's work. We endeavoured to find how this might compare with experience in work of a comparable nature, but could only learn of one test that had been done privately in an industrial organisation.

This showed that in an engineering design office an average of 40% of a $7\frac{1}{2}$ hour working day was spent in actual productive work. From this it would appear that the indexers did reasonably well to reach 66%, particularly when it is remembered that some of their unrecorded time would be taken up with discussions directly relevant to their work. The practical implication of this recorded time as against time spent in the office is that our average time of 16 minutes would under normal working conditions be 25 minutes, and the other times would be increased proportionately. The result is that the difference in output for the various timings would be 18, 25, 36, 72 and 144 items indexed for a working day of $7\frac{1}{2}$ hours.

At first it seemed that the quality of the indexing was inconsistent, but greater standardisation through discussion, greater familiarity with the various schemes, and a general working up to peak efficiency led to a more satisfactory situation, and by the time that the first 6,000 documents had been dealt with, the indexers had established a tempo which was maintained to the end of the whole of the indexing. We feel confident that consistency reached a standard that will be more than high enough to ensure that the testing will be done on material of acceptable quality.

It was desirable to have one person on the staff with overall responsibility for each system used in the indexing, and from the start Mr. J. Sharp was in charge of the U.D.C. and Mr. J. Hadlow of the alphabetical subject catalogue. The Director was concerned with the Uniterm index until the appointment of Miss Warburton, who then resumed responsibility for this system.

With the facet schedules, Mr. Opatowski spent a great deal of time in the early stages carrying out technical revisions. (This aspect is

discussed later in Chapter 4 and more particularly in Ref. 7). After his departure Mr. Sharp and Mr. Hadlow prepared an authoritative list of headings to be used for the chain index, but when this had been completed, we "froze" the schedules and made no alteration of any kind. As is discussed later, we had a temporary device which enabled us to introduce subjects which were not included in the original schedules, this being done by giving to all subjects the notation of "Zz". These were comparatively few in number, and as a result there was no need for any further control of this system.

With the U.D.C., for which Mr. Sharp was responsible, if either of the other two indexers wished to generate a new number which had not previously been used, they would use the number and make out an appropriate indexing slip

e.g. Planetary gears 621.833.6

These would be passed daily to Mr. Sharp, who would be responsible for checking that the use of this number did not contravene any previously arrived at policy decisions. He would then edit the slip to conform to the accepted layout, and make any additional entries that were necessary,

e.g. Planetary gears. Power transmission. Mechanical engineering
621.833.6

Gears, planetary. Power transmission. Mechanical engineering
621.833.6

These slips would next be passed to the typist, who would make three copies, one to be filed in each indexer's alphabetic index of the U.D.C.

A similar procedure worked with the alphabetical system, although in this case Mr. Hadlow had the added responsibility of checking that a new heading was not, in fact, a synonym for a heading that was already in the authority list.

With uniterm the procedure was slightly different, in that the indexers entered on their master index cards (see Fig. 1) the code numbers of the uniterms (see Chapter 5). When it was necessary to use a new term, they would not have a number to use, so they wrote the term instead. At the completion of the indexing of each group of documents, the master index cards were passed to Miss Warburton, who looked through the cards to find any new terms that had been used. Having checked that the term was not synonymous with a term already in use, she would allocate to it the appropriate code number and enter this number on the master index card.

In spite of our best endeavours before starting the programme, not only of those closely concerned with the project but of many other individuals who were kind enough to comment on the original proposals, we came up against many difficulties that had not been envisaged. The question of the recorded time as compared to the working time has already been discussed, but probably our main difficulty came in getting started with the indexing. This is illustrated by the fact that whereas we started indexing in April 1958, it was not until the end of January 1959, nearly ten months later, that Mr. Sharp and Mr. Hadlow had completed their first 2,000 documents. By this time most difficulties had been solved and they only took about thirteen months to do a further 4,000 documents each.

It proved, for instance, quite impossible to plunge into indexing by four systems at once, that is to say we could not carry out the indexing by the main and subsidiary systems from the start. The compromise adopted was that the first 100 documents of each indexer were done only by U.D.C. The next hundred were done with alphabetical as the main system, with U.D.C. as the only subsidiary system. Then we did a

hundred documents by facet with U.D.C. and alphabetical as subsidiary systems and finally we did the fourth hundred with uniterm as a main system and the other three systems as subsidiaries.

At this stage it was clear that with the facet classification we were getting into a complete mess and a technical revision of the schedules was necessary, together with some procedural alterations. While this work was being undertaken, indexing proceeded, albeit somewhat slowly, with the other systems but no facet indexing was done of the next 400 documents. During this stage it also became obvious that we had to tighten our control of the form of headings in the alphabetical subject catalogue, and it was at this stage we made up our first set of rules, as discussed later in Chapter 4. As a result of these rules, it was necessary to alter many of the headings already in use. The U.D.C. schedules which we were using suffered from inadequate alphabetical indexes, and as a result there was a continual stream of minor difficulties. In general, however, U.D.C. did not present the major problems which we encountered with the facet and the alphabetical systems, although this, no doubt, was partly due to the several years experience which Mr. Sharp had in starting and maintaining a U.D.C. catalogue in his previous post. The Uniterm system at this stage was perfectly straightforward and it can be said that, as far as the indexers were concerned, they encountered only very minor problems with this system throughout the project.

With the revision of the facet schedules completed, we resumed indexing by this system, but again ran into difficulties, this time with the freedom that had been given to change terms from substantives into adjectives, which caused resultant difficulties in the chain index (as

discussed in Chapter 4). This was a problem that should, I feel, have been forseen by us but it had never been raised in any discussions or in any papers dealing with facet classification. The alterations which we had to make more or less invalidated all the work that had been done so far, and to be able to use this earlier indexing, we were involved in a considerable amount of revision. However, as previously indicated, from this time onwards, the facet schedules remained unaltered and we had no further major problems in indexing by this method.

As indexing continued, the original rules for the alphabetical subject indexing appeared to be too restrictive and we had to make some slight modifications. This occurred at the end of the first stage of indexing but did not seriously affect the earlier indexing that had been done. Gradually the number of problems associated with the U.D.C. also declined and by the commencement of the second stage of indexing (i.e. documents 6001 - 12,000), we were in the clear with all systems.

It is difficult to know exactly how to assess our experience in setting up these systems, because few people appear to have attempted to review objectively their own experience. In 1959 there was published the results of an investigation in Germany into the costs incurred in indexing by U.D.C. (Ref. 8), and in this case it was found that six months work was required before the system was reasonably well established. From this it would appear that our time of approximately 9 months to establish three systems (it being accepted that Uniterm created no problems) was not unreasonable, even though at the time I was considerably worried at the delay in reaching a stable situation. However, there is no doubt but that it would have been most unwise to attempt to proceed more rapidly with the indexing without first solving the problems that arose.

CHAPTER 4

DETAILED ANALYSIS OF THE PROBLEMS ENCOUNTERED

Universal Decimal Classification

The flexibility of U.D.C., provided (a) by multiple possibilities of placing, according to context, and (b) by the facility for synthesis of its various auxiliary devices with main numbers, appears to be at once its strength and its weakness. Its strength lies in the provision for exhaustive specification by elaborate synthesis, its weakness in that if synthesis is carried to extremes by the use of every auxiliary device which can be brought to bear for a particular document, there is a tendency to produce a catalogue with so many 'distributed relatives' that searching is laborious, and indeed, without the use of a very exhaustive and elaborate index, there is the danger of failure to find everything relevant to a particular subject. For example, if the subject 'damage to gears' in many possible applications is classified at the numbers for those applications, the following kinds of numbers are produced :-

621.438-257.004.65	Damage to gears in gas turbines
621.313.12-257.004.65	Damage to gears in generators
621.65-257.004.65	Damage to gears in pumps

The searcher must therefore consult each of these numbers and possibly many others, if his requirement is for 'damage to gears' in all its applications.

One alternative is to colon the numbers for the subject to those for the various applications, e.g.

621.438: 62-257: 6.004.65

in order to provide for permutation for the purpose of bringing all entries for each aspect of the complex subject together. Each number is then used as entry number and reference to a single point in the catalogue is all that is required to exhaust all possibilities in relation to a given search. Another is to combine the two methods by using the fully synthesised number basically, but providing separate numbers for the various auxiliary aspects for the purpose of grouping.

The latter course would obviously provide a catalogue which would be something of a hybrid, and it was felt that this would be unsatisfactory. The first alternative was at first considered to be the best principle, but it was found that the length of the numbers when coloned together was unacceptable, that, in practice, the need for elaborate synthesis was rare, and that most subjects, in spite of the complexity of the subject field, did not lend themselves to the use of many of the auxiliaries provided by U.D.C.

It was decided, therefore, to synthesise numbers by the use of common subdivisions, special analyticals, etc. to whatever degree was found to be necessary to specify a particular subject as fully as possible. The alphabetical index was constructed with a view to overcoming the dangers of losing concepts because of their being widely distributed under various main numbers. (The compilation of the alphabetical index is dealt with later in this section).

One specific exception to the general principle of full synthesis was made. This applied to the use of 621-4 the numbers for materials shapes, which it was decided to use always as main numbers. The reason for this was that the concepts represented by these numbers are very often of greater importance than those concepts represented by the

main numbers to which they are attached. The latter are usually materials, and the course was adopted of coloning the 621-4 number to the number for the material and making entries under both coloned numbers, e.g.

669.715: 621-415 Aluminium alloy sheets

was entered under this form and also under

621-415: 669.715

Additionally entry might also be made under 621-415 coloned directly to a third number. This might occur if the subject were 'stress analysis of aluminium alloy sheets', when it might be considered that the material was irrelevant, and entry would be made under :-

621-415: 531.22

In certain other cases the principle of full synthesis was obviously not the best course and no rule was necessary to prevent its use. The use of the common subdivisions at 629.13, for parts of aeroplanes, by attaching them to main numbers for particular types of aircraft would have produced a state of chaos in the catalogue. This procedure would have produced numbers such as :-

629.138.5.014.3 Wings for transport aircraft
629.138.5.066 Electrical systems for transport aircraft

Consequently, a block of such numbers would have appeared under every type of aircraft encountered in the literature, with the separation of material on, say, 'air systems' under many different main numbers. The type of aircraft is usually irrelevant in such cases, and was therefore ignored, the subject being placed directly at 629.13 with common

subdivisions, e.g.

629.13.066 Aircraft electrical systems

Where appropriate, use was made of subdivision alphabetically by proper names. This was done at such numbers as :-

629.13(42)(De Havilland - Comet)	(Aircraft names, except helicopters)
629.135.45(42)(Westland - Whirlwind)	(Helicopter names)
533.6.071(N.P.L. -)	(Specific wind tunnels)
621.432(Bristol - Pegasus)	(Piston engine names)
621.438(Bristol - Orpheus)	(Gas turbine engine names)
629.136.3(Atlas)	(Missile names)
669.14(En -)	(Specified steels)

When using this device, the basic number was always used, in order to have a simple sequence of <u>all</u> aircraft, <u>all</u> wind tunnels, etc. It was felt to be unwise to assign the most specific number possible before adding the name of the aircraft, material, etc., as in :-

629.138.5(42)(De Havilland - Comet)

In these cases, the type of aircraft (transport), etc. is specified before adding the designation, but when information is required on such topics, it is usually sought by the names used, and a single sequence of all aircraft, all wind tunnels, etc., is the preferable method. Where it was thought to be justified, entry was also made under the full number, without the addition of the alphabetical designation. This sort of requirement arose when material on a designated aircraft might have been of interest both from the point of view of that aircraft, and from that of the type of aircraft, e.g. entries for the subject 'ground equipment

for the Comet' might reasonably have been made under :-

629.13(42)(De Havilland - Comet): 629.139 (Ground equipment for Comet)

629.138.5: 629.139 (Ground equipment for transport aircraft)

Certain decisions had to be made with regard to the use of particular numbers for particular purposes, where ambiguity existed in the schedules. A particular case of this kind is the treatment of stresses, deformation, and strength in 53. The following rules were followed for this purpose :-

1. The various kinds of stresses are to be placed at 531.22 and its subdivisions, e.g. Bending stresses 531.224
2. The deformations resulting from these stresses are to be placed at 539.38 and its subdivisions, e.g. Bending 539.384
3. The ability to resist these stresses, i.e. strength, is to be placed at 539.4 and its subdivisions, e.g. Bending strength 539.413.

A rule had also to be made for the application of the numbers 533.692 and 533.693. The former is provided for material on section shapes, the latter for wings in general. Confusion arises, however, when subjects such as 'cambered wings', 'sweptback aerofoils', etc. appear. The following rule was made to clarify this problem :-

> 533.692 is to be used for all two-dimensional aerofoils, including wings, and for three-dimensional aerofoils and wings when the shape of the aerofoil section is paramount. For three-dimensional aerofoils and wings in general, particularly when planform is paramount, 533.693 or its appropriate subdivision is to be used.

One of the greatest difficulties in applying U.D.C. is the achievement of consistency in the way the various available numbers and auxiliary devices are used. The kind of problem which arises is the specification of materials in various applications. For the subject 'raw materials for turbine blades for gas turbine engines' the number 621.438.1-352.5.002.3 may be used. If the subject is 'steel for turbine blades for gas turbine engines', then the number should be 621.438.1-253.5.002.3: 669.14. In practice one seldom sees the use of the .002.3 number, because it is apparently redundant in that the steel must obviously be the material of which the blades are made. It is also very difficult to remember all the applications in which the 'points of view' numbers and other auxiliaries should be used, but they ought to be used <u>always</u> because of the separation of related subjects by their absence :-

1.	621.438.1-253.5.002.3	Raw materials for turbine blades
2.	621.438.1-253.5: 621.9	Machining of turbine blades
3.	621.438.1-253.5: 669.14	Steels for turbine blades

1 and 3 ought obviously to file together, but are separated because of the absence of .002.3 in 3. An exactly analogous problem arises in alphabetical subject cataloguing, because of the tendency to ignore the obvious and the avoidance of the inclusion of redundant terms. They are redundant as far as the statement of the subject is concerned, but certainly not from the point of view of filing order :-

1. WINGS - Sweepback
2. WINGS, CRESCENT
3. WINGS, DELTA
4. WINGS, SWEPTBACK

This separates material on sweptback wings, and the solution to the problem would be to include all qualifying terms in every case. The difficulty of ensuring such consistency and the resulting complexity, with undesirable headings such as :-

WINGS, SWEPTBACK - Sweepback
GASES, COMBUSTIBLE - Combustion

and class numbers of a similar structure in U.D.C. militate against the workability of such a procedure and it was felt that the adoption of the principle was not justified.

The many cases in which several different numbers are available for placing a given concept repeatedly caused difficulty. This problem seems to stem basically from the 'tree of knowledge' basis of U.D.C. which has resulted in the development independently of specific areas of the scheme. The inevitable result is that each of several different areas draws in a common subject as reasonably belonging to that area. The subject 'lubricants' for instance appears at 62-72, 621.89 and could conceivably appear in 665. Whilst the context often shows the appropriate place for a given document, it is difficult to make a decision between numbers such as 62-72 and 621.89. The problem is even more complex when a subject such as 'Fuel systems for ram jets for test vehicles' is encountered. 'Ram jet propelled test vehicles' should be placed at 629.138.744.035.53. A number for fuel systems exists at 629.13.012.525.3, but there is also the number 621.439.4.032 for 'fuel systems for ram jet engines'. For the sake of grouping in the most convenient way, the tendency was to use whatever appropriate main numbers were available, with one or more auxiliaries, and colon where

appropriate. This subject was therefore placed at :-

621.439.4.032: 629.138.744.035.53

and a second entry made by reversing round the colon. The first number in each case has some real significance in its own right, and though the whole entry is rather long, and the concept 'ram jet engines' is repeated, the second number does qualify the first. It is on problems such as this that the Facet scheme appears likely to score. The 'one place' principle inherent in Facet should go a long way to helping in this respect.

The various kinds of provision made for auxiliaries also show serious inconsistencies in the scheme, and though good alphabetical indexing will to a large extent, rectify these faults, there seems to be no reason why some rationalisation of the scheme should not eliminate many of them. A simple example of this is the provision at 621.43.018.55 for 'starting' internal combustion engines. There is also provision at the more basic number 621-57 for 'starting' and it is unfortunate that this duplication has been allowed to creep in. The number used for 'starting afterburners' was in fact 621.438.019.93.018.55, but it could have been 621.438.019.93-57. The reason for this was that where common subdivisions, etc. existed at the particular level of the schedules in question, (in this case 621.43), then those subdivisions were used in preference to those at the more basic number (in this case 621-).

At the same time, the analysis of a complex subject so logically as to ensure a 'one place' arrangement completely free from overlapping and ambiguity is extremely difficult. Facet analysis seems to be the proper approach to the problem, but in the present state of the art it is

doubtful whether even this approach has reached a sufficiently sophisticated level to justify claims that it will be an improvement on a system based on the 'tree of knowledge' principle, with its schedules largely empirically derived. It is this sort of question which it is hoped the testing will answer.

Where no place could be found for a specific subject, the usual procedure of using the number for the containing head was followed, if it was felt that a new number could not satisfactorily be assigned. This is a most unsatisfactory answer to the problem, for a subject such as 'stagnation point' had to be placed at 532.526 (boundary layer). It was often necessary to link this subject with a subject which was a subdivision of the number so assigned (in this case perhaps 'laminar boundary layer'). It is patently unsatisfactory to have such entries as 532.526.2: 532.526. For this reason the procedure was avoided whenever possible, and a new number created for the subject. The argument that the principle is acceptable, provided that the subject is entered in the alphabetical index to the classified catalogue, can hardly be accepted here.

Alphabetical index to U.D.C.

One very striking feature regarding the use of classified catalogues is the difference in emphasis placed on the value of an alphabetical index of high quality, as between the users of Dewey in public libraries, and the users of U.D.C. in special libraries. The very low standard of alphabetical indexing in special libraries probably stems from a confusion between 'indexing' and 'cataloguing'. If 'cataloguing' is taken to mean 'listing' (and this is a dictionary definition, not an invention of documentalists or bibliographers), then it follows that an

index is needed to 'point out' (again a dictionary definition) the location in the catalogue of a given subject, unless the catalogue happens to be of the kind where the known order is an alphabetical order of the names of subjects (an 'alphabetical subject catalogue'). Unfortunately 'indexing' has been used loosely to describe the listing, or cataloguing, of subjects in classified order (e.g. U.D.C. order) and the alphabetical index to this list has been regarded as of little importance.

The development of faceted classification systems has again put the alphabetical index into proper perspective, because it is rightly recognised that the index is an integral part of such a scheme of information retrieval. Moreover the principle of 'chain indexing' has introduced a rigorous discipline into the compilation of such indexes.

It was felt that the misconception outlined above should be squarely faced for the purpose of the project and that, as with all other three systems, no shortcomings which could reasonably be eliminated should be allowed to jeopardise the fair comparison of U.D.C. with the other systems. It was decided at the outset, therefore, that the best possible alphabetical index should be compiled in the course of indexing. There is apparently little literature on this aspect of the classified catalogue (Footnote 1) and the actual form of headings, etc. had to be decided in the light of experience. It is not sufficient to lay down that each term in the

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Footnote This is just one of a number of statements in this chapter which was (to the best of our knowledge), true at the time of writing the draft of this report, and equally true in 1958 when work on the project commenced. The position has changed with the publication of the book "Subject catalogues; headings and structure" by E.J.Coates, (London. The Library Association. 1960).

schedules which is used must be indexed, for problems of the form of heading for each entry are just as pronounced as those encountered in alphabetical subject headings work. The basic principle on which index entries were formed was that of selecting the word or words representing the most specific elements of the class number indexed, and adding the terms for superordinate classes in ascending order, to that level which it was considered would eliminate ambiguity by differentiating between homonyms and between entries for the same subject in different contexts. No attempt was made at chain indexing, i.e. the superordinate terms were not indexed as a matter of course, though many of them appeared as index entries in their own right, because documents appeared on the subjects which they represented. The type of entry produced by this method was as follows :-

Cooling. Gas turbines. Internal combustion engines.	621.438-71
Performance. Gas turbines. Internal combustion engines.	621.438.018.5
Blades, Turbine. Gas turbines. Internal combustion engines.	621.438.1-253.5
Flip-flops. Electronic switches. Relays. Electrical engineering.	621.318.572

This produced a standard form of entry and worked very well, but it was felt that whilst entries of this type should all be included, a modified type should be made additionally in some cases. The entry term 'performance' for instance, is unlikely to be sought except in connection with the 'thing' whose performance is concerned. The term 'production' could conceivably be useful for the searcher interested in production methods generally, and not just in connection with gas turbines, whilst 'blades; turbine' certainly ought to be used as entry term.

For these reasons, in many cases an additional entry was made by transposing the entry term to the end of the heading, producing entries of the form :-

Gas turbines. Internal combustion engines. Cooling.
" " " " " . Performance.

The transposed term was underlined to show that this had been done.

In the vast majority of cases the terms transposed were of the kind which in a faceted classification would fall into the 'energy' facet, i.e. operations, etc. There were a few exceptions to this rule such as properties (e.g. 'vulnerability') or substantives (e.g. 'materials'), but parts, such as 'blades, turbine' were never transposed.

The reason for transposition were as follows: if the form of entry produced by the basic rule is the only type used, then in some cases the substantive part of the entry (e.g. 'gas turbines') would not appear as entry word, and this is obviously undesirable. Provision could be made for this by part or whole chain indexing. The argument put forward for chain indexing is that if a higher term than the most specific is selected for entry into the classified catalogue, the subdivision of this term is self evident by the arrangement in the catalogue. But it is also admitted that the arrangement has to be supplemented by suitable guiding in the catalogue and this surely can only be described as 'listing' the subdivisions, for if the arrangement were in a known and recognisable order, guiding would be superfluous. The method of finding a specific topic by searching for it under the containing head (say 'Gas turbines') in perhaps three drawers of catalogue cards can hardly be claimed to be logical. This does, in fact, amount to 'sorting through' as distinct from 'known order'. It was felt, therefore, that as

the known order (alphabetical) was the basis of the index to U.D.C., its extension to showing the particular points in the catalogue at which subdivisions of a subject would be found would serve a useful purpose. The result was groups of entries of this kind :-

Gas turbines. Internal combustion engines.
" " " " " . Breathing.
" " " " " . Combustion.
" " " " " . Control.
" " " " " . Cooling.
" " " " " . Damage.

etc., etc.

In a few cases two terms were transposed, particularly where one was an operation (e.g. 'measurement') on another (e.g. 'property'):

Noise. Acoustics. Physics. Intensity. Measurement.

In a few others, where a superordinate term was likely to be unsought (though useful as a qualifier in the basic entry), both entry word and superordinate term were transposed, but the basic entry word was placed before the superordinate term, e.g.

Wind tunnels. Density. Tunnel conditions.
" " . Humidity. " "

Though chain indexing was not practiced, some of the principles relative thereto are obviously relevant here. One of these is Ranganathan's statement that the breakdown in the classification should show an 'expressive structure', i.e. it must be hierarchical. It is evident that the breakdown must not only be expressive, but must be consistent in its expressiveness, if searching is to be a logical process.

In other words, if in one part of the schedules 'processes' are to follow 'concretes', then this must be the arrangement in all other parts of the schedules. It is inherent in a faceted classification that this consistency is achieved, but it is certainly not always the case in enumerative schemes and U.D.C. is a case in point. If the alphabetical index to the classified catalogue is to be based on the principles adopted for use with U.D.C. on the project, then such inconsistencies must inevitably be reflected in the index.

Perhaps the worst example which we encountered of this inconsistency in U.D.C. is the treatment of the process 'measurement'. Provision is made at 534.839 for 'measurement of noise', at 534.61 for 'measurement of intensity of noise'. Both of these are main numbers, without the necessity for synthesis by common subdivision, etc. At 53.08 provision of common subdivisions is made, and it was found necessary to use these, for instance, at 536.2.08 for 'measurement of conductivity'. At 531.7 is a substantive number for 'measurement of geometrical and mechanical magnitudes', divided by the kinds of thing measured, such as 'density' at 531.75, 'height' at 531.719.4, etc., this being the reverse of the 'thing - process' breakdown at such numbers as 534.839.

It is impossible to cater for all difficulties of this kind, and the entries under 'measurement' for those numbers under 531.7 were omitted. Entry does appear, however, under the thing measured in every case, regardless of the section of the schedules from which the number is derived.

Another difficulty of the same kind arises because of inconsistency in the method of splitting down a physical 'thing' into its component parts.

In addition we used supplementary schedules for the following sections which were of particular interest to the subject field of the project :-

Class 532.5 and 533.6
Class 62-, 620, 621.1/2
Class 621.7, 621.8, 621.9
Class 629.1

The schedules for these sections have been worked out in greater detail than was available in the printed editions, but they have not been internationally approved. The schedules covering 532.5 and 533.6 were a revision of the existing schedules put forward by the Aslib Aeronautical Group. The schedules for 533.6 Aerodynamics are reprinted in Appendix B together with a sample page of the alphabetical index.

Alphabetical Subject Catalogue

Before the commencement of work, a survey was made of existing subject headings lists, and information relevant to the compilation of alphabetical subject catalogues, in an attempt to find (a) a list which would form a nucleus for the building up of a suitable set of headings and (b) rules or guiding principles which would ensure consistency in extending the list as the work proceeded.

Certain lists, which were mainly of U.S. origin, were examined but were all found wanting for our particular purpose. Possibly the most satisfactory seemed to be the Special Libraries Association 'List of Subject Headings for Aeronautical Engineering Libraries', but it was inadequate on three counts :-

a. It did not contain many of the headings required
b. Those headings which it did provide were too broad
c. There was no facility for building compound headings of sufficient specificity.

The attempt to find literature on guiding principles was even less successful. Most of what has been written seems to be devoted to the problem of what entries ought to be made to cover adequately the subjects of documents, i.e. the principles of multiple entry, and the technique of 'see' and 'see also' referencing. What was sought for the purpose of the project was, in effect, a 'grammar' of subject headings, that is the principle of forming consistently individual headings of any degree of complexity. The problem of multiple entry under such headings, and the linking of headings by references, whilst admittedly a complex problem, was felt to be subordinate to this fundamental problem of what form an individual heading should take. Indeed, the solving of the first problem should contribute to the simplifying of the second.

One of the latest excursions into the field of alphabetical subject cataloguing was the article by E.J.Coates 'The use of B.N.B. in dictionary cataloguing' (Ref. 14). This advocates the derivation of subject headings from the schedules of a classification scheme and in principle is an excellent system for mechanically marshalling terms, and ensuring their proper linkage by way of referencing. This is the kind of principle which workers in the field of information retrieval would like to see established as it removes cataloguing from the realms of art and establishes a science, but unfortunately this particular method appears to suffer from two fatal weaknesses :-

a. It does not provide for the actual form of individual headings (the 'grammar' mentioned above)
b. It presupposes a perfect classification scheme

With regard to (b), not only is there as yet no such perfect scheme, but a given subject is capable of breakdown by more than one system of characteristics. This is borne out by the fact that 'preferred order' in faceted schemes implies that there is choice of order, and consequently different possible breakdowns. It is therefore possible to derive different kinds of subject headings lists because of the dependence of linking of headings by referencing on several different possible classification schemes.

It was felt that it would be unwise to adopt the principle for the purpose of the project because it is possible that the quality of the subject catalogue would suffer rather than gain, by being tied to classification. Though consistency is achieved, the method limits flexibility in compiling a subject headings list, and it was felt that it should be left to the indexers to make the best possible list by knowledge of relationships gained in the course of indexing. It would also have been unwise to compare a subject catalogue based on headings derived from one of the classification schemes used on the project, with a classified catalogue using that scheme, for it is possible that the free choice of terms for subject headings is an advantage compared with the rigid grouping of terms in a classification scheme, at least in a scheme of the enumerative type such as U.D.C. It is possible that the testing programme will throw some light on questions such as this.

When indexing began, the S.L.A. list was used as a basis for the building up of a subject headings list, but as work proceeded and the particular requirements of the project became clearer, new

headings were generated quite independently and at this stage an attempt was made to formulate some simple rules. These rules were found to be somewhat restrictive and slight modifications were therefore made. In their final form the rules were as follows :-

1. Headings

   Headings are composed of Main Headings with Sub-headings if required.

2. Main Headings

   The Main Heading is composed of a noun (or a phrase), or a noun qualified by one or two adjectives. Normally an inverted form is used, so that the adjective follows the noun. A comma is interposed between the noun and the adjective, e.g. DIFFUSERS, WIND TUNNEL. Where TRANSONIC, SUPERSONIC or HYPERSONIC is used to qualify a heading in addition to another adjective, this speed qualification is to be regarded as subordinate and is to be placed last, e.g. DIFFUSERS, WIND TUNNEL, SUPERSONIC. Where common usage demands, the un-inverted form is used, e.g. WIND TUNNELS. In case of ambiguity, where the same word can be used with different meanings, a defining term may be added in square brackets, e.g. BLOWING [BOUNDARY LAYER CONTROL]. Names of specific items may be added in curved brackets, e.g. AEROPLANES (DE HAVILLAND - COMET), AEROFOIL SECTIONS (NACA 64010), ASPECT RATIO (9.43).

3. Sub-Headings

Sub-headings are used to qualify the main headings and are preceded by a hyphen. In general, sub-headings fall into three groups :-

a. Processes such as "Production" or "Anodising"

b. Things which can be measured, calculated or otherwise determined

For example 'lift' can be measured, 'Stress distribution' can be calculated, 'collapse' can be determined.

c. Form such as "Charts"

In some cases, sub-sub-headings may be used further to qualify main headings and sub-headings, e.g. WINGS - Lift. Measurement.

These rules may appear to be inadequate for the purpose of building up a subject headings list in a field as complex as aeronautics, but it appeared that there were two alternatives: either to use a simple set of rules of this kind and decide on individual headings as they arose, or to endeavour to cover every individual case which might arise. There is little doubt that the complexity of the second alternative is the reason why no satisfactory guiding principles exist, and in fact the end result would doubtless consist not of a set of rules, but of a list of arbitrary decisions, one for each heading used. This result is reached in practice, of course, in that the subject headings list itself is a list of terms resulting from such arbitrary decisions. Inevitably, there is inconsistency in the form of headings used because of the impossibility of determining form in principle, instead of by

empirical decisions on individual headings.

The provision of rules to meet every case would determine unambiguously what the form of a heading should be for both indexer and searcher, and this would ensure that coincidence between the two which is the essence of successful information retrieval. To illustrate the magnitude of the problem, the following is a list of some of the possible adjectival qualifications of 'blades' :-

Blades, Steel
, Twisted
, Hollow
, Propeller
, Thin
, Supersonic
, Tapered
, Adjustable

It is conceivable that it may be necessary to form a heading of this kind :-

Blades, Propeller, Steel, Twisted, Tapered, Hollow, Supersonic.

It is difficult to imagine what logical analysis of a subject could possibly determine in what order these qualifications should be. In practice, of course, it is possible to determine the sequence by using facet analysis and having categories of terms, with the categories arranged in a 'preferred' order. But this is a specification of only one kind of object (a 'blade') and the order that is suitable for this will not necessarily be the best for other subjects. The question of 'preferred order' and the unlikelihood of a single commonly acceptable order has already been

mentioned and will be discussed again in the section on the Faceted Classification Scheme. Additionally, the characteristics which determine these qualifications, may as a group be quite different from those required to analyse another subject, and each case seems to need its own rule.

This aspect of the problem is only the beginning of the difficulties encountered in subject headings work. Simple adjectival qualifications of this kind, whilst presenting difficulties in the alphabetical subject catalogue, cause no complication emanating from 'relational' problems, because they merely exist side by side as characteristics which the object possesses, and it is likely that mechanical sorting could satisfactorily handle them without the risk of 'false drops'. There is usually, however, the need further to qualify a heading by sub-headings to show such things as processes, the conditions under which processes are applied, the 'agents' in the processes, properties, problems, applications, etc.

It is at this stage that the forming of headings becomes really difficult. Certain kinds of relations between subjects are recognisable in practice, but it is impossible to estimate how many such relations may exist in the field of human knowledge. Some such recognisable relations encountered in indexing were :-

a. Affected by -
b. Affecting -
c. Compared with -
d. Applied to -
e. Controlled by -
f. Controlling -
g. Under the conditions of -

Examples of the contexts in which these relations might be relevant are as follows :-

a. Boundary layer transition - affected by - surface roughness

b. Boundary layer transition - affecting - drag

c. Aluminium - compared with - steel (for a particular application)

d. Computers - applied to - air traffic control

e. Missiles - controlled by - gyroscopes

f. Tapes, Magnetic - controlling - machine tools

g. Propellers - under the conditions of - supersonic speed

(This is a different concept from that of propellers designed for operation at supersonic speed, i.e. Propellers, Supersonic)

This type of problem is a far cry from the simple principles advocated by those such as Kaiser (Ref. 15). His 'concrete' and 'process' methods make for consistency and are excellent for the type of catalogue which does not demand the specificity required in such a field as that covered by the project. It is obvious that the examples given above are not the only forms in which the subjects might be stated, and that some (e.g. a. and b.) are complementary in that the two-directional relations 'affected by' and 'affecting' can be reduced to a single one-way relation by transposition of the terms.

It was evident that the magnitude of the problem of rationalising the types of entry was such that any attempt of this kind was out of the question. The chances of success were, in any case, slim in the present state of the art. It was felt, therefore, that it was unwise to go further than the use of the type of heading permitted by the rules set out above,

i.e. a main heading consisting of a substantive and a maximum of two adjectives, together with a maximum of two subheadings. Usage usually decided the order of two adjectival qualifications and in the case of speed (e.g. 'supersonic'), this always appeared as the last word in the main heading, e.g.

WINGS, SWEPTBACK, SUPERSONIC

As far as sub-headings were concerned, where two were used, it was usually clear what the order should be, as the second qualified the first, e.g.

WINGS, SWEPTBACK, SUPERSONIC - Lift. Measurement.

An early decision which had to be made was whether to use the principle of direct entry or inverted headings. It was decided that the inverted form should be used, firstly on account of the useful grouping which this brings about, and secondly because of the advantage of eliminating what would have been extremely elaborate referencing. It seems that most of the writings on alphabetical subject headings work has been concerned with the cataloguing of very general material, where subjects fall into a very large number of largely separate pigeon holes, with only comparatively small groups of such subjects needing linking by cross reference. In a field as complex as aeronautics, the pattern is such that direct entry would lead to the separation of large numbers of headings which are usefully grouped by inversion.

It is not practicable to state categorically that all headings must be inverted, because the relative significance of substantive and qualifier varies very considerably from one term to another. The following examples illustrate this :-

a. Double flaps

b. Fuel injectors

c. Generating plant

It is evident that to enter (a) in the univerted form is to place the entry where it is very likely to be unsought. (b) is a doubtful case, where it might be argued that either form would be acceptable, whilst (c) is a case where what is strictly the substantive part of the heading (plant) is such a nebulous term that entry under it would invite risk of losing the material indexed. These examples show the two extremes, and a middle case where the balance in favour of one word or the other is not decisive. In practice every degree of difference in emphasis is met and decisions can only be made on the merits of the particular case, and not by rule. Exception to the basic requirement that headings should be inverted was therefore made where usage definitely demanded the uninverted form and where the substantive was decidedly of less significance than the first term.

One feature of the rules about which some doubt was felt was that the facility for using a substantive as a subheading was excluded. This was considered to be a disadvantage in some cases, as some useful headings could have been made in this manner. A particular example is the desirability of being able to use 'boundary layer' as a subheading, e.g.

CONES - Boundary layer

The non-existence of this rule would also have enabled names of parts of things to be used as subheadings, e.g.

ENGINES, RAMJET - Fuel systems

This, of course, is tending towards alphabetico-classed entry, and it was certainly not intended that this principle should be used. For this reason, the rule was probably justified. It was satisfactory in this case to use :-

FUEL SYSTEMS, RAMJET

which is no less specific than the thing-part type of entry, and which is manageable with proper 'see also' referencing. This form of heading could not be used to solve the earlier problem, as it would have produced :-

BOUNDARY LAYER, CONE

This again illustrates the existence of many different shades of meaning and different relationships which make the consistent forming of headings so difficult.

It is doubtful whether the qualifying terms 'ramjet' and 'cone' in the inverted headings quoted could legitimately be called 'adjectival', but whatever they may be, further problems are created when two such qualifiers appear. 'FLYING BOATS, SUPERSONIC' and 'BOATS, FLYING, SUPERSONIC' are both acceptable, but 'AEROFOIL THEORY, SUPERSONIC' is not strictly correct as the only term to which 'supersonic' can apply is 'aerofoil'. 'Aerofoil theory' as an entity cannot be supersonic. The form given above was in fact accepted as being in general use, though AEROFOILS, SUPERSONIC - Theory might be better. However, the undesirable headings which can be produced by using the latter method to break down everything of this kind are illustrated by the examples given by Prevost in her article on theory and method in general subject headings (Ref. 16).

Alphabetical subject catalogues seem to be at their weakest when concerned with two or more substantives linked by one or more relationships. The subject 'the diffusion of light rays in turbulent boundary layers' can be catered for only partially satisfactorily, and would probably take the entries :-

BOUNDARY LAYER, TURBULENT - Properties
LIGHT - Diffusion

No doubt the subject would not be lost, but in a large collection of documents in a specialised field, this kind of problem becomes acute, and greater specificity is required. The form of entry quoted above, was in fact the kind used during the indexing, but the indexers were conscious of the fact that greater sophistication will be required in the future as quantity of documents and complexity of subject increase.

The facility for incorporating names of specific aircraft, engines, aerofoil sections, etc. was provided and was used as with the other systems. The facility for showing quantitative values of aspect ratio, sweepback, etc. was also provided, but the tendency was not to use this much, as the headings could not normally be as specific as was desirable in the first place and the use of bracketed quantities was not likely to relieve the situation.

In spite of apparently insoluble problems on this question of specificity, the alphabetical system may prove to be far more satisfactory than would appear, for the reason that the specificity provided by other systems may be a snare and a delusion. The testing will show up the respective merits of the various systems.

The question of cross-references was another matter on which we were unable to obtain much practical guidance. Normal "see" references were of course, made in all cases of inverted headings and synonyms, and it was also a routine procedure to index "see also" references where a term for a main heading was also used as a sub-heading, e.g.

ANODISING, see also as sub-heading with specific subjects, e.g. BRASS - Anodising

Our problem came with "see also" references which linked related subjects, and after long discussion it was decided that these should, for the purpose of the indexing, not be used. Our reasons for this somewhat radical departure from accepted practice are given below.

Firstly it is necessary to consider the reason for including "see also" references. A subsidiary use is to suggest to the indexers other or more suitable headings. Their main use, however, is in the retrieval of information, the intention being that where the searcher fails to find all the information he requires under a particular heading, he will find references to other subject headings which may possibly contain relevant information.

"See also" references can be of various kinds. They can refer from the general to the more specific, e.g. Aircraft see also Airplanes; Airships; Balloons; Cyclogyros; Gliders; Helicopters; Rotor Aircraft, or from the specific to the general; e.g. Airplanes see also Aircraft. Alternatively they can refer to subjects related on the same level, e.g. Seaplanes see also Flying boats, or they can

refer to subjects which basically appear to come into a separate category, e.g. Machinery see also Patents.

It is, presumably, a policy decision as to which of these types of "see also" references should be used, and in the S.L.A. "Subject headings for aeronautical libraries", there appears to have been the decision not to refer from the specific to the general in the case of physical objects, so we do not find the example given above "Airplanes see also Aircraft". With theoretical subjects, however, this ruling does not appear to apply since we find "Flow of Fluids see also ..... Fluid Mechanics; Fluids; Hydraulics; .....". The other examples given in the preceding paragraph are taken from the S.L.A. list, and we attempted to find the basic principles which governed the compilation of the "see also" references.

We immediately became aware of a number of contradictions which are illustrated by the examples given above. "Aircraft" can reasonably have "see also" references to "Airplanes; Airships; Balloons; Rotor Aircraft", but "Cyclogyros; Helicopters" are types of "Rotor Aircraft" from which they receive "see also" references, together with "Autogyros". "Airplanes" has "see also" references to "Amphibians; Biplanes; Flying Boats; Hydroplanes; Seaplanes;" and there appears no reason why these should not also be listed under the "see also" references from "Aircraft" if "Cyclogyros; Helicopters" are to be so included.

If related subjects at the same level, such as "Seaplanes see also Flying Boats" are to be given, then one would have expected to find "Cyclogyros see also Autogyros", but there is no such entry. The person searching under "Ailerons" will find no "see also" references

unless he thinks of the containing head "Control Surfaces". Under "Flaps" he will find "see also Air brakes" but if he should go straight to "Flaps, Dive", he will find no such cross reference.

The inconsistencies in the S.L.A. list are not peculiar to this particular list, but were apparent in a number of other lists which we reviewed, and we mention this list only because of the authority which is given to it by the number of distinguished persons who helped in its compilation. We came to the conclusion that "see also" references were made in a haphazard and arbitrary fashion, a fact which was borne out in correspondence with a number of librarians in Canada and the United States.

To do the job thoroughly, it would seem that every time a new heading was generated it would be necessary to go through the complete list of headings to ascertain which of the headings merited "see also" references. If this were done conscientiously it would take care of all the required "see also" references from the general to the specific and also the references to allied subjects at the same level, but it would obviously be a very time-consuming task. The only logical method of doing this work appeared to be by compiling a set of classified schedules or alternatively a form of thesaurus which would embrace all the headings in the list and which could be used by searchers whenever they wished to have ideas of new headings to search. It is not a new proposal that "see also" references should be constructed in this manner, but we were unable to find any cases of its having been done in any subject field approximating to aeronautics. If such a schedule or thesaurus is compiled and used, it must obviously carry the implication that there is no guarantee that useful information will be found in any of the other

headings. We took the view, as strongly stated by Metcalfe (Ref. 6), that there is no justification to use cross-references in an attempt to justify bad indexing, and that any document which clearly dealt with two separate subjects should receive entry under both subjects and therefore we would see no occasion to use the example given above of "Machinery see also Patents".

The only way to judge how important cross-references are to the user is to conduct tests first without and then with their aid. This was done by Swanson in his work on machine indexing (Ref. 17) and it is the method which we shall be adopting. From the complete list of subject headings, we have constructed classified schedules and, in those searches where, without its use, we failed to find the required document, we shall repeat the search with the extra aid of the schedules.

A representative page from the list of subject headings is given in Appendix C.

The Faceted Classification Scheme

A summary of the principles incorporated in the Faceted Classification Scheme used for the project can be found in 'Classification Research Group Bulletin' No. 5, (Ref. 7) and it is not intended here to go into great detail regarding its construction and the breakdown of the schedules.

Facet analysis is probably the most powerful tool ever to be introduced into the science of classification and it undoubtedly provides a most rigorous method for the proper marshalling of terms in a given field. Its application results in the formation of a number of conceptual categories, each of which comprises terms representing items of like nature, i.e. terms derived by the application

of a single characteristic. These categories are then arranged in a 'preferred order' so that a proper arrangement of superordinate and subordinate terms is arrived at when a number of terms are selected and synthesised to represent a complex subject.

The categories of terms derived by this method for the purpose of the project were such as: Aircraft types, Aircraft parts, Engines, Flying operations, Aerodynamic entities, Forces, Materials, Processes, etc. These categories were then arranged in that order which it was considered was best suited to the subject field, and terms selected to represent the subject of a document were cited in this order in synthesising a class symbol.

A simple alphabetical notation was used, and for the sake of brevity, the base of 26 letters was spread more or less evenly over the schedules. The notation is not hierarchical except in places where the breakdown fortuitously makes it so, as the authors of the scheme are of the opinion that notation need not reflect the hierarchy of the schedules. Each term is represented by a capital letter, usually followed by one or two lower-case letters. This provided a fairly homogeneous arrangement of letters in a class symbol, and seemed to make such a symbol more manageable than might have been the case if long runs of either capitals or lower case letters had appeared, or if the notation had been mixed.

The process of classifying consisted of selecting from the schedules those terms which were relevant to the complex subject of the document and synthesising the class symbol for the document by citing the notational elements in the order of the schedules. The subject 'wind tunnel tests on blowing over flaps for high lift on short take-off aircraft'

would be represented by the following terms :-

Wind tunnel tests	Vn
Blowing	Okd
Flaps	Cr
Lift	Nq
High	(Zqn)
S.T.O. Aeroplanes	Bmd

The notation would then be arranged as follows, to give the complete class symbol for the document :-

BmdCrNq(Zqn)OkdVn

Except in the comparatively few cases where more than one quite separate complex subject appeared, a single entry only was made in the classified catalogue. The purpose of faceted classification is to facilitate such one-place classification, and it is evident that the classified catalogue must be supplemented by some device to enable access to be made to a given term at every point at which it appears, regardless of context. This was achieved by 'chain indexing'. Chain indexing consists of citing the terms represented by the class symbol in the reverse order of the schedules in order to provide the basic index entry to the full class symbol for a document, and thereafter making additional entries by the process of deleting one term at a time from the beginning of the entry and similarly deleting the corresponding notational element at the end of the class symbol. The chain index entries for the above subject would appear as follows :-

a.	Wind tunnel tests: Blowing: High: Lift: Flaps: Short take-off aeroplanes	BmdCrNq(Zqn)OkdVn
b.	Blowing: High: Lift: Flaps: Short take-off aeroplanes	BmdCrNq(Zqn)Okd
c.	High: Lift: Flaps: Short take-off aeroplanes	BmdCrNq(Zqn)
d.	Lift: Flaps: Short take-off aeroplanes	BmdCrNq
e.	Flaps: Short take-off aeroplanes	BmdCr
f.	Short take-off aeroplanes	Bmd

It is evident that all information on "Short take-off aeroplanes" is gathered at Bmd in the classified catalogue. Other terms which are represented by notational elements further down the class symbol, e.g. 'Blowing' - Okd are shown to exist in this context by the chain index entry (b). In all other cases where 'Blowing' appears, chain index entries show the contexts and all the 'distributed relatives' are thus gathered under 'Blowing' in the chain index. Such entries may be inspected and entries under the relevant class symbols consulted in the various parts of the classified catalogue. Typical chain index entries might appear thus :-

Blowing: Air intakes: Gas turbine engines	GfGqOkd
Blowing: Delta: Wings	Cd(Ij)Okd
Blowing: High: Lift: Flaps: Short take-off aeroplanes	BmdCrNq(Zqn)Okd

In searching for a given subject, the process is as follows: If the required subject is that shown in the basic chain index entry above (a), the searcher examines the chain index under 'Wind tunnel tests' and may pick out this actual entry by inspection. This directs him to the class symbol quoted and entries for this subject appear at that

point in the catalogue. Any subdivisions of the subject follow this symbol. If there is the possibility that more general subjects will be of interest, the searcher works up the catalogue through entries such as BmdCrNq(Zqn)Okd, BmdCrNq(Zqn), BmdCrNq, etc. It is evident that the subject of "flaps on Short take-off aeroplanes" in general at the broad symbol BmdCr may be of interest and the searcher passes through numerous combinations of terms before reaching a point such as this, many of which might be relevant.

It is also possible that terms in the notation selected may appear in other contexts, in some cases being entry terms, and for this reason, the searcher works down the catalogue to such terms as CrNq(Zqn)OkdVn, Nq(Zqn)OkdVn, etc. Some terms will not, of course appear as entry terms, and it is probably better to achieve this aspect of searching by judicious use of the chain index than by searching down.

If the searcher selects a term other than the entry term of the basic chain index entry, i.e. other than 'Wind tunnel tests' in the example given above, and assuming that the term selected is one of those in the basic entry, he is led to a point in the classified catalogue above that at which the specific subject he seeks is entered. It is therefore always wise to examine all entries which are subordinate to those at the class symbol given by the chain index entry, as many are likely to be relevant. Suitable guiding of the catalogue is a help in this respect.

Certain modifications to the scheme as first drawn up were made before indexing began and during the early stages of indexing. It

should be emphasised that the authors of the scheme were considered to be the best judges of the form which the structure of the scheme should take and the method of application of facet principles for this purpose. The revision which was carried out was done with this in mind and the approval of the authors was sought regarding all the changes which were made.

The first changes consisted of minor alterations to correct errors of a purely technical nature and Mr. Opatowski, the subject specialist, was responsible for practically all of this work. None of these changes altered the structure of the scheme in any way.

The first difficulty encountered in the practical application of the scheme arose out of the facility for placing notational elements out of order. This provision was made because it is evident that no single order can cater for every requirement, though experience showed that the authors' choice of preferred order was probably the best possible. The type of term most commonly subject to this treatment was that which has valid applications to other terms in many different places in the schedules, usually for the purpose of adjectival qualification, though in some cases these terms were of the 'process' type and could conceivably cause 'false drops' if not associated properly with the thing to which the process applied.

Initially, any term was regarded as being capable of being placed out of order, provided that it was placed in curved brackets. This caused difficulty on two counts :-

a. Such free movement permitted such inconsistency in synthesising class symbols that the purpose of the scheme was largely defeated.

Almost any complex concept could be coded in several different ways and the choice of combination depended largely on how the indexer would state the subject in words.

b. Filing order was seriously affected as brackets were significant in filing and for a single subject they might appear in one context and not in another because the one demanded them and the other did not, e.g.

Cd (Ij)Fdb	Spars for delta wings
Cd Ij Nud	Rolling moments of delta wings

Both these problems were largely solved by a decision that terms in only certain parts of the schedules could be placed out of order, and that these terms should always be bracketted. The terms concerned were those at Igb - Iyw, Prb - Px and Za - Zvm. All these terms are either adjectival or are the names of general properties. Whilst there were other cases where it might be desirable to place terms out of schedule order, the majority of subjects were stated reasonably satisfactorily by working to this rule, and the number of 'false drops' is not expected to be large.

It was implied in the first instance that when terms were used in a sense other than that stated in the schedule, e.g. Std used for 'sweat cooled', when in fact this is stated as the process 'sweat cooling', a modified form of wording, e.g. the adjectival form could be used in the chain index. This facility again lead to inconsistency in the form of heading in the chain index and it was evident that standardisation must be ensured. There was, at the same time, some doubt about the form certain terms should take in the chain index

entries even when used in their normal context, and it was decided, therefore, that the schedules be examined thoroughly and a definitive form for every term laid down. This was done and thereafter no modification whatsoever of the form given in the schedules was permitted, even though a slightly different sense was sometimes produced in chain index entries. At the same time, an exhaustive alphabetical index to the schedules was compiled, and the form of terms here followed that of the schedules themselves exactly.

Whilst these steps were fairly rigorous modifications, it was agreed that no modification to the structure of the scheme had been made, and the great simplification and consistency which the changes brought about has undoubtedly justified this course. This overall rationalisation, including simplification of the notation by dropping the original intention to use a hyphen instead of the capital letter for any second or further elements taken from a given notational facet (details of which appear in Ref. 7, C.R.G. Bulletin No. 5), also helped a great deal in simplifying the clerical work of producing chain index entries. This procedure became entirely mechanical in that the typist, after typing the basic entry, formed the second and subsequent entries by merely removing everything before the first colon in the wording of the last entry, and the last notational element. Notational elements were easily recognised as they always consisted of a group of letters, all of which were lower case, except the first which was a capital. The only exception to this rule was the use of :b and :c for bibliographies and charts respectively.

It was felt that the simplification described above was essential for the practical application of the scheme and experience has shown that the system has probably gained rather than lost in terms of

efficiency of retrieval. Nevertheless it seems that some sophistication might improve the actual arrangement of entries in the catalogue. One fault which has come to light is that the old problem of 'inversion' occurs. The following is an example of this :-

1.	Gf	Gas turbines
2.	Gf Hku	Gas turbine combustion chambers
3.	Gf Hku Vbd	Design of gas turbine combustion chambers
4.	Gf Vbd	Design of gas turbines

It is clear that 4 should have followed immediately after 1 in order to have the general followed by the general treated specifically, followed by the specific treated specifically. In other words the design of gas turbines generally should precede material on combustion chambers and should certainly precede material on the design of combustion chambers.

One solution to this problem is to make 'parts' of things into 'dependent facets' as are 'parts of rotors and propellers' and to substitute a symbol such as the hyphen for the capital letter in the notation, so that we have :-

1.	Dc	Propellers
2.	Dc Vbd	Design of propellers
3.	Dc - j	Propeller blades
4.	Dc - j Vbd	Design of propeller blades

The facility for substitution of the hyphen for the capital letter was originally provided, but it should be emphasised that its provision was not for this purpose, and it would in any case have satisfied only those cases where :-

a. the facet was a dependent one

b. both main and dependent facets were in the same notation facet

These requirements were met in the second example above, but not in the first, for it was not permissible to substitute the hyphen for 'H' to give Gf - ku instead of Gf Hku. It is apparent that a facet connector of universal application would have met the case, but the scheme is so complex, merely on account of the complexity of the subject matter, that it is doubtful whether this added complication could have been justified.

The non-hierarchical nature of the notation caused no difficulty in indexing, though it might have presented difficulties, from a clerical point of view, if chain indexing had been done up to containing heads within notational facets. This latter procedure was not adopted, though there are some who advocate it. Its adoption would have meant continuous reference to the schedules by the typist compiling chain index entries and it would have meant indexing combinations of terms which did not actually exist in the catalogue in some cases. A simple example of this is as follows :-

Bj Cr Flaps on high wing aeroplanes

If this is fully chain indexed (omitting unsought terms) the following entries appear :-

1. Flaps: Control surfaces: Aerofoils: High wing aeroplanes Bj Cr
2. Control surfaces: Aerofoils: High wing aeroplanes Bj Cp
3. Aerofoils: High wing aeroplanes Bj Cc
4. High wing aeroplanes Bj

It is quite possible that no entries appear in the classified catalogue under the class symbols for entries 2 and 3. This can only be confusing to the searcher, though adequate 'featuring' and guiding of the catalogue would help very considerably.

Further to this, assuming that the searcher seeking 'flaps' entered the catalogue at Cc (Aerofoils) he should find what he seeks by searching down the catalogue from this point. But supposing that no entries exist on 'Flaps", how is he to know how far down to search, when the notation is not hierarchical ? He does not know that 'flaps' are at Cr and how is he to know that he has not exhausted the 'aerofoil' group when he reaches, say, Cp (control surfaces). The aerofoil group does, in fact, end at Cxe, but only reference to the schedules will show this. Again, featuring and guiding should be of help here.

It is generally claimed that chain indexing gathers the 'distributed relatives', by grouping together in the chain index those entries for a given subject concept which are distributed throughout the classified catalogue because they appear in different contexts. This is generally true :-

Lubricants: Roller bearings: Compressors: Gas turbines
Gf Gw Hin Pdd

Lubricants: Ball bearings: Pumps: Fuel systems: Rocket Engines Gj Gn Gzd Hik Pdd

But if we have two subject concepts which are considered to be very closely related, have different names, and appear in different contexts, we do not bring them together in any way by this method. Take 'Boundary layer fences' and 'End plates'. We may have entries such as this :-

Wind tunnel tests: Transonic flow: Boundary layer Fences:
Crescent: Wings Cd (Ipg) Cx Nbj Vn

Flight tests: End plates: Rectangular: Wings: Gliders
Bud Cd (Ikb) Cxe Vif

The entries in the classified catalogue are obviously widely separated and there is only one common term in the chain index entries, i.e. Wings. Even though the searcher did choose to look under wings the mass of entries there, with no mention, of course, of either boundary fences or end plates would be virtually useless for a search for the subject concerned. The difficulty does not arise in a hierarchical scheme such as U.D.C., for regardless of context, we should certainly make entries under :-

533.694.731 and 533.694.733

The notation here, with 533.694.7 representing 'boundary layer control' groups these, and all other devices for this purpose, together.

Assuming that the order selected for the arrangement of categories is the best possible, the question of permutations does not arise, because only a single order of a given set of terms is possible. What does present a problem is the question of combinations, i.e. a selection of a given number of terms from a larger number, because the terms selected for search in the chain index may appear with other terms interspersed, and only an exhaustive examination of all contexts in which the terms may appear in combination, will ensure that every possibility has been examined. A simple example of this problem is a search for 'Pressure gradient on cones'. Pressure gradient (Nvk) is so widely separated from cones (Fr) that we find numerous terms

intercalated between them, and the wording in the chain index entries assumes the same form in reverse order, e.g.

Fr Nbk Nep Nvk	Pressure grad:	Shear flow: Supersonic flow: Cones
Fr Ncd Nfk Nvk	Pressure grad:	Boundary layer: Laminar flow: Cones
Fr Nhd Nfk Nvk	Pressure grad:	Boundary layer: Shock waves: Cones
Fr Nvk	Pressure grad:	Cones

This situation demands that every entry under pressure gradient must be examined, in case the two terms appear, for though other terms may exist between them in the index, they may be irrelevant as far as the search is concerned, and any such entry may refer to a useful document.

These are anticipated difficulties with regard to searching and may prove less severe than seems to be the case at present. In any case chain indexing is not necessarily the best way of taking advantage of a faceted classification scheme, and it is obvious that whenever the last-mentioned problem occurs (that of combinations of terms), there is no other satisfactory or economic method but mechanised sorting.

Once the initial difficulties of ensuring consistency and standardisation of terminology, and of simplifying the clerical work of chain indexing had been solved, the scheme was quite simple to use from the point of view of indexing. These difficulties were, in any case, of no greater magnitude than could reasonably have been expected with a completely new classification scheme.

The main outline of the facet schedules and the full schedules for a section of Aerodynamics are given in Appendix D.

Uniterm

The Uniterm System of co-ordinate indexing is such a simple scheme that there is little to report as far as experiences on the project is concerned. Whilst the system is simple in practice, the principle of subject analysis is just as relevant here as it is with any information retrieval scheme, but, as discussed earlier, the system has been used in its present form for the purpose of comparing the result of indexing based on 'literary warrant' with the more sophisticated methods of analysis such as that provided by facet classification.

Initially the three indexers were allowed to compile independent lists of uniterms and this procedure was continued until the end of the indexing of the first 6,000 documents. At this stage the three independent lists were integrated and problems of synonyms and cross-referencing were resolved. Up to this point, conventional posting of terms had been carried out, but it was decided that posting could be done more economically by assigning simple numbers to the terms and recording these, together with document numbers on Powers Samas punched cards. Synonyms were catered for, by simply assigning the same uniterm number to all terms in a group of synonyms.

The use of punched cards will provide indexes in two forms:

(a) The punched cards themselves form one index and searching can be done by keeping the cards in uniterm number order, and feeding one block of cards bearing a common uniterm number against another similar block, into the collator, and seeking coincidence of document number.

(b) The cards will be fed into the interpreter having been

sorted into (1) uniterm number and (2) document number within batches bearing the same uniterm number. The interpreter will then print out lists in this order, providing a conventional visual uniterm index. Suitable programming will provide for posting in terminal digit order.

The only problem which arose in the indexing was the common one of how far to go in splitting down concepts into 'unit terms'. It seems impossible in the present state of knowledge to lay down specific rules, and as with alphabetical subject cataloguing, general usage is probably still the best guide. The vast majority of terms cause no problem, but compound terms in common use are not so easy. 'Turbojets' and 'Turboprops' are commonly used, but 'Turborockets' is not. Should we split the latter into 'Turbines' and 'Rockets' and if so, should we treat 'Turbojets' and 'Turboprops' in the same way ? 'Engines' provides no problem, but how do we cater for the searcher under 'Power plants' ? For the purpose of the project the commonly used compound terms were used in their usual form, e.g. 'Turbojets', etc. and where terms did not appear in this form in the list, the compound term was split into its component terms. The first appearance of a difficult term resulted in a discussion and a decision by the indexers. No serious difficulty arose as a result of this procedure, and there was usually no need for recording such decisions, as the indexers' personal knowledge was adequate to avoid different treatments at different times of troublesome terms.

A difficulty which is always probable with Uniterm is the likelihood of 'false drops' because of two or more terms being unintentionally related. A simple example is the coding of a document on

the 'vibration of helicopter rotors'. If these terms 'vibration', 'helicopters', 'rotors' are used, then if a search is made for documents on 'vibration of helicopters induced by rotors', the former document will be retrieved, though the subject is not the same. There is some argument about the seriousness of such 'false drops', and the results should provide some fairly conclusive evidence on this point.

Another problem which appeared was that of the document which contained material on more than one distinct subject. All the uniterms were posted to the single document number, and it is evident that this could also cause 'false drops'. The solution to this would obviously be to assign more than one number to such documents, in order that each subject concept can be isolated and identified by a unique number, but the seriousness of this problem will depend on how much common ground exists between the separate subjects in the document. Again, the tests will show whether any such special provision is justified.

There was no doubt that uniterm was quite the simplest of the four systems to apply. Whether it loses in difficulty of retrieval what is gained in simplicity in indexing, remains to be seen.

A representative page from the list of uniterms is given in Appendix E.

CHAPTER 5

SUPPLEMENTARY PROCEDURES

The project is being deliberately restricted to those matters which are concerned with the intellectual problems of indexing documents and formulating search programmes. The question of which particular physical form the completed index should take is a completely separate matter that is largely irrelevant to the investigations. Whereas certain systems such as the alphabetical subject catalogue or the U.D.C. are conventionally used with catalogue cards, a system such as the Uniterm can take several different forms. Originally it was proposed that lists of document numbers should be written on cards to be compared; many organisations use some form of peek-a-boo cards; others make use of punched card equipment and some are reported to use computers. Irrespective of which method is used, if the indexing and the search programme are constant, so will the result be the same.

However, the opportunity was taken in the course of the investigation to record some results of the work involved in the compilation of the necessary indexes. The form which these should take and the methods used were dictated by practical and economic consideration of the equipment and personnel that were available and no way is it suggested that they would be ideal solutions in all circumstances.

With the alphabetical subject catalogue and the U.D.C., conventional 5" x 3" catalogue cards were used. The same was the case with the classified catalogue and the chain index for the facet system. With Uniterm it was decided to prepare lists of document numbers for visual comparison.

Preparation of catalogue cards

For each document that was indexed we had a known requirement for a minimum of six cards up to an unknown maximum, with the average requirement being estimated at twelve. The minimum of six was made up of at least one card for each of the three systems, (i.e. U.D.C., Alphabetical and Facet), plus one card for each of the three supplementary indexes that were being maintained, these being an index in numerical order of the project document references, an author index and a source reference index.

We considered a number of methods of producing these cards, and rejected many either on account of cost, lack of permancy of the master, or poor quality of the product. At one time we did discuss making use of the services of the equipment used for producing catalogue cards for the British National Bibliography, and the Director, Mr. A.J.Wells, was very helpful in working out a possible satisfactory method. A major difficulty would have been in the transportation of masters and cards between London and Cranfield, and while discussions were still in progress, certain equipment was installed in the Business Systems Laboratory of the College which made possible a most satisfactory method.

The equipment was the Graphotype Embossing Machine manufactured by Addressograph-Multigraph Ltd. The Laboratory already contained an Addressograph printer, so we had available equipment which gave us all the flexibility, combined with economic working, which we required. The Graphotype is an electrically driven keyboard operated model, which embosses characters on metal plates. Since we could use this equipment without charge, the only material costs involved were in the purchase of the metal plates and the holders into which the plates have to be put for

printing. (Fig. 2). 18,000 metal plates were purchased at a cost of 0.9 pence a plate. The holders cost $2\frac{1}{2}$ pence each and we found that 300 holders met our requirements. As each holder was used on an average of 60 times, our basic material costs were just about one penny for each document.

The plates which we used had a capacity of nine lines of type, with a maximum of 40 characters in each line. The layout of the cards is shown in Fig. 3 and consists of author and project document number on the top line, the title of the paper or article and the source reference. Typing on the Graphotype is slower than with a conventional typewriter, due to the time lapse necessary between each letter to allow for the embossing of the metal plate, but it was possible to maintain an average of 35 plates an hour for masters of the kind shown in Fig. 3.

The typing of these plates was done ahead of actual requirements, and the plates were stored in order until required. Documents were indexed in batches of 100, and as each batch was completed, the appropriate plates were put in the holders and placed in the Addressograph machine. We knew from the master indexing card the number of catalogue cards that would be required for the various indexes, and this number of cards was run off before passing on to the next plate.

The cards had to be placed in position by hand, and improved ability to do this consistently and speedily came with experience. We found that it was possible to print an average of 700 cards an hour on this machine.

REQUIRED NO. OF CARDS	3	5	10	25	50
Cost of plate and holder	1d	1d	1d	1d	1d
Labour charges (at 5/- an hour):					
Typing master plate	1.7d	1.7d	1.7d	1.7d	1.7d
Fixing plate in holder and removing	.2d	.2d	.2d	.2d	.2d
Printing cards	.25d	.42d	.85d	2.1d	4.2d
Total Costs	3.15d	3.32d	3.75d	5.0d	7.1d
Cost per card	1.05d	.66d	.37d	.2d	.14d
Labour charges (at 10/- an hour):					
Cost per card	1.77d	1.13d	.65d	.36d	.26d
Labour charges(at 15/- an hour):					
Cost per card	2.48d	1.59d	.92d	.52d	.39d

TABLE 1 COSTS FOR PREPARING CATALOGUE CARDS BY GRAPHOTYPE AND ADDRESSOGRAPH MACHINES

As has been said earlier, this method of producing cards was made economic because we had the relatively expensive equipment available without cost. The resulting printed card was perfectly satisfactory in appearance and the only obvious limitation of this method is the amount of information which can be put on the plate. Working from the figures that we achieved over a long period, the cost of this method of producing catalogue cards in varying numbers is given in Table 1. It should be emphasised that this is only the cost of printing, and that the cost of the cards is an additional charge.

Entering headings on catalogue cards

For reasons connected with the availability of clerical labour, it was decided that the headings for the alphabetical subject catalogue and the notation for the U.D.C. should be entered by hand. The time taken to do this by any particular individual is a compound of three points :-

a. Length of symbol to be written
b. Readability of symbol to be transcribed
c. Familiarity with terminology or notation

A frequent criticism of the Universal Decimal Classification is the length of the notation required. In practice we found that the number of separate letters in an alphabetical subject heading was larger than that of a combination of numbers in U.D.C., e.g. "WINGS, SWEPTBACK, SUPERSONIC - Stability, longitudinal, Wind tunnel tests" contains 60 letter characters and five punctuation marks. The corresponding entry in U.D.C. would read :-

533.693.1:533.6.013.412:533.6.011.5:533.6.071

and contains 32 figures and 13 punctuation marks, or a total of less

than 70% of alphabetical. Any such arguments are, however, rather inconclusive for we substituted certain letters in place of commonly used groups of numbers, e.g. A = 533.6, B = 629.13, etc. The notation above would have been written as A93.1:A.013.412:A.011.5: A.071, or 20 figures and 9 punctuation marks. Equally so, the alphabetical heading could have been reduced to :-

W., SWEPT., SUPER. - Stab., long. W.t.t.

and still retain sufficient meaning for sorting purposes.

In transcribing the symbols from the master indexing card on to the catalogue cards, greater difficulty was experienced by the clerical staff in transcribing U.D.C. numbers, which meant nothing to them, than to the words used in the alphabetical subject headings. However, for anyone having considerable experience of the notation of the U.D.C., there was no more difficulty in transcribing U.D.C. numbers than alphabetical headings, and the only difference in the time factor was accounted for by the number of characters.

The notation that was used in the facet classification was a combination of upper and lower case letters, and without doubt it caused us more difficulty than either of the other systems. It would seem that a random grouping of letters is more awkward than a random grouping of numbers, for the mind is presumably accustomed to the latter, while with letters one tends to expect some pronouncable form. The difficulties which we experienced could have been lessened if care had been taken, when compiling the notation, to avoid letters which, particularly when hand-written, were easily confused, e.g. 'u' and 'v', 'q' and 'g' etc. From the viewpoint of the length of the complete entry, the facet notation was an improvement on the others.

The example previously given would read, in facet, Cd(Iibb)Nbk Ocb Vn, and therefore this compensated for the other disadvantages in entering the headings for the classified index. It was felt in this case, however, that it was essential that they should be typed and checked by the indexers, so as to minimise errors in filing due to failure to transcribe correctly. To ease the difficulty of reading a complete notation we found it necessary to interpose a space between the end of one element and the start of the next.

While the compilation of the alphabetical index to the U.D.C. and the list of headings for the Alphabetical Subject Catalogue is an important task, yet they do not compare with the clerical effect involved in preparing the chain index. As has been stated earlier, the chain index involved typing a separate card for each entry in the chain and the example given a few lines above would require the following cards :-

Wind tunnel tests: longitudinal stability: supersonic flow: sweptback: wings

Longitudinal stability: supersonic flow: sweptback: wings

Supersonic flow: sweptback: wings

Sweptback: wings

Wings

Whereas once any such card was in the index it was unnecessary to add a further card, yet there is a time loss in checking whether such a card is already there. The chances are that cards already in the index will be those with only a few elements to the notation (see Chapter 6 and Table 7) and therefore the cards involving most typing work all have to be typed. In spite of the time cost of checking previous typing, it is desirable that this should be done since inclusion of unnecessary cards not only wastes typing time but also results in

extra sorting and filing time. The method we used was that the typist made a personal list of each single and two element notation that occurred at the commencement of each notation, e.g. where the notation was

Ca Cd Ea Nbk Ocb Vn

the typist entered Ca and Ca Cd, in a sequential list and if the next complete notation was

Ca Cn Ea Nbk Ocb Vn

she would enter Ca Cn, but would know that it was unnecessary to type a card for Ca. The element combinations were so varied that to have included all these in the list would have made it so long that the effect would have been to make the time-loss greater than the saving. As a compromise, we also entered in the list any combination of three or more elements that occurred more than once, these occasions being revealed when the cards were sorted into the chain index. Certain combinations of elements, e.g. Ca Cd Cn Ea, occurred frequently, and this method is believed to have been of value in cutting out unnecessary work.

Filing cards in the catalogues

With approximately 200,000 cards to file it was desirable to make certain that we were using the most efficient method of sorting and filing cards. This is, of course, largely a matter of common sense but it also appeared possible that we might be able to do some useful investigations on the comparative "filability" of the three systems.

When taking any pack of cards that have to be sorted into a certain order, the first requirement is to divide the cards into smaller packs and maybe subdivide these, until all the packs are small enough to be

rapidly hand-sorted into their final order. The size of this final pack will largely depend on the ability of the individual to hand-sort a batch of cards, and this may well vary from five to twenty or more.

A work study investigation was done to determine the most efficient method of reducing the complete pack of cards down to this final batch. The basic problem resolves itself into striking the best balance between (a) making the fewest possible sorts, since the cards have to be re-handled for each sort, and (b) the time which is taken in placing each card on the correct pack. The fewer the packs, the quicker can be the mental decision as to the correct pack for each particular card; the greater the number of packs, the longer will it take to make such a decision.

Another factor to be considered is the size of the original pack in relation to the maximum number of cards in each of the final packs. Presuming there are 1,000 cards to be sorted and that the objective is final batches of ten cards for hand-sorting, there are various possible approaches. The cards can be put into a comparatively small number of groups, such that there is the certainty that each group will have to be resorted, but which will permit rapid placing of the cards. Alternatively an attempt can be made to sort straight away into 100 groups in the hope that most of the resulting batches of cards will be small enough to hand-sort without further subdivision.

We found that there was a definite limit as to the number of groups that were desirable for the first sort and that this number depended to some extent on the system, but also on the individual doing the sorting.

With alphabetical, or with the facet chain index it was possible to sort into twenty groups, based on initial letters, with a few obvious doubles, such as I and J, K and L, N and O, P and Q, U and V, and X, Y and Z. With the U.D.C. cards, a maximum of 15 groupings was as much as could be managed economically by an experienced sorter. To obtain reasonably level distribution between the resulting batches, the limits of the U.D.C. numbers were as follows :-

0 to 52	621-
53 to 532	621.1 to 621.4
533 to 533.6.011	621.5 to 628
533.6.013	629
533.6.015 to 533.68	63 to 65
533.69	66
534 to 539	67 to 99
54 to 620	

Presuming that the original pack was 1,000 cards, the alphabetical sort would produce twenty sub-packs which would range in size between 20 and 100 cards. This meant that with one further sort of each sub-pack, the stage would be reached where final hand-sorting could be done. Assuming an average time of one second was taken to place a card on the correct pack, and an average of eight seconds to pick up each sub-pack or prepare it for resorting, by this method the time taken to break down the original pack of 1,000 cards into batches small enough to hand-sort would be as follows :-

First sort into 20 packs	1,000 seconds
Picking up 20 packs	160 seconds
Second sort into final packs	1,000 seconds
Total	2,160 seconds or 36 minutes

When we attempted to combine the two sorts into a single sort by having

approximately 100 sub-packs it was found that the complications were such that it would take an average of three seconds to place each card on the correct pack. Therefore the total time for this one sort was 50 minutes, and we still had a number of packs which were too large for hand-sorting.

If, however, the original size of the pack was only 500 cards, there was some justification for altering the strategy. Taking two sorts, the time would be 500 seconds plus 160 seconds plus 500 seconds, a total of $19\frac{1}{3}$ minutes. By making fifteen extra packs for some headings that were known to occur frequently (e.g. Aerofoils, Aeroplanes, Bodies, Flow, etc.), the result was that there were 35 packs of which 25 might be small enough for hand-sorting. The time for placing each card in the first sort went up from 1 second to 1.3 seconds, so with this method the timing would be :-

Original sort into 35 packs	650 seconds
Picking up 10 packs	80 seconds
Second sort of 310 cards into final pack	310 seconds
Total	1,040 seconds or $17\frac{1}{3}$ minutes

This shows a small saving of 2 minutes over the other method.

If the original pack was several times larger than given in the first example, a combination of these strategies might be most effective. With five thousand cards to be sorted, the sub-packs might be expected to range in size from 100 to 500 cards. In some cases one further sub-sort would be sufficient, but often two further sub-sorts would be required.

The situation with the project was that there was no particular urgency

for cards to be sorted into the catalogues, since the catalogues were not being actively used until the completion of the indexing. As a result, we could allow the cards to collect until a large number were available, but in normal library practice, it would be more desirable for new cards to be sorted into the catalogues as soon as possible.

It is obvious that the larger the number of cards to be sorted into the catalogue in a single sequence, the less time that will be taken in the second stages of the total operation of sorting and filing cards. On the other hand, the larger the pack of cards to be sorted the longer the pro-rata time taken to sort them.

One pack can be interfiled with another pack most efficiently when the packs are equal in size. This condition would obviously only prevail in the very early stages of a new catalogue, and our tests showed that the time to sort a given number of cards into a catalogue increases regularly until the ratio is reached, of 1 to 20 in regard to cards to be filed as against cards in the catalogue. After this stage down to a ratio of 1 to 100, there is no significant increase in the time. That is to say, if a catalogue already contains twenty-thousand cards, unless the pack to be filed contains more than 1,000 cards, there will be little significant difference in filing time per card if the size of the pack to be filed is 1,000 cards, 500 cards or 200 cards. Such increase as there is, is not due to the time taken in locating the correct position and actual insertion of the card but is due to the time taken in opening and shutting the drawers of the catalogue, particularly when a card retaining rod has to be taken out and put back. The time to do this adds significantly to the time for filing each card if less than ten cards are to be filed in one drawer.

The example given above was generalised by making certain assumptions concerning time and ability to hand-sort. Actual figures are shown for three members of the staff who did a number of timed tests in sorting and filing catalogue cards. Figures for this are given in Table 2, while Table 3 gives a detailed breakdown of the sorting of a pack of 2,031 cards for the facet classified catalogue.

In all cases the alphabetical subject catalogue give the quickest filing times, and if the figure for this is taken as unity, the percentage times for the other systems are as follows :-

	Alpha.	U.D.C.	Facet Chain Index	Facet Classified
Sorter A	1	1.3	1.2	1.1
B	1	1.1	1.1	1.1
C	1	1.5	1.3	1.3

Against this there is the fact that we did not file more specifically than the notation or subject heading demanded, so that with the alphabetical subject catalogue, if the heading was one such as "HEATING, AERODYNAMIC", for which there are over fifty cards in the catalogue, a new card could be placed anywhere in this group of fifty cards. For the chain index, however, each card had to be placed in an exact position, and with the U.D.C. and Facet Classified catalogues the placing would have to be more exact than with Alphabetical. The result of these qualifications to the figures given is that there appears to be little significant difference in filing by any of the systems.

	First Example			Second Example		
	Sorting (500 cards in pack)	Filing (Ratio 1 to 100)	Total	Sorting (5000 cards in pack)	Filing (Ratio 1 to 10)	Total
ALPHABETICAL						
Indexer A	2.8 sec.	8.9	11.7	5.5	4.5	10.0
Indexer B	3.3 sec.	8.7	12.0	5.3	5.7	11.0
Indexer C	3.6 sec.	11.1	14.7	6.2	7.7	13.9
U.D.C.						
Indexer A	4.5 sec.	9.5	14.0	6.5	7.0	13.5
Indexer B	5.6 sec.	7.5	13.1	7.0	5.4	12.4
Indexer C	7.8 sec.	12.3	20.1	12.0	9.5	21.5
CHAIN INDEX						
Indexer A	4.3 sec.	8.1	12.4	6.1	5.8	11.9
Indexer B	4.5 sec.	8.6	13.1	6.2	6.0	12.2
Indexer C	6.2 sec.	12.2	18.4	8.0	9.6	17.6
FACET CLASSIFIED*						
Indexer A	4.8 sec.	6.8	11.6	5.9	5.3	11.2
Indexer B	4.5 sec.	7.6	12.1	5.1	6.5	11.6
Indexer C	7.2 sec.	10.2	17.4	8.4	9	17.4

TABLE 2 EXAMPLES OF SORTING AND FILING CARDS IN CATALOGUES

In the filing column, the ratio denotes the number of cards to be filed against the number already in the catalogue.

*With the facet classified, the size of the packs was 200 and 2,000.

FIRST SORT into 17 groups. Time 34 minutes 45 seconds

	No. of cards	2nd Sort Time	2nd Sort No. of cards	3rd Sort Time	Final Sort Time	Total time in minutes
A	18				1.05	1.05
B	254	7.00	8		0.15	
			34	0.50	1.40	
			46	1.15	1.45	
			5		0.15	
			44	1.10	1.45	
			5		0.08	
			17		1.00	
			2		0.03	
			2		0.03	
			9		0.20	
			32	1.00	1.05	
			39	1.10	0.50	
			4		0.08	
			7		0.15	22.07
C	318	8.00	40	1.00	1.15	
			41	1.30	2.30	
			59	1.45	3.20	
			71	1.30	4.05	
			79	1.20	3.40	
			42	1.00	3.00	
			16		0.50	
			8		0.25	
			4		0.06	
			2		0.03	
			16		0.40	35.49
D	33	0.35			1.30	2.05
E	106	2.10	15		0.41	
			8		0.15	
			4		0.06	
			14		0.36	
			10		0.20	
			9		0.18	
			20		1.10	
			9		0.20	
			12		0.28	
			15		0.42	6.56

TABLE 3 DETAILED TIMING FOR SORTING OF CARDS FOR FACET CLASSIFIED CATALOGUE.
(Further breakdowns for G and P not shown)

TABLE 3 (Continued)

	No. of cards	2nd Sort Time	2nd Sort No. of cards	3rd Sort Time	Final Sort Time	Total time in minutes
F	321	7.20	5		0.08	
			81	2.00	5.10	
			54	1.00	2.20	
			4		0.05	
			31	0.40	1.15	
			15		0.40	
			4		0.05	
			8		0.15	
			20		1.20	
			20		1.00	
			41	1.10	2.15	
			14		0.26	
			24		0.58	28.02
G	222	5.05		1.20	12.09	18.34
H	135	3.00			8.44	11.44
I-L	33	0.35			1.15	1.50
M	60	1.20			2.30	3.50
N	138	3.50			9.05	12.55
O	22				0.55	0.55
P	149	4.10		1.05	7.37	12.52
Q-R	37	0.45			1.25	2.10
S-T	35	0.45			1.30	2.15
U	24				1.15	1.15
V-Z	66	1.20			2.20	3.40

Total of all sorts 202 minutes 49 secs.

Average per card 5.9 seconds

TABLE 3 DETAILED TIMING FOR SORTING OF CARDS FOR FACET CLASSIFIED CATALOGUE.
(Further breakdowns for G and P not shown)

Posting of Uniterms

While it was accepted that other methods might be more attractive in practice, it was decided for reasons relevant to local conditions that we would write uniterms on aspect cards for visual comparison. The time taken for posting uniterm numbers on cards has been the subject of earlier critical comment but we hoped that we should manage without too great difficulty. Inevitably the time taken increases as the size of the index grows and after a few thousand documents had been posted this way, we found that there was a growing tendency for clerical errors to be made, and that the time being taken merited an investigation into an alternative method.

We therefore decided to use a method originally proposed by Dr. Sanford at the National Security Agency, who commented that "the bottleneck caused by posting threatened the collapse of our entire system" (Ref. 18). This involved the punching of cards with the document number and a uniterm code number, the sorting of the cards into uniterm and document number and then transferring these to aspect cards. Having the necessary equipment available in the Business Systems Laboratory, this method was adapted for the final 12,000 documents.

We first had to punch approximately 100,000 cards, in that there was an average of $8\frac{1}{2}$ uniterms for each document. We had a four-figure code number for each uniterm, so with the five figure document number, nine holes had to be punched in each card. The document number was gang-punched, and therefore these five holes had only to be punched once for each document. As a result we had to punch a total of 12,000 x 5 + 100,000 x 4 = 460,000 holes. This could be done at an average speed of 4,000 punches per hour, making a total time for this stage of 115 hours work. We next put the cards through an interpreter which printed the

numbers on each card. This worked at a speed of 4,000 cards an hour giving a further 25 hours work. It was not essential to do this but it had certain advantages for other reasons than the immediate objective. The sorter was used for putting the 100,000 cards into uniterm and document order and worked at an average speed, including putting in and removing from the machine, of 25,000 cards an hour. As it was necessary to make nine sorts of the 100,000 cards, this involved a further 36 hours work. The final stage of printing the cards on to rolls of paper took a further 30 hours, making a total time for the whole operation of 216 hours.

In the work described by Dr. Sanford, the punched cards were used as masters to enter the document number on the aspect cards. In our case we were not in the position of requiring this to be done continuously throughout the two years of the project, and therefore all this work, apart from the initial punching of the cards, was done in one operation at the completion of the indexing. As a result we were able to use the printed lists, cutting them up and pasting them straight on to the aspect cards.

We did, however, investigate whether this method might be reckoned to show any saving in time over the random posting of numbers in a more conventional situation. Assuming that 200 documents with an average of $8\frac{1}{2}$ uniterms per document have to be posted, then the time taken to prepare the lists of these documents would be (from our figures given above) $\frac{216}{12,000} \times 200$ hours $= 3\frac{1}{2}$ hours. To enter the 1,700 numbers on to the appropriate aspect cards, took 6 hours, making a total of $9\frac{1}{2}$ hours. To enter the number of uniterms without presorting would have taken us 15 hours.

As a postscript, it might be stated that the machine times given are representative of what we were able to obtain when the various pieces of equipment were working satisfactorily. Unfortunately for us the equipment which we used was old and had only been used intermittently for demonstration purposes during the last few years, and we had numerous breakdowns, with the result that the time spent on the operation was probably well over 500 hours. However, we have no reason to think other than that with properly maintained equipment, the figures which are given would be quite practical.

CHAPTER 6

STATISTICAL DETAILS

In Tables 4 - 9 are given various statistical details of the indexing. Some of these may have little value at the present stage, but will become significant in relation to the test results.

The first set of tables gives detailed figures of the postings for each group of 100 documents during the indexing of the final 6,000 documents. As was to be expected, there was a regular falling off in the number of postings with indexing times; in addition we have, as was hoped, a variation between the indexers. While it would obviously be incorrect to suggest that there is a correlation between the standard of indexing and the number of entries required for each document, yet we hope that in the testing we shall be able to ascertain whether over-indexing has an equally bad effect as under-indexing.

Table 5 compares the indexing done during the first two sub-

programmes with the figures from Table 4; the general increase during the whole programme is presumably an indication of the indexers growing familiarity with the systems.

Table 6 shows the variation in postings between research reports and articles in journals, while Table 7 gives data on the postings for individual series and journals. Table 8 gives figures for the new headings originated during the final batch of 6,000 documents. Throughout the whole programme, the number of headings or notations used was as follows :-

U.D.C.	4052	headings in alphabetical index
	2350	different notational elements
Alphabetical	2864	main headings
	1560	"see" references
	592	subheadings
Facet	1686	notational elements
Uniterm	3174	terms

(including 607 Proper names and 267 numbers)

An interesting table (No. 9) concerns the compilation of the chain index to the facet classification. As has already been stated, in theory a card is required for every notational element used in indexing a document. In practice certain elements and combination of elements will be repeated, so that on the second and subsequent occasions when it is used, no card is required for insertion in the chain index. The result of this is that in theory there should come a time when all possible permutations will have been used, and therefore no further cards will require to be entered in the chain index.

Document Numbers	U.D.C.		ALPHABETICAL			FACET		UNITERM
	Total	Elements	Total	Main Headings	Sub Headings	Total	Elements	
12001 - 100	635	339	385	236	210	228	918	1181
12101 - 200	584	340	324	210	194	232	877	1192
12201 - 300	565	325	352	203	194	232	905	1156
12301 - 400	512	303	310	221	233	184	713	1294
12401 - 500	507	311	339	227	252	210	818	868
12501 - 600	420	270	300	227	208	192	654	876
12601 - 700	298	251	271	209	202	173	559	899
12701 - 800	319	243	283	206	217	150	503	1042
12801 - 900	382	266	261	183	210	150	525	961
12901 -13000	438	297	281	209	225	159	602	922
13001 -13100	388	274	274	205	219	179	679	917
13101 -13200	363	272	278	210	228	156	577	1044
13201 -13300	376	250	264	215	172	156	496	857
13301 -13400	336	257	265	209	184	148	505	782
13401 -13500	284	220	219	184	124	149	412	746
13501 -13600	339	255	242	193	154	146	483	994
13601 -13700	283	219	220	165	180	141	396	720
13701 -13800	304	258	245	187	213	143	475	745
13801 -13900	315	237	240	174	195	151	479	749
13901 -14000	240	212	199	169	160	120	369	842

TABLE 4A DATA ON POSTINGS FOR DOCUMENT GROUPS DURING FINAL SUB-PROGRAMME (DOCUMENTS 12,001 - 18,000) INDEXER A

Note: The columns "Total" represent the number of cards required by the indexer to be put in the catalogues. For U.D.C. and Facet the column "Elements" represents the number of different notational elements which were actually used. In Alphabetical, "Main Headings" and "Sub-Headings" represent the different headings which were actually used.

TOTALS FOR DIFFERENT TIME ALLOWANCES

Indexer A	U.D.C.		ALPHABETICAL			FACET		UNITERM
	Total	Elements	Total	Main Headings	Sub Headings	Total	Elements	
16 minutes	2317	1307	1371	870	831	876	3413	4813
12 minutes	1544	1075	1193	869	879	725	2534	3685
8 minutes	1571	1109	1094	807	882	644	2383	3844
4 minutes	1335	982	990	801	634	599	1896	3379
2 minutes	1142	926	904	695	748	555	1719	3056
Indexer B								
16 minutes	2349	1645	2120	1417	1047	597	2908	5581
12 minutes	1866	1430	1244	947	918	662	2631	4691
8 minutes	1434	1254	1246	902	680	569	2241	4093
4 minutes	1109	1107	871	783	554	576	1621	3150
2 minutes	947	959	724	649	537	45[illegible]	1274	2950
Indexer C								
16 minutes	2763	1997	2069	1523	1190	841	3278	4464
12 minutes	2479	1768	1940	1344	1090	789	3154	3845
8 minutes	1764	1464	1494	1096	851	616	2078	3084
4 minutes	1529	1287	1195	915	728	477	1682	2751
2 minutes	1074	1013	883	740	566	426	1351	2311

TABLE 4D TOTAL POSTINGS FOR DIFFERENT TIME ALLOWANCES DURING FINAL BATCH

Note: The columns "Total" represent the number of cards required by the indexer to be put in the catalogues. For U.D.C. and Facet the column "Elements" represents the number of different notational elements which were actually used. In Alphabetical, "Main Headings" and "Sub-Headings" represent the different headings which were actually used.

		U.D.C.		ALPHABETICAL			FACET		UNITERM
		Total	Elements	Total	Main Headings	Sub-Headings	Total	Elements	
Indexer A									
16	a	427	352	301	248	153	101	554	915
	b	435	255	249	194	162	132	434	919
	c	579	327	343	217	208	219	853	1203
8	a	310	252	226	178	138	100	380	858
	b	405	255	268	203	175	157	496	939
	c	393	277	273	202	220	161	596	961
2	a	224	189	168	141	98	105	276	651
	b	249	205	232	180	158	132	391	831
	c	285	231	226	174	187	139	430	764
Indexer B									
16	a								
	b	293	296	365	322	190	105	606	1106
	c	587	411	530	354	262	149	727	1395
8	a								
	b	284	286	296	261	140	116	425	954
	c	358	313	314	225	170	142	560	1023
2	a								
	b	177	184	179	221	79	102	284	545
	c	237	240	181	162	134	114	318	737
Indexer C									
16	a	306	269	283	270	98	102	519	608
	b	488	412	436	293	214	130	567	834
	c	691	499	517	381	297	210	809	1116
8	a	373	294	288	247	130	101	384	595
	b	376	339	350	260	188	112	472	727
	c	441	366	373	274	213	154	519	771
2	a	215	130	203	159	115	101	278	454
	b	196	208	193	159	137	102	298	542
	c	268	253	221	185	141	106	338	573

TABLE 5A AVERAGE INDIVIDUAL POSTINGS PER HUNDRED DOCUMENTS FOR 16 MINUTES, 8 MINUTES AND 2 MINUTES FOR THREE SUB-PROGRAMMES

a = Documents Nos. 1 - 6000, b = Nos. 6001 - 12000, c = Nos. 12001 - 18000

N.B. Indexer B did not index any documents in sub-programme 1 - 6000

		U.D.C.		ALPHABETICAL			FACET		UNITERM
		Total	Elements	Total	Main Headings	Sub-Headings	Total	Elements	
16	a	366	310	292	259	125	101	536	761
	b	405	321	350	270	189	122	536	953
	c	619	412	463	317	256	193	796	1238
8	a	341	273	257	212	134	100	382	726
	b	355	293	305	241	168	128	464	873
	c	397	318	320	227	201	152	592	918
2	a	219	159	185	150	106	103	277	552
	b	243	199	201	187	135	112	324	637
	c	263	241	209	174	154	120	362	691

TABLE 5B AVERAGE COMBINED POSTINGS PER HUNDRED DOCUMENTS FOR 16 MINUTES, 8 MINUTES AND 2 MINUTES FOR THREE SUB-PROGRAMMES

a = documents 1 - 6000

b = documents 6001 - 12000

c = documents 12001 - 18000

Time in minutes	U.D.C.		ALPHABETICAL		FACET		UNITERM	
	Report	Jnl.	Report	Jnl.	Report	Jnl.	Report	Jnl.
16	9.1	7.6	5.0	4.7	1.8	1.7	11.8	11.0
12	5.5	4.4	4.5	3.8	1.9	1.7	9.5	8.4
8	4.7	3.2	3.0	2.7	1.9	1.8	8.6	7.3
4	3.7	2.8	2.6	2.2	1.3	1.3	10.4	8.5
2	2.8	2.3	2.2	2.2	1.2	1.2	7.2	6.0
Average	5.4	4.1	3.5	3.2	1.6	1.5	9.5	8.2

TABLE 6 AVERAGE POSTINGS PER DOCUMENT FOR REPORTS AND JOURNAL ARTICLES

	U.D.C.	ALPHABETICAL	FACET	UNITERM
Royal Aircraft Est. Reports and Notes	5.5	3.5	1.7	9.0
National Advisory Committee for Aeronautics. Notes and Memoranda	6.1	3.8	1.6	10.3
Flight & Aeroplane	1.5	1.6	1.4	6.3
Aircraft Engineering	5.5	4.5	2.0	9.3
Metallurgica & Metal Progress	7.3	5.3	2.3	12.0
Royal Aeronautical Society Journal	3.6	3.1	1.8	6.8
Journal Aeronautical Sciences	4.1	3.2	1.5	8.8

TABLE 7 AVERAGE POSTINGS BY SERIES AND JOURNALS

	U.D.C.			ALPHA-BETICAL			UNITERM		
Indexer:-	A	B	C	A	B	C	A	B	C
Indexing Time									
16	31	22	47	30	19	29	16	34	6
8	16	2	24	25	14	14	12	10	4
2	4	6	19	5	13	9	10	10	1
4	9	3	16	14	1	11	11	2	8
12	13	14	33	21	19	6	22	17	5
Individual Totals	76	47	139	95	66	69	71	73	24
Group Totals	265			230			168		

TABLE 8 NEW HEADINGS ORIGINATED FOR GROUPS OF 100 DOCUMENTS IN FINAL BATCH AT VARIOUS INDEXING TIMES

No valid information was available as to how long it would take to reach that position or alternatively whether there was any likelihood of the stage being approached.

Clearly the more compact the subject field, the greater the chance that the possible permutations will be repeated. Further, where the notation is made up of few separate elements, the notation is more likely to be repeated than in those cases where the notation is long and complex. As will be seen from Table 9, the figure for cards required dropped fairly quickly, but appeared to level out at the figure of approximately 50% and it seems that continued indexing would not bring it very far below the figure.

A claim made for the facet classification is the economy in total entries which results from a fixed order with the chain index. For the three card catalogues during the final six thousand documents, the following figures show the number of cards actually inserted.

U.D.C.		Alphabetical	Facet	
Classified catalogue	Alpha-betical Index		Classified Catalogue	Chain Index
25223	1736	19338	9511	18083
Total: 26,959		19,338	27,594	

It would appear that in our subject field it is doubtful if the position would ever be reached where the total number of cards required for the facet catalogue was appreciably less than those considered necessary for the other systems.

We did not specify any term in facet as an "unsought" term, although we were aware that certain terms, such as Tests, Wind Tunnel Tests, Flight Tests, Design, Analysis, Calculation and Measurement, would in

No. of documents	Possible No. of chain index cards	Cards Inserted	Cards Duplicated	% of possible cards inserted	Duplicate cards with three or more elements			
					3	4	5	6
1200	4111	3094	1017	75.2	21	2	-	-
1200	3711	2228	1483	60.0	51	7	1	1
1200	5101	2990	2111	58.8	84	17	4	1
1200	5271	2937	2334	55.8	135	46	10	3
1200	4456	2385	2071	53.0	133	34	7	1
1200	4855	2379	2476	49.0	154	33	8	1
1200	6943	3271	3672	47.3	263	72	18	3
1200	7709	4277	3432	55.5	292	78	20	4
1200	7309	3865	3444	52.8	302	81	22	3
1200	5268	2719	2549	51.6	253	71	20	1
1200	6946	3211	3735	46.2	382	113	23	2
1200	8121	4011	4110	49.5	425	118	26	4

TABLE 9 CARDS INSERTED IN CHAIN INDEX OF FACET CATALOGUE DURING WHOLE PROGRAMME

most cases be unsought terms as far as the chain index was concerned. This matter will be investigated in the test programme, but if it had been decided not to prepare chain index entry for any of these terms the number of cards inserted would have been reduced from 18,083 (as shown above) to 16,475. On the other hand, as discussed in Chapter 4, we did not do full chain indexing up to the containing head. If this had been done, it is estimated that the number of inserted cards would have risen to over 30,000.

CHAPTER 7

SUPPLEMENTARY INDEXING

For the testing programme we estimated that we should require 1600 questions which were to be based on documents in the collection, and we sought the co-operation of a large number of organisations and individuals. Discussion of the questions will be given in a later report dealing with the test programme, and it is sufficient to say here that we obtained the required number of questions.

We decided that at the same time we would invite people to index documents for us. The original purpose for doing this was so that we might have a comparison with which the standard of indexing of the project staff could be checked. The following is an extract from the notice which we sent to those whom we thought might be interested enough to help.

> "Assistance of two kinds is requested from individuals or organisations who are interested in this project. Firstly, we wish to have a number of the project documents indexed by persons or groups of persons who are familiar with the subject content,

and/or the particular indexing system used. Arising from such indexing, entries would be made in the appropriate project catalogues and should help to provide a check on the indexing done by the project staff.

"It would be expected that the selected indexing system would be that used by the individual or organisation, but should anyone wish to try another, or all the systems, there is no objection to this. To assist with the indexing we will provide the following items:

(1) Universal Decimal Classification

"An alphabetical index, compiled by the project staff, of all terms used in the indexing of the first 10,000 documents, and copies of any appropriate schedules that are not generally available.

(2) Alphabetical Subject

"A list of the main headings, sub-headings and all cross references originated during the indexing of the first 10,000 documents together with the project rules for the formation of new headings.

(3) Facet

"A set of the special schedules, the alphabetical index and the rules for using the schedules.

(4) Uniterm

"A list of the terms originated in the indexing of the first 10,000 documents."

"It would be most satisfactory if those who are willing to co-operate would agree to index twenty papers or multiples of twenty.

"Approximately half of the papers to be indexed will deal with high

speed aerodynamics while the remainder will range over a broad field of subjects that are relevant to aeronautical engineering. The papers will be in technical periodicals or reports from various research establishments. On the reverse side of the accompanying form is a list of the periodicals and reports series which have been used in the project and those co-operating are asked to indicate which periodicals or report series are readily available to them. Copies of the documents to be indexed can, if necessary, be made available in England from the College of Aeronautics Library, while aeronautical librarians in other countries have also offered to lend the papers to anyone co-operating."

The response which we received exceeded all reasonable expectations, and to those who agreed to assist, we sent the relevant items as mentioned in the above extract, together with instructions regarding the methods to be used in the indexing. Selected lists of documents were prepared from which the indexers could select any document they wished. These lists were set out in such a way that we had external indexing for documents in all groups throughout the programme. In Appendix A is given a complete group of documents for the project numbers 14001 - 14100, and Appendix F is a copy of the documents extracted from this group from which the indexer was able to make his own selection. Each indexer received twenty such sheets, and if they agreed to index twenty documents, they were asked to select one document from each sheet. If indexing forty documents, they would select two from each sheet, and so on.

Altogether 3793 items were indexed, the indexing being fairly equally spread over all four systems. We shall not only in our test programme be able to check our indexing against that done by many other people, but

in addition it seems that we might also be able to obtain some quite interesting information by analysing the different methods which have been used to index the same report by people of widely differing qualifications and interests. A list of the organisations and individuals who helped with this indexing is given in Appendix G. Table 10 gives data on the indexing done by outside organisations in regard to the number of postings and the times taken for the four systems. From a comparison with the indexing done by the project staff it will be seen that the average time considered necessary to index the type of document used in the project, fell reasonably near to the middle of the various fixed times which we used, and it therefore appears that our range from 16 minutes to 2 minutes covered the conditions very adequately. The average entries requested by external indexers are, in the main, in line with project indexing, the only significant difference being with facet, where we thought it necessary to make a greater number of entries than did external indexers. It is interesting to note, as can be seen from Table 5B, that in the early stages the facet indexing of the project staff was in line with that done by external indexers, and that only with greater experience of using the system did they come to the opinion that additional entries were more often required.

Where the same document was indexed by three or more organisations, we have recorded in Table 11 information concerning the duplication of notational elements or headings. Column 1 gives the document number and Column 2 shows the number of elements and headings used by each indexer. These are totalled in Column 3, while Column 4 shows the number of different elements or headings used by all the indexers. This number can never be less than the number used

by the indexers using most elements or headings, so in Columns 5 and 6 we show the result when this number is deducted from the figures in Columns 3 and 4. The first two columns therefore represent the possible and the actual number of different notations or headings that were used.

It appears to be a reasonable assumption that in an ideal system the same document would have the same notation or heading whoever may do the indexing. The nearer this consistency is approached in the index, the greater the chance that the searcher will locate the required information in the expected place. One might assume, therefore, that the lower the ratio of Column 6 to Column 5, the more likely will the system prove to be successful. If we take the results given in Table 12 at their face value, it would seem that the systems come out, in descending order of efficiency as :-

Uniterm	21%
Facet	32%
U.D.C.	52%
Alphabetical	78%

There are, however, various factors which might modify the basic figures, and a fuller analysis of this matter will be considered in conjunction with the test results.

	No. of Documents indexed		Average Time	Average Entries	Average Elements	
U.D.C.	1,115		10.8 mins.	3.6	3.2	
		Project	12 mins.	4.9	3.5	
			8 mins.	3.9	3.1	
FACET	902		11.3 mins.	1.1	5.0	
		Project	12 mins.	1.8	6.9	
			8 mins.	1.5	5.9	
UNITERM	775		10.8 mins.		12	
		Project	12 mins.		10.2	
			8 mins.		9.2	
					Main Headings	Sub Headings
ALPHABETICAL	1,001		8.0 mins.	3.6	2.1	1.6
		Project	12 mins.	3.5	2.6	2.2
			8 mins.	3.2	2.3	2.0

TABLE 10 DATA ON EXTERNAL INDEXING WITH COMPARATIVE PROJECT INDEXING FOR 12 MINUTES AND 8 MINUTES

1	2							3	4	5	6
Document No.	External Indexing							Total Elements	Different Elements	Total Less 2A	Difference Less 2A
	A	B	C	D	E	F	G				
420	5	5	4	4	3	3		24	10	19	5
6082	5	3	3					11	10	6	5
6846	4	3	3					10	9	6	5
6905	2	2	1					5	2	3	0
7606	4	4	1	1	1			11	9	7	5
8003	4	2	2	1	1	1		11	8	7	4
8011	7	3	2	1				13	11	6	4
8020	6	3	1					10	8	4	2
8858	5	4	3	3	2			17	12	12	7
9651	8	2	2	1	1			14	11	6	3
9889	3	3	2					8	8	5	5
10819	5	3	2					10	7	5	2
11696	4	4	3					11	8	7	4
12018	5	4	4	3	3			19	6	14	1
12063	3	2	2					7	4	4	1
12086	3	3	3	1	1			11	8	8	5
12093	8	4	4	3				19	11	11	3
12095	3	3	2	2				10	6	7	3
12428	5	4	4	4	3	2	2	24	17	19	12
12436	4	4	3					11	5	7	1
12462	4	1	1					6	6	2	2
12465	7	3	3	3	1	1	1	19	12	12	5
12482	7	5	3					16	12	9	5
12654	7	4	3					15	14	8	7
12810	7	6	3					16	11	9	4
12831	3	2	2	2				9	7	6	3
12870	8	5	3					16	14	8	6
12895	3	3	1	1				8	8	5	5
12910	4	4	3					11	8	7	4
12979	6	3	2					11	8	5	2
						Totals		385	270	234	120

TABLE 11A ANALYSIS OF U.D.C. INDEXING OF 30 DOCUMENTS INDEXED BY THREE OR MORE ORGANISATIONS

1	2						3	4	5	6
Document No.	External Indexing						Total Postings	Different Headings	Total Less 2A	Difference Less 2A
	A	B	C	D	E	F				
565	4	3	2				9	5	5	1
1771	3	3	2	1			9	8	6	5
4487	9	6	4				19	16	10	7
5779	6	5	1	1			13	11	7	5
5781	8	5	3				16	16	8	8
5785	11	10	1				22	20	11	9
6105	2	2	1				5	2	3	0
6905	3	3	3	2			11	9	8	6
7782	7	6	6	2	1		22	15	15	8
8104	5	3	2				10	10	5	5
8114	6	2	1				9	9	3	3
8995	4	3	1				8	6	4	2
9759	3	2	1				6	5	3	2
12143	5	3	1				9	8	4	3
12163	3	3	2				8	7	5	4
12186	5	2	1				8	6	3	1
12190	10	9	3				22	22	12	12
12514	2	2	1				5	5	3	3
12576	6	1	1				8	8	2	2
12671	6	5	3	3	2		19	17	13	11
12910	16	6	5				27	25	11	9
12918	3	1	1				5	3	2	0
12939	6	4	3	2	1		16	14	10	8
12979	7	6	1				14	12	7	5
13264	8	4	2				14	13	6	5
13321	4	3	1				8	8	4	4
13363	3	3	2				8	7	5	4
13367	3	2	1				6	6	3	3
13369	4	2	2				8	8	4	4
13763	15	4	4	3			26	25	11	10
						Totals	370	326	193	149

TABLE 11B ANALYSIS OF ALPHABETICAL INDEXING OF 30 DOCUMENTS INDEXED BY THREE OR MORE ORGANISATIONS

1	2							3	4	5	6
Document No.	External Indexing							Total Elements	Different Elements	Total Less 2A	Difference Less 2A
	A	B	C	D	E	F	G				
670	9	6	2					17	15	8	6
675	4	3	3					10	5	6	1
685	9	3	3					15	9	6	0
1607	4	4	3					11	6	7	2
4607	6	6	5	4	3	3	2	29	13	23	7
4678	8	3	2	1				14	11	6	3
4681	8	5	5	4	1			23	15	15	7
5819	4	4	4	3				15	7	11	3
6231	4	4	3					11	5	7	1
6249	5	5	2	2	2	1	1	19	7	14	2
7028	8	5	4	3				20	14	12	6
7096	8	8	6					22	19	14	11
8221	7	3	3	3	3			19	10	12	3
9016	6	4	3					13	7	7	1
9854	10	5	4	3	3	2		27	13	17	3
9863	7	4	3					14	8	7	1
9874	5	5	3	3	2	1		19	10	14	5
10245	11	4	4	3				22	12	11	1
11037	7	3	1					11	7	4	0
12095	4	2	2					8	6	4	2
12257	7	5	4	4	4			24	15	17	8
12270	6	4	2					12	7	6	1
12619	7	6	6	6				25	13	18	6
12654	6	4	4	3	3			20	14	14	8
12667	4	4	3	2				13	5	9	1
12671	4	4	3	3				14	11	10	7
12675	4	3	3	3	3	2	2	20	4	16	0
13073	5	5	3					13	7	8	2
13074	5	3	3					11	7	6	2
13080	4	1	1	1				7	4	3	0
	186				Totals			498	286	312	100

TABLE 11C ANALYSIS OF FACET INDEXING OF 30 DOCUMENTS INDEX BY THREE OR MORE ORGANISATIONS

1	2					3	4	5	6
Document No.	External Indexing					Total Terms	Different Terms	Total Less 2A	Difference Less 2A
	A	B	C	D	E				
670	14	6	4			24	15	10	1
1915	14	11	10	4		39	15	25	1
4487	19	7	7			33	24	14	5
5929	50	17	12	12		91	55	41	5
7028	27	21	3			51	34	24	7
8221	15	13	7			35	20	20	5
9148	16	15	10	8		49	25	33	9
10121	15	10	7			32	19	17	4
12671	18	11	9			38	24	20	6
13153	14	12	6	6		38	16	24	2
13156	13	8	4			25	14	12	1
13451	20	9	7			36	25	16	5
13987	11	9	6			20	14	15	3
14384	67	28	15			113	77	46	10
14565	15	9	4			28	18	13	3
14758	13	10	10			33	14	20	1
15058	15	9	8			32	19	18	4
15079	20	9	8			37	23	17	3
15504	20	15	10			45	33	25	13
15506	20	17	10	5		52	23	32	3
15553	15	12	11	9	6	53	18	38	3
15590	13	9	6			28	20	15	7
16395	21	8	7			36	28	15	7
16678	12	9	7			29	16	17	4
16763	26	17	10			53	29	27	3
16985	9	8	6			23	11	14	2
16988	8	7	6			21	10	13	2
17107	15	11	9			35	20	20	5
17462	24	20	10			54	36	30	12
17983	9	4	4			17	11	8	2
					Totals	1,206	706	639	138

TABLE 11D ANALYSIS OF UNITERM INDEXING OF 30 DOCUMENTS INDEXED BY THREE OR MORE ORGANISATIONS

CHAPTER 8

CONCLUSIONS

This report has dealt with an important but a relatively uninteresting stage of the project, for it has really involved nothing more than the construction of a piece of test equipment which had to be available before any investigations could be made. While any firm conclusions will have to await the result of using the equipment in the test programme, there are certain comments which can be made regarding this stage of the work, partly in pointing out some obvious mistakes. Primarily we were at fault in our calculations of time and were only able to complete the programme as planned because we had allowed a generous amount of spare time. The original intention of this allowance was partly so that the indexing staff would be able to help with the clerical routines, but mainly so that they would have reasonable breaks from indexing. The fact that they were unable to do any other work was relatively unimportant, since this could be done by part-time staff. It was more serious that throughout the second year they could have only short breaks from indexing, and I feared that staleness brought on by mental indigestion would affect the standard of indexing. Fortunately this does not appear to have happened.

We had two separate delays. First, following the announcement of the award of the grant, there was a gap of seven months before we started the indexing. Secondly we had the long period when indexing proceeded very spasmodically due to difficulties in setting up the systems. Our difficulties were partly due to the fact that we were forming what virtually amounted to a new organisation. Had there been a documentation research unit already in being in England, it might have been possible to have

followed the suggestion made by the National Science Foundation that, prior to the award of the main grant, we should have carried out a small pilot investigation. The difficulty for us lay in finding suitable qualified staff who would be willing to join an investigation whose future was not definitely certain. Now that Aslib are setting up a research unit, it is to be hoped that it will be possible for permanent staff to do preliminary work which might thereafter be continued by staff who are taken on for the duration of the main project.

One possible weakness of the programme was the lack of feedback to the indexers. In normal circumstances, an indexer in an organisation will be continuously aware of the type of enquiry which is being put to the indexes, and quite often it would be the case that the indexer is himself carrying out searches. As a result, he will be influenced in his indexing and might be expected to index more effectively for the needs of the particular organisation. Mr. Sharp had some years experience of working in an aircraft firm, and therefore knew the types of question which we might expect to receive. Mr. Hadlow, on the other hand, had no previous practical experience which could help him with the indexing and was not able to obtain any during this stage of the project.

It can be counted as a retreat from our original plans that we did not have the services as an indexer of a person with technical qualifications. I do not think that this can be considered as seriously affecting the basic purpose of the project, namely the comparative efficiency of the systems, and there are other methods which we can use to assess whether a technical indexer would have been more or less efficient than the librarians who did the work.

Future stages

The National Science Foundation have awarded a further grant for the completion of the project, and the basic test programme is now under way. This is expected to be completed by December 1960, and will be followed by a detailed analysis of the results which may, in turn, show the need for further testing.

It will be possible to analyse our results so as to ascertain in detail the reasons for the success or failure in locating information. Within this general framework lie the decisions by the indexer of the significant matters in the text; the assistance which is given by the different systems to enable him to decide on satisfactory codings for the selected information; the ease or difficulty of translating the language of a question enquiry into the language of the index; the comparative assistance which the various systems give the searcher in finding specific or further relevant information.

We shall be able to isolate many of the variables which are inherent in the problem and find the effect of altering our original actions. Eventually it should be possible to arrive at a position where we can state with reasonable certainty exactly which requirements an information retrieval system must meet and propose methods for the design of such a system. Writing of the advances that have taken place in aeronautics during the past 50 years, Mr. M.J. Lighthill, F.R.S., Director of the Royal Aircraft Establishment, says "Countless ingenious experiments on models lay at the back of every advance, and brilliant theories have been evolved to make sense of the experiments". We hope that the data obtained from this experiment will provide many others working in the field with information which will enable them to advance their theories in the basic design of retrieval systems.

REFERENCES

1.	de Kock, A.C., van der Vooren, A.I.	The N.L.L. Card Catalogue of Aerodynamic Measurements. N.L.L. Report F125 1953.
2.	Cleverdon, C.W., Thorne, R.G.	A Brief Experiment with the Uniterm System of Co-ordinate indexing for the Cataloguing of Structural Data. R.A.E. Library Memo 7. 1954.
3.	Vessey, H.F.	Tests of N.L.L. Card Catalogue of Aerodynamic Measurements. R.A.E. Library Memo 1954.
4.	Cleverdon, C.W.	Some Aspect of Information Retrieval. Aslib Proceedings, Vol.7, 1955 pp 153-6.
5.		Editorial "The Truth, the Whole Truth..." American Documentation, Vol.6, 1955 pp 56.
6.	Metcalfe, I.J.	Information Indexing and Subject Cataloguing. New York. Scarecrow Press, 1957.
7.	Classification Research Group	Bulletin No. 5, Jnl. of Documentation. Vol.15, 1959, pp 39 - 57.
8.	Mathieu, J., Barlen, S.	Guiding Principles for Time and Cost in Documentation work. Forschber. Wirts-U. Verkehrsm. N-Rh-Westf., (636) 1958.(M. of S. TIL/T4966)
9.	Whelan, S.	Library Retrieval: The R.R.E. Pilot Retrieval Scheme. R.R.E. Jnl. October 1958, pp 59 - 68.

References (Continued)

10. Mooers, C.N. — Zatocoding and Developments in Information Retrieval. Aslib Proceedings, Vol. 8, 1956 pp 3 - 22.

11. Wildhack, W.A., Stern, J., Smith, J. — Documentation in Instrumentation. American Documentation, Vol. 5, 1954, pp 223 - 237.

12. Wadington, J.P. — Unit Concept Co-ordinate Indexing. American Documentation, Vol. 9, 1958, pp 107 - 113.

13. Farradane, J.E.L. — A Scientific Theory of Classification and Indexing. Jnl. of Documentation, Vol. 6, 1950 pp 83 - 99. Vol. 8, 1952, pp 73 - 92

14. Coates, E.J. — The Use of the B.N.B. in Dictionary Cataloguing. Library Ass. Record, Vol. 59, 1957, pp 197 - 202.

15. Kaiser, J. — Systematic Indexing. London, 1911.

16. Prevost, M.L. — An Approach to the Theory and Method in General Subject Headings. Library Quarterly, Vol. 12, 1942, pp 140 - 151.

17. Swanson, D.R. — Word Correlation and Automatic Indexing Phase I Final Report. An Experiment in Automatic Text Searching. Ramo Wooldridge, 1960.

18. Sanford, J.A. Theriault, F.R. — Problems in the Application of Uniterm Co-ordinate Indexing. College and Research Libraries, Vol. 17, 1956, pp 19 - 23.

APPENDIX A

LIST OF PROJECT DOCUMENTS 14,001 - 14,100

14001 LOVE, E.C. Pressure rise associated with shock-induced boundary layer separation. NACA TN. 3601.

14002 SEABERG, E.C. Laboratory investigation of an autopilot utilizing a mechanical linkage with a dead spot to obtain an effective rate signal. 1956. NACA TN. 3602.

14003 ADAMS, J.J. & MATHEWS, C.W. Theoretical study of the lateral frequency response to gusts of a fighter airplane, both with controls fixed and with several types of auto-pilots. 1956. NACA TN. 3603.

14004 HORNE, W. & others. Low speed yawed rolling characteristics and other elastic properties of a pair of 26-inch diameter, 12 ply rating, type VII aircraft tires. 1956. NACA TN. 3604.

14005 QUEIJO, M.J. Theoretical span load distributions and rolling moments for sideslipping wings of arbitrary plan form in incompressible flow. 1955. NACA TN. 3605.

14006 HUCKEL, Vera. Tabulation of the functions which occur in the aerodynamic theory of oscillating wings in supersonic flow. 1956. NACA TN. 3606.

14007 DALEY, B.N. & DICK, R.S. Effect of thickness, camber and thickness distribution on airfoil characteristics at Mach numbers up to 1.0. March 1956. NACA TN. 3607.

14008 EDGE, P.M. Hydrodynamic impact loads in smooth water for a prismatic float having an angle of dead rise of 10°. 1956. NACA TN. 3608.

14009 BOBBITT, P.J. Linearized lifting-surface and lifting line evaluations of sidewash behind rolling triangular wings at supersonic speeds. 1956. NACA TN. 3609.

Appendix A (Continued)

14010 HARRIN, E.N. Comparison of landing-impact velocities of first and second wheel to contact from statistical measurements of transport airplane landings. 1956. NACA TN. 3610.

14011 SPAHR, J.R. Theoretical investigation of the effects of configuration changes on the center-of-pressure shift of a body-wing-tail combination due to angle of attack and Mach number at transonic and supersonic speeds. 1955. NACA RM A55F02.

14012 CHAPMAN, D.R. & others. Preliminary report on a study of separated flows in supersonic and subsonic streams. 1956. NACA RM A55L14.

14013 MOECKEL, W.E. Flow separation ahead of a blunt axially symmetric body at Mach numbers 1.76 to 1.10. 1951. NACA RM E51I25.

14014 BERNSTEIN, H. & BRUNK, W.E. Exploratory investigation of flow in the separated region ahead of two blunt bodies at Mach number 2. 1955. NACA RM E55D07b.

14015 JAGGER, J.M. & MIRELS, H. Experimental pressure distributions over wing tips at Mach numbers 1.9. January 1949. NACA TN. E8K2b.

14016 BULL, G.V. Aeronautical studies in the aeroballistics range. 1957. CARDE REPORT No. 302/57.

14017 KRIEGER, F.J. & WHITE, W.B. The composition and thermodynamic properties of air at temperatures from 500 to 8000 ^{o}K and pressures from 0.00001 to 100 atmospheres. 1957. Rand Corp. R. 149.

14018 HINZ, E.R. Stability and control characteristics of the vertical attitude, VTOL aircraft. 1957. I.A.S. Preprint 763.

14019 LOWRY, J.G. & others. The jet-augmented flap. 1957. I.A.S. Preprint 715.

Appendix A (Continued)

14020 HOUGHTON, D.S. & CHAN, A.S.L. Discontinuity stresses at the junction of a pressurised spherical shell and a cylinder. 1957. C. of A. Note 80.

14021 MILLER, A.E. An analysis of the requirements for oxygen in commercial turbo-prop and jet transports. 1957. SAE Preprint.

14022 MILLER, A.E. Work and progress in oxygen and aviation oxygen equipment. 1957. Aero. Medical Ass. Reprint.

14023 ALLEN, H. Combustion of various highly reactive fuels in a 3.84 by 10 inch Mach 2 Wind Tunnel. N.A.S.A. Memo 1-15-59E.

14024 MEYER, R.E. & MAHONY, J.J. Analytical treatment of two-dimensional supersonic flow. Part 1: Shock free flow. 1954. A.R.L. (Australia) Report A93.

14025 MEGSON, N.J.L. Structural plastics for airframe construction. 1957. AGARD Report 162.

14026 PURSER, P.E. Review of some recent data on buffet boundaries. 1951. NACA RM. L51E02a.

14027 HOFFMAN, S. Comparison of zero lift drag determined by flight tests at transonic speeds of pylon, underslung, and symmetrically mounted nacelles at 40 per cent semispan of a 45° swept-back wing and body combination. June 1951. NACA RM. L51D26.

14028 STRASS, H.K. & others. Some effects of spanwise aileron location and wing structural rigidity on the rolling effectiveness of 0.3 - chord flap type ailerons on a tapered wing having 63° sweep-back at the leading edge and NACA 64A005 airfoil sections. 1951. NACA RM. L51D18a.

14029 LUOMA, Arvo. A. Aerodynamic characteristics of four wings of sweepback angles 0°, 35°, 45°, and 60°, NACA 65A006 airfoil section, aspect ratio 4, and taper ratio 0.6 in combination with a fuselage at high subsonic Mach numbers and at a Mach number of 1.2. 1951. NACA RM. L51D13.

Appendix A (Continued)

14030 SPREEMAN, K. P. & ALFORD, W. J. Investigation of the effects of twist and camber on the aerodynamic characteristics of a 50° 38' sweptback wing of aspect ratio 2.98. NACA RM. L51C16.

14031 JOHNSON, H. S. Wind tunnel investigation at subsonic and low transonic speeds of the effects of aileron span and spanwise location on the rolling characteristics of a test vehicle with three untapered 45° sweptback wings. April 1951. NACA RM. L51B16.

14032 HELDENFELS, R. & VOSTEEN, L. Approximate analysis of effects of large deflections and initial twist on torsional stiffness of a cantilever plate subjected to thermal stresses. 1957. NACA TN. 4067.

14033 THOMPSON, W. E. Measurements and power spectra of runway roughness at airports in countries of the North Atlantic Treaty Organisation. 1958. NACA TN. 4303.

14034 MAYO, A. P. Matrix methods for obtaining spanwise moments and deflections of torsionally rigid rotor blades with arbitrary loadings. 1958. NACA TN. 4304.

14035 WILLIAMS, J. L. Wind tunnel investigation of effects of spoiler location, spoiler size and fuselage nose shape on directional characteristics of a model of a tandem-rotor helicopter, fuselage. 1958. NACA TN. 4305.

14036 GEORGE, J. M. The measurement of air temperature in high speed flight. C. of A. Note 86.

14037 GARNER, H. C. Numerical aspects of unsteady lifting-surface theory at supersonic speeds. 1956. A. R. C. Report 19,268.

14038 MILES, D. J. The improvement of the voltage waveform of high frequency alternators. 1956. R. A. E. TN. El. 136.

14039 MITCHELL, A. H. Alkali vapour and plasmatron valves as power rectifiers. 1957. R. A. E. TN. El. 139.

Appendix A (Continued)

14040 COX, W.J.G. Development of the types IT.3-1-1 and 3-2-1 accelerometers. 1957. R.A.E. TN. Instn.158.

14041 HAYWARD, D.C. The mechanical properties of RR58 aluminium alloy sheet in tension and compression at room and elevated temperatures. 1957 R.A.E. TN. Met.261.

14042 ROWLEY, G.C. Basic cold cathode electronic units for the assembly of special purpose decimal computers. 1957. R.A.E. TN. M.S.34.

14043 ROWLEY, G.C. The decimal adder for data handling systems. 1957. R.A.E. TN. M.S.36.

14044 BORGARS, S.J. Measurement of optimum coolant flow for radio equipment in supersonic aircraft. 1957. R.A.E. TN. RAD.667.

14045 TAYLOR, A.S. The laws of aeroelastic similarity and their application, with particular reference to the design and testing of elastic wind tunnel models. 1957. R.A.E. Report Aero.2393.

14046 MANGLER, K.W. & SMITH, J.H.B. Calculation of the flow past slender delta wings with leading edge separation. 1957. R.A.E. Report Aero.2593.

14047 ROWE, P.N. Deflection by vanes with particular reference to small angles. 1957. D.G.G.W. Report EMR/57/4.

14048 WILLIAMS, W.H. Thermodynamic charts for the combustion products of nitric acid and kerosene. 1954. A.R C. R&M.2982.

14049 THOMLINSON, J. A study of the aircraft arresting-hook bounce problem. 1954. A.R.C. R&M.2980.

14050 KNOWLER, A.E. & HOLDER, D.W. The efficiency of high-speed wind tunnels of the induction type. 1954. A.R.C. R&M.2448.

Appendix A (Continued)

14052 SCHJELDERUP, H.C. Accumulative fatigue damage caused by random loading. Jnl. Aero. Scs. 1959 pp 394 - 395.

14053 BLOOM, M.H. On hypersonic similarity for nozzles. Jnl. Aero. Scs. 1959 p 395.

14054 FERRI, A. & ZAKKAY, V. Pressure distributions for a two dimensional blunt nosed body at different angles of attack. Jnl. Aero. Scs. 1959 pp 395 - 396.

14055 NESS, N. On the continuity of the Schmidt number at the interface between the laminar sublayer and the other turbulent region. Jnl. Aero. Scs. 1959 pp 396 - 397.

14056 SUTTON, G.W. A comparison of several approximate theories of melting ablation. Jnl. Aero. Scs. 1959 pp 397 - 398.

14057 BOYCE, W.E. The elastic-plastic bending of an eccentrically loaded sandwich column. Jnl. Aero. Scs. 1959 pp 398 - 399.

14058 HOSHIZAKI, H. & SMITH, H.J. The effect of helium at an axially symmetric stagnation point. Jnl. Aero. Scs. 1959 pp 399 - 400.

14059 NUDELMAN, H.B. & others. Fiber metallurgy - its use for slip ring bushes. Aero. Eng. Rev. 1955 (Dec.) pp 31 - 32.

14060 HOVGARD, P.E. The comparative performance of helicopter convertiplanes, and slow flying airplanes. Aero. Eng. Rev. Dec. 1955 pp 40 - 44.

14061 ZAUSTIN, M. On the danger of combined stresses in pressurized structures. Aero. Eng. Rev. Dec. 1955 pp 45 - 48.

14062 WATTSON, R.K. Effects of boundary layer control system efficiency on performance. Aero. Eng. Rev. Dec. 1955. pp 49 - 51.

14063 NONWEILER, T. The design of wing sections. Aircraft Engng. 1956 pp 216 - 227.

Appendix A (Continued)

14064 GASSNER, E. The problem of fatigue strength in aircraft structures. Aircraft Engng. 1956 pp 228 - 234.

14065 JOHNSON, A.E. Turbine disks for jet propulsion units. Aircraft Engng. 1956 pp 235 - 243.

14066 STUBBS, R.A. Specific aeronautical problems in high performance aircraft. Canadian Aeronautical Jnl. 1957 pp 216 - 219.

14067 SONEY, C.I. Reliability control of electronic equipment in aircraft and weapon systems general and management aspects. Canadian Aeronautical Jnl. 1957 pp 222 - 231.

14068 NOWN, J.S.Mc. Drag in unsteady flow. Proc. 9th Int.Con. App.Mech. Vol.3 1957 pp 124 - 130.

14069 HASIMOTO, H. The unsteady axial motion of an infinitely long cylinder in a viscous fluid. Proc. 9th Int.Con. App. Mech. Vol.3 1957 pp 135 - 143.

14070 ECKHAUS, W. Asymptotic solution of the two-dimensional oscillating aerofoil problem, for high subsonic Mach numbers. Proc. 9th Int. Con.App. Mech. 1957 pp 114 - 123.

14071 RUDINGER, G. Boundary conditions in non-steady flow. Proc. 9th Int.Con. App.Mech. Vol.3 1957 pp 152 - 163.

14072 KAPLUN, S. Low Reynolds number flow past a circular cylinder. Proc. 9th Int.Con.App.Mech. Vol.3 1957 pp 167-175.

14073 KAPLUN, S. Asymptotic expansion of Navier-Stokes solutions for small Reynolds number. Proc. 9th Int.Con.App.Mech. Vol.3 1957 pp 177 - 186.

14074 RIVLIN, R.S. Some flow properties of visco-elastic fluids. Proc. 9th Int.Con.App.Mech. Vol.3 1957 pp 187 - 195.

14075 BROER, L.J.F. Laminar flow of a visco-elastic fluid. Proc. 9th Int.Con.App.Mech. Vol.3 1957 pp 205 - 209.

Appendix A (Continued)

14076 PARET, R.E. Fabrication of low nickel high manganese steels. Metal Progress May 1956 pp 54 - 57.

14077 ADAMS, C.M. Gating and risering of investment castings. Metal Progress May 1956, pp 58 - 60.

14078 BERNSTEIN, H. Delayed cracking of rolled Ti-150. Metal Progress, May 1956, pp 65 - 66.

14079 KAUFMAN, J.W. Prestressing ultra high strength steel to perform even higher duty. Metal Progress, May 1956, pp 87 - 90.

14080 LAMBOURNE, N.C. On the conditions under which energy can be extracted from an air stream by an oscillating aerofoil. Aero. Quarterly, 1952-54, pp 55 - 68.

14081 ROBINSON, A. Aerofoil theory for swallow tail wings of small aspect ratio. Aero. Quarterly, 1952-54, pp 69 - 82.

14082 WITTRICK, W.H. Correlation between some stability problems for orthotropic and isotropic plates under bi-axial and uni-axial direct stress. Aero. Quarterly, 1952-54, pp 83 - 90.

14083 COLLIS, D.C. The dust problem in hot-wire anemometry. Aero. Quarterly, 1952-54, pp 93 - 102.

14084 POWELL, A. On the noise emanating from a two dimensional jet above the critical pressure. Aero. Quarterly, 1952-54, pp 103 - 122.

14085 GADD, G.E. Some aspects of laminar boundary layer separation in compressible flow with no heat transfer to the wall. Aero. Quarterly, 1952-54, pp 123 - 150.

14086 COX, H.L. & FIELD, J.E. The initiation and propagation of fatigue cracks in mild steel pieces of square section. Aero. Quarterly, 1952-54, pp 1 - 18.

Appendix A (Continued)

14087 ZIMMERMAN, R.H. A method for predicting super-compressibility factors of natural gases. ASME Trans. Oct. 1958, pp 1358 - 1362.

14088 WOODS, L.C. Compressible subsonic flow in two dimensional channels. Aero. Quarterly, 1955, pp 205 - 220.

14089 DONALDSON, I.S. The effect of sting supports on the base pressure of a blunt-based body in a supersonic stream. Aero. Quarterly, 1955, pp 221 - 229.

14090 JESSOP, H.T. Photoelastic investigation in connection with the fatigue strength of bolted joints. Aero. Quarterly, 1955, pp 230 - 240.

14091 TANNER, L.H. Note on a null method for the direct measurement of pressure coefficient. Aero. Quarterly, 1955 pp 241 - 253.

14092 WOODS, L.C. Compressible subsonic flow in two dimensional channels. Aero. Quarterly, 1955, pp 254 - 277.

14093 GUNN, K. Effect of yielding on the fatigue properties of test pieces containing stress concentrations. Aero. Quarterly, 1955, pp 277 - 294.

14094 COLEMAN, W.S. Stabilisation of the aeroplane in symmetric flight at zero or very small air speeds. Aero. Quarterly, 1955, pp 295 - 328.

14095 Ultrasonic Inspection. Semi-Automatic installation for large aluminium alloy slabs. Aircraft Prod. 1957, pp 250 - 252.

14096 HALL, L.G. Chemical milling application of the process to airframe structures. Aircraft Prod. 1957, pp 257 - 259.

14097 Integral Skins: Production techniques and equipment used in the manufacture of large wing panels. Aircraft Prod. 1957, pp 260 - 272.

Appendix A (Continued)

14098 Drilling and lapping components in hydraulic servo equipment. Aircraft Prod. 1957, pp 274 - 278.

14099 Milling high tensile steel. Some notes on the use of Atrasmann roughing cutters. Aircraft Prod. 1957, pp 278 - 281.

14100 DRIEST, E. R. van. Aerodynamic heating. App. Mech. Rev. Feb. 1958, pp 51 - 53.

APPENDIX B

533.6 AERODYNAMICS

533.6 Aerodynamics

Special analytical subdivisions

.01 subdivisions may be used throughout 533.6
.03/.04 " are only applicable to 533.69
.01/.04 " may be used as main numbers where no other number has been allocated
.05/.08 " should be used as main numbers

It is undesirable that one analytical number should be added to another.

533.6.011	Motion of and in gases. Flow.
.011.1	Theory of dimensions
.011.12	Reynolds number effect. Scale effect.
.011.32	Flow at subsonic velocities - without compressibility effect
.011.34	" " " " - with compressibility effect
.011.35	" " transonic "
.011.5	" " supersonic "
.011.55	" " hypersonic " (Mach 5 and above)
.011.6	Heat transfer phenomena of moving bodies and gases (To include all problems of aerodynamics with heat, including cooling. See 532.546 for flow of liquids through porous media)
.011.72	Shock waves. Shock wave configuration.
.011.8	Super aerodynamics. Flow in rarefied gases.
.013	Dynamics of aeronautical machines
.013.1	Forces and moments
.013.12	Drag (Cooling, induced, pressure, form, surface friction, base drag)
.013.122	Drag reduction. Area rule
.013.13	Lift. Normal force
.013.14	Lateral force. Side force
.013.15	Pitching moment
.013.16	Rolling "
.013.17	Yawing "
.013.18	Hinge "

Appendix B (Continued)

533.6.013.2	Unsteady motion
.013.4	Stability (Papers dealing with stability and control in general go here)
.013.412	Longitudinal stability
.013.413	Lateral "
.013.415	Directional "
.013.417	Stability derivatives
.013.418	Cross coupling. Inertia coupling
.013.42	Aeroelasticity
.013.422	Flutter
.013.423	Damping. Balances. Mass balances
.013.424	Divergence. Increased oscillation
.013.425	Effect on controls (Control reversal and loss of control effectiveness)
.013.43	Buffeting
.013.47	Aircraft response
.013.6	Conditions of flight
.013.63	Turning flight
.013.65	Manoeuvring flight
.013.66	Stalling
.013.67	Hovering. Low speed flight
.013.68	Non-powered flight
.013.682	Gliding "
.013.685	Towed "
.013.686	Parasitic "
.013.7	Spinning
.015	Performance
.015.1	Take-off
.015.2	Approach and landing
.015.3	Speed. Rate of ascent. Rate of descent
.015.32	Speed
.015.34	Rate of ascent and descent
.015.342	Rate of ascent. Climbing
.015.343	Rate of descent. Diving
.015.5	High altitude
.015.7	Duration and distance
.015.72	Duration
.015.74	Range. Radius of action. Air miles per gallon
.015.8	Prediction of performance. Reduction to standard atmospheric conditions

Appendix B (Continued)

533.6.031	Aspect ratio
.032	Camber
.033	Taper and twist
.034	Thickness distribution
.035	Dihedral
.036	Surface conditions
.037	Fineness ratio
.048	Airflow variables
.048.1	Aerodynamic loading
.048.2	Pressure distribution
.048.3	Downwash. Wakes
.048.5	Gust loads. Acceleration stresses. Vg tests
533.6.05	Flight testing techniques (for flow visualisation methods see 533.6.071.31)
.053	Full scale. Piloted
.055	Model. Pilotless
533.6.07	Ground testing techniques. Wind tunnels, water tunnels, etc.
.071	Wind tunnels May be divided alphabetically by type if required. e.g. Blowdown. Use only for descriptions of testing plants, equipment and techniques. Reports on tests in wind tunnels, etc. go under the configuration tested with the addition of .001.5 if desired.
.071.1	Construction. Working section. Vanes. Cascades. Diffusers. Bulges. Contractions. Screens. Nozzles. Wave makers.
.071.11	Walls - slotted, porous, flexible
.071.2	Power plant
.071.3	Apparatus
.071.31	Visualisation methods
.071.32	Balances. Model mountings. Stings
.071.33	Models (For other instruments use existing U.D.C. number coloned to 533.6.071.3 e.g. Manometers 533.6.071.3 :531.787)

Appendix B (Continued)

533.6.071.4	Flow problems. Interference. Turbulence. Calibration. Corrections. Scale effect. Use of gases other than air.
.071.5	Tunnel conditions. Ventilation. Noise. Temperature. Humidity. Pressure, etc.
.072	Spinning tunnels
.073	Shock tubes
.074	Water tanks. Water tunnels
.075	Apparatus with rotating devices
.075.2	Whirling arms
.075.5	Propeller and rotor testing plant
.076	Analogies. Tanks for solving potential flow problems
.077	Ballistic ranges, etc.
.078	High speed railways. Sleds.

Note: The divisions .072/.078 may be subdivided as .071. For different types of wind tunnels use subdivisions of 533.6 e.g. Supersonic tunnels 533.6.071.011.5

533.6.08	Flow measurement
	Divide as 53.08 e.g. :-
.082.3	Use of aerodynamic and aerostatic phenomena (i.e. measurement in pressure head, static head or vent, trailing static, air log etc.)
.082.7	Use of electrical phenomena (i.e. hot wire anemometers)
.088	Accuracy. Errors. Correction (e.g. Position error)
.089	Calibration
	(For meteorological anemometers see 551.508.2
	" airspeed indicators see 629.13.053.2
	" fluid flow measurement 532.57)

533.61	Lighter-than-air-machines
.62	Free balloons
.63	Captive balloons
.64	Dirigible balloons. Airships
.65	Aeroplanes
.652	Landplanes

Appendix B (Continued)

533.652.1	Monoplanes
.652.2	Biplanes
.652.3	Multiplanes
.652.5	All wing aircraft
.652.6	V.T.O.L., S.T.O.L., Convertiplanes. (Not rotorcraft)
.652.9	Other types including Canard
.655	Seaplanes
.655.2	Float seaplanes (subdivide as 533.652)
.655.3	Boat " " " "
.655.4	Ski " " " "
.657	Amphibians

.655/7 may be subdivided as .652 if required
e.g. 533.655.35 all wing boat seaplanes

533.66	Theory of other flying machines
.661	Helicopters
.661.2	Autogyros
.662	Airscrews
.662.2	Propellers
.662.21	Single propellers
.662.22	Co-axial, contra rotating. Tandem propellers
.662.3	Fans. Ducted fans
.662.6	Lifting airscrews. Helicopter rotors
.662.62	Axially driven
.662.63	Circumferentially driven. Jet driven rotors
.662.64	Autorotating. Driven by the relative wind
.662.7	Windmills
.663	Cyclogyros
.664	Ornithopters. Aircraft with moving wings. (except rotorcraft)
.665	Missiles
.666	Machines for nonpowered flight
.666.2	Parachutes
.666.4	Kites
.666.6	Gliders

533.68	Aerodynamic study of bodies moving on or near the ground, deck or water
.682	Ground. Taxying. Forced landing. Ground effect

Appendix B (Continued)

533.683	Deck
.685	Water. Ditching
533.69	Aerodynamics of aircraft elements The following analytical subdivisions are particularly applicable here.
533.69.001.1	Theory
.001.5	Experiment
.031	Aspect ratio
.032	Camber
.033	Taper and twist
.034	Thickness distribution
.035	Dihedral
.036	Surface conditions
.037	Fineness ratio
.048	Airflow variables
.048.1	Aerodynamic loading
.048.2	Pressure distribution
.048.3	Downwash, wakes
.048.5	Gust loads. Acceleration stresses. Vg tests
533.692	Wing sections
.1	Designated
.2	Diamond and hexagonal
.3	Biconvex and circular arc
.4	Flat plate
.5	Wedges
.6	Section varying along span
533.693	Complete wings
.1	Swept) Use only when planforms below are not
.2	Unswept) the subject of the report
.3	Delta. Double delta. Diamond. Arrowhead
.4	Sweep varying along the span. Crescent. Cranked. M & W.
.5	Elliptic. Circular
.6	Rectangular
.7	Trapezoidal
.8	Ring wings
.9	Other e.g. aeroisoclinic, cruciform

Appendix B (Continued)

533.694	High lift devices. Controls
.2	Flaps. Slats. Slots
.21	Split
.22	Slotted
.23	Dive flaps. Brakes
.25	Leading edge flaps. Chord extensions. Drooped Leading edge
.26	Slats
533.694.5	Control surfaces
.51	Lateral controls
.511	Ailerons, trailing edge
.512	" moving wing tip
.513	Other types. Spoilers
.52	Elevons
.53	Longitudinal controls
.531	Fixed tail plane
.532	All moving tail plane
.533	Elevators
.54	Directional controls
.541	Fins
.542	Rudder
.58	Tabs
.6	Jets used as high lift devices or controls (If the jets are used purely as boundary layer control devices they should be classified at 533.694.72)
.7	Boundary layer control
.71	Suction
.72	Blowing
.73	Fences. Vortex generators. End plates
533.695	Components in combination (For interference between aircraft and ground or water see 533.682) For interference between parts of an aircraft, combine the following as appropriate in ascending numerical order, e.g. interference between propeller and tailplane 533.695.45, interference between wing and tailplane 533.695.14)

Appendix B (Continued)

533.695.1	Wing
.2	Body
.3	Nacelle
.4	Tail, vertical and horizontal
.5	Propeller, rotor
.6	External stores, drop tanks, pods, weapons carried externally, landing gear.
.7	Jet or exhaust
.8	Cascades. Multiplanes
.9	Protuberances. Recesses. Doors. Bays (for dropping, landing gear retraction, etc.)
533.696	Bodies
.2	Spheres
.3	Cylinders
.4	Cones
.5	Other circular cross section. Bodies of revolution
.6	Non-circular cross section
.7	Designated bodies
533.697	Internal aerodynamics (For energy losses, colon appropriate subdivisions of 532.55 to appropriate subdivision of 533.697)
.2	Intakes
.23	Nose intakes
.24	Side "
.242	Scoops
.244	Submerged
.25	Wing leading edge intakes
.3	Ducts. Passages. Bends. Diffusers (See also 533.6.071.1 for wind tunnel diffusers)
.4	Nozzles. Jets (See also 533.6.071.1 for wind tunnel nozzles)
.5	Ejectors. Jet pumps. Outlets. Bleeds
.6	Bodies in ducts (See 533.662.3 for ducted fans)

APPENDIX B (Continued)

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629.13.067	Cabin pressurisation systems. Aircraft engineering.
629.13.012.531	Cabins. Aircraft structures.
629.13.012.59	Cabins, pressurised. Aircraft structures.
621.315.2	Cables. Electrical engineering.
629.13.014.5-427.4	Cables. Flying controls. Aircraft engineering.
624.071.2	Cables. Structural elements. Civil engineering.
621.315.212	Cables, coaxial. Electrical engineering.
669.73	Cadmium. Metallurgy.
621.822.722	Cages. Ball bearings. Power transmission. Mechanical engineering.
621.822.822	Cages. Roller bearings. Power transmission. Mechanical engineering.
624.042	Calculation. Loads. Structures. Civil engineering.
518	Calculation. Mathematics.
518.4	Calculation, graphical. Mathematics.
518.12	Calculation, numerical. Mathematics.
517.3	Calculus, integral. Analysis. Mathematics.
519.21	Calculus of probability. Mathematics.
519.3	Calculus of variations. Mathematics.
533.6.071.43	Calibration. Flow problems. Wind tunnels.
53.089.6	Calibration. Principles of measurement. Physics.
536.6	Calorimetry. Heat. Physics.
533.69.032	Camber. Aircraft elements. Aerodynamics.
533.692.032	Cambered aerofoil sections. Aerodynamics.
771.3	Cameras. Photography.
621.397.3	Cameras, television. Television. Electrical engineering.
621.835	Cams. Power transmission. Mechanical engineering.
621.835.001.1	Cams. Power transmission. Mechanical engineering. Design.
(71)	Canada.
533.652.9	Canards. Aerodynamics.
629.13.012.134.4	Canopies, aircraft. Aircraft structures.
533.695.9	Canopies, aircraft. Interference. Aerodynamics.
532.6	Capillarity. Mechanics of fluids. Physics.
621-415	Cantilever plates. Thin plates. Materials shapes. Mechanical engineering.

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621.319.4	Capacitors. Electrical engineering.
532.66	Capillary tubes. Capillarity. Mechanics of fluids. Physics.
629.13.012.217	Capsules, escape. Aircraft structures.
546.261	Carbides. Carbon. Inorganic chemistry.
661.665	Carbides. Chemical technology.
546.26	Carbon. Inorganic chemistry.
621.3.047.43	Carbon brushes. Current collection. Electrical engineering.
621.43.019.942	Carbon deposits. Combustion problems. Internal combustion engines.
661.97	Carbon dioxide. Chemical technology.
661.993	Carbon monoxide. Chemical technology.
546.262.3	Carbon monoxide. Inorganic chemistry.
547.58	Carboxylic acids, aromatic, Organic chemistry.
547.46	Carboxylic acids, polybasic. Organic chemistry.
621.785.51	Carburising, case. Heat treatment. Workshop practice.
621.785.52	Carburising, pack. Heat treatment. Workshop practice.
629.138.4	Cargo aircraft. Aircraft engineering.
629.13.071.55	Cargo weight. Aircraft engineering.
621.394.441	Carrier waves. Telegraphy. Electrical engineering.
623.822.7	Carriers, aircraft. Warships. Naval engineering.
533.695.8	Cascades. Interference. Aerodynamics.
621.785.51	Case carburising. Heat treatment. Workshop practice.
621.785.5	Case hardening. Heat treatment. Workshop practice.
669.14.018.462	Case hardening, steel. Metallurgy.
669.13	Cast iron. Metallurgy.
669-14	Cast metals. Metallurgy.
669.14-14	Cast steel. Metallurgy.
621.746	Casting. Workshop practice.
621.746.585	Casting, arc. Workshop practice.
621.746.57	Casting, centrifugal. Workshop practice.
621.746.045	Casting, investment. Workshop practice.
621.746.045	Casting, lost wax. Workshop practice.
669-14	Castings. Metallurgy.
669.018.28	Casting alloys. Metallurgy.
541.128	Catalysis. Chemical mechanics. Physical chemistry.
678.044	Catalysts. Macromolecular materials.

APPENDIX C

ALPHABETICAL SUBJECT HEADINGS

CABIN CONDITIONING see AIR CONDITIONING
CABINS
CABINS, PRESSURE see CABINS, PRESSURISED
CABINS, PRESSURISED
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CABLES, COAXIAL
CABLES, ELECTRIC
CABLES, TRANSMISSION
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CADMIUM ALLOYS
CADMIUM-NICKEL BATTERIES see BATTERIES, NICKEL-CADMIUM
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CAMBER
CAMBER, NEGATIVE
CAMBERED AEROFOIL SECTIONS see AEROFOIL SECTIONS, CAMBERED
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CANOPIES, COCKPIT
CANOPIES, PARACHUTE see PARACHUTES
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CANTILEVER PLATES see PLATES, CANTILEVER
CAPACITORS
CAPILLARITY
CAPILLARY TUBES see TUBES, CAPILLARY
CARBIDE, CHROMIUM see CHROMIUM CARBIDE

Appendix C (Continued)

CARBIDES
CARBON
CARBON DEPOSITION
CARBON DIOXIDE
CARBON MONOXIDE
CARBON-TUNGSTEN ALLOYS see TUNGSTEN-CARBON ALLOYS
CARPETS (GRAPHS)
CARS see AUTOMOBILES
CARTRIDGE STARTERS see STARTERS, CARTRIDGE
CARTRIDGES
CASCADES
CASCADES, TWO DIMENSIONAL
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CASE HARDENING see HARDENING, CASE
CASE HARDENING STEEL see STEEL, CASE HARDENING
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CAST IRON see IRON, CAST
CASTING
CASTING, ARC
CASTING, CENTRIFUGAL
CASTING, INVESTMENT
CASTING, LOST WAX see CASTING, INVESTMENT
CASTING ALLOYS see ALLOYS, CASTING
CASTINGS
CASTINGS, ALUMINIUM ALLOY
CASTINGS, MANGANESE ALLOY
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CASTINGS, STEEL
CASTINGS, ZINC ALLOY
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CATALYSTS
CATAPULTS
CATAPULTS, HYDRAULIC
CATHODE RAY OSCILLOGRAPHS see OSCILLOGRAPHS
CATHODE RAY TUBES see TUBES, CATHODE RAY
CAUSES
CAVITATION
CAVITATION FLOW see FLOW, CAVITATION
CAVITIES
CAVITY MILLING MACHINES see MILLING MACHINES, CAVITY

Appendix C (Continued)

CEILING (PERFORMANCE)
CELLS, LECLANCHE
CELLS, PHOTOELECTRIC see PHOTOELECTRIC CELLS
CELLS, PRIMARY
CELLS, SECONDARY
CELLULOSE ACETATE
CEMENTED JOINTS see JOINTS, CEMENTED
CEMENTS
CEMENTS, ADHESIVE
CENTRE, AERODYNAMIC
CENTRE OF GRAVITY
CENTRE OF PRESSURE
CENTREBODY INTAKES see INTAKES, CENTREBODY
CENTRIFUGAL CASTING see CASTING, CENTRIFUGAL
CENTRIFUGAL COMPRESSORS see COMPRESSORS, CENTRIFUGAL
CENTRIFUGAL FORCES see FORCES, CENTRIFUGAL
CENTRIFUGAL GOVENORS see GOVENORS, CENTRIFUGAL
CENTRIFUGAL IMPELLERS see IMPELLERS, CENTRIFUGAL
CENTRIFUGAL PUMPS see PUMPS, CENTRIFUGAL
CENTRIFUGAL SUPERCHARGERS see SUPERCHARGERS, CENTRIFUGAL
CENTRIFUGES
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CERAMICS
CERMETS
CERTIFICATION
CESIUM
CHANNELS (HYDRODYNAMICS)
CHARACTERISTIC AERODYNAMIC TIMES see TIMES, CHARACTERISTIC
CHARACTERISTICS
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CHARTS
CHEMICAL ENERGY see ENERGY, CHEMICAL
CHEMICAL MILLING see MILLING, CHEMICAL
CHEMICAL REACTION see REACTION, CHEMICAL
CHEMICAL SHOCK TUBES see SHOCK TUBES, CHEMICAL

APPENDIX D

SYNOPSIS OF FACET SCHEDULES

A	Aviation in general
Ab	Civil (by field of service, ownership, area of service)
Ai	Sporting
Aj	Military
Az	Other engineering structures
B	Aircraft (various characteristics of division)
C	Structural parts, including
Ca	Combinations
Cd	Wing
Cn	Tail unit
Cp	Control surfaces
Db	Rotor
Dc	Propeller (various characteristics of division, also its parts)
Ea	Fuselage, body (and their parts)
Ei	Nacelle, pod
Ej	Envelope
Ek	Cowling
Em	Skin
En	Alighting gear (and its parts)
Ev	Flying controls (and their parts)
Eyt	Trimming controls
Ez	Model-testing equipment (when object of study)
Fa	Structural parts and elements
Fm	Bodies in general
Ga	Engine, power-plant (various characteristics of division)
Gn	Ancillary equipment
Gu	Auxiliary systems and equipment
Ha	Machine components
Hx	Machine properties and processes
I	Spatial properties
Ia	Portion
Ig	Shape
Iv	Dimensions
Ix	Arrangement
Ja	Performance
Jt	Conditions of flight

Appendix D (Continued)

K	Flying operations, manoeuvres
La	Navigation
Lw	Air Traffic control
Ma	Aircraft instruments and aids
Mn	Maps and charts (and their characteristics)
Mr	Ground services
Mu	Personnel
Mv	Accidents and hazards
N	Aerodynamics in general
Na	Fluids
Nb	Aerodynamic entities
Nbd	Interface
Nbf	Flow (by speed, type, dimension)
Nfl	Boundary layer
Ng	Flow elements
Ni	Attributes
Nn	Fluid properties
Np	Aerodynamic forces
Oa	Control, stability, &c.
Ok	Processes and properties
Om	Aeroelasticity
Op	Buffeting
Oq	Aerodynamic reference parameters
P	Materials (by use, by constitution)
Pr	State and form of matter
Q	Manufacturing processes
Ra	Mechanics of rigid bodies
Rg	Mechanics of deformable bodies
Rt	Surface properties
Rx	Porosity
Sa	Mechanical vibration (with properties and processes)
Sg	Electromagnetic wave and particle motion
Sgb	Radiations
Sh	Particles
Sm	Thermal behaviour of materials
Sr	Thermodynamic properties and processes
Ta	Structure
Td	Crystal properties (and phenomena)
Tk	Chemical properties and behaviour
Tv	Biological properties

Appendix D (Continued)

Ua	Aviation medicine
Um	Meteorology, weather
V	General technical operations
Vk	Apparatus (including mode-testing equipment)
Vv	Recording (methods and equipment)
W	Electrical and electronic equipment
Wd	Circuits
Wf	Components
Wq	Properties
Wt	Processes
Xa	Managerial operations
Xg	Personnel operations
Xk	Research
Y	Mathematics
Yp	Methods
Yx	Computers
(Z)	General properties
(Zq)	Magnitude
(Zu)	General attributes
(1/9)	Geographical schedules
:b	Literary form
:c	Charts

Appendix D (Continued)

SCHEDULES FOR AERODYNAMICS

N Aerodynamics, Including fluid dynamics

Na Fluids
Nad Perfect, Ideal fluids
Nap Real fluids
Naq Gases (Aerodynamics)
Nar Air (Aerodynamics) Other gases divide by P, Materials
Nas Rarefied gases
Nat Compressed gases
Nav Liquids (Fluid dynamics)
Naw Water, (Fluid dynamics) Other liquids divide by P, Materials

Nb Aerodynamic entities
Nbd Gaseous interfaces, free surfaces
Nbf Flow
By speed
Nbg Low speed (< Mach 0.3) flow
Nbh Subsonic flow
Nbj Transonic flow
Nbk Supersonic flow
Nbm Hypersonic (> Mach 5) flow
Definitions: Subsonic: No part sonic or supersonic
Transonic: Partly subsonic, partly supersonic
Supersonic: No part subsonic

Nc Types of flow
Ncb Free stream flow
Ncd Laminar flow
Nce Transitional flow
Ncf Turbulent flow
Nch Steady, continuous flow
Nci Unsteady flow
Ndb Rotational flow
Ndd Irrotational flow
Ndf Potential flow
Ndh Adiabatic flow
Ndj Diabatic flow
Ndm Isentropic flow
Ndp Non-isentropic flow

Appendix D (Continued)

Nec	Reversible flow	
Nee	Irreversible flow	
Neg	Prandtl-Meyer, Expansion flow	
Nei	Slip flow	
Nek	Free molecule flow	
Nep	Shear flow	
Ner	Cavity flow	
Net	Separated flow	
Nev	Mixed flow	
New	Re-energised flow	Divide Nbf also by shape, bracketed e.g. Conical flow Nbf(Igr)
Nf	By dimension	Add number Two dimensional flow Nf2
Nfd	Non-viscous flow	
Nff	Viscous flow	
Nfh	Incompressible flow	
Nfj	Compressible flow	
Nfk	Boundary layer	
Nfn	Transition (boundary layer)	
Nfp	Separation (boundary layer)	
Nfr	Bubble (Boundary layer)	
	Flow elements	
Ngc	Streamlines	
Nge	Sources	
Ngg	Sinks	
Ngi	Doublets	
Ngk	Vortices	
Ngm	Bound Vortices	
Ngn	Vortex Filaments	
Ngp	Vortex Sheets	
Ngs	Vortex Streets	
Ngx	Jets	
Nh	Waves	
Nhb	Expansion waves	
Nhd	Compression, shock waves	
Nhf	Normal shock waves	
Nhh	Oblique shock waves	
Nhj	Attached shock waves	

Appendix D (Continued)

Nhk	Detached shock waves	
Nbm	Mach waves	Divide by S, Mechanical vibration - e.g. Attenuation: Shock waves Nhd Sfr
	Attributes	
Ni	Velocity (Aerodynamics)	
Nic	Mass flowrate	
Nie	Velocity gradient	
Nj	Similarity parameters	
Njb	Mach number	
Njd	Critical Mach number	
Njf	Mach number of divergence	
Njh	Prandtl number	
Njj	Nusselt number	
Njm	Reynolds number	
Njp	Froude number	
Nkb	Profile	
Nkd	Thickness ratio	
Nkf	Circulation	
Nkh	Vorticity	
Nm	Hydrodynamic characteristics	
Nmd	Spray	
Nn	Fluid properties	
Nnc	Density (fluids)	
Nng	Compressibility	
Nni	Viscosity	
Nnk	Kinematic viscosity	
Nns	Surface tension, capillarity	
Np	Aerodynamic characteristics	
Npa	Aerodynamic forces	
Npb	Aerodynamic loads	
Nq	Lift	
Nqb	Non-linear lift	
Nr	Drag	
Nrb	Profile, Zero lift drag	
Nrd	Form drag	
Nrf	Skin friction drag	
Nrh	Wave drag	

Appendix D (Continued)

Nrh	Induced drag, Drag due to lift
Nrm	Parasite, Interference drag
Nrp	Base drag
Ns	Side force
	Other loads
Ntb	Buffeting load
Ntq	Gust loads
Nti	Impact loads (hydrodynamics)
Nu	Moments
Nub	Pitching moments
Nud	Rolling moments
Nuf	Yawing moments
Nuh	Hinge moments
Nv	Pressure
Nvd	Dynamic pressure
Nvf	Pressure distribution
Nvh	Centre of pressure
Nvk	Pressure gradient
Nvm	Pressure recovery
Oa	Control
Oaf	Later control
Oak	Longitudinal control
Oap	Directional control
Ob	Stability (aerodynamics)
Obb	Static stability
Oc	Dynamic stability
Ocb	Longitudinal stability
Ocd	Phugoid stability
Ocf	Short-period longitudinal stability
Och	Lateral, directional stability
Ocj	Snaking
Ocm	Dutch rolling
Ocp	Stability derivatives
Od	Manoeuvrability (aerodynamics)
Oe	Interference, interaction
Of	Stagnation
Og	Choking

Appendix D (Continued)

Oi	Aerodynamic heating	
Ojb	Downwash	
Ojd	Upwash	
Ojf	Sidewash	
Ojh	Wake	
Ojm	Slipstream	
Ojp	Turbulence	
Ojr	Surging	
Ojt	Ground effect	
	Process and properties	
Okb	Suction	
Okd	Blowing	
Okk	Autorotation, Windmilling	
Okm	Feathering	
Om	Aeroelasticity	
Omb	Vibration, (Aeroelasticity)	
On	Flutter	
Onb	Flexure-torsion flutter	Divide by Ws Wave properties e.g. Frequency: flutter, On Wsd
Onf	Buzz	
Op	Buffeting	
Oq	Aerodynamic reference parameters	
	Fixed wing	
Oqb	Angle of incidence, Angle of attack	
Oqd	Angle settings	
Oqf	Wing-fuselage angle settings	
Oqh	Tail-fuselage angle settings	
Oqj	Decalage (Wing-wing)	
Oqm	Planform	Attach Iid etc. directly to Cd etc. Use Oqm for generalities on planform only
Oqp	Sweepback)	Add number of degrees, e.g. 45^{o} Sweepback Sweptback 45^{o}: Wings Cd Oqp 45 See Iibb Sweptback, Iibd Sweptforward
Oqr	Sweepforward)	
Oqt	Aspect ratio	
Oqv	Taper ratio	
Oqw	Thickness ratio	

Appendix D (Continued)

Oqx	Twist
Oqy	Dihedral
Oqz	Wing area
Osb	Span
Osg	Quarter chord line
Osi	Chord
Osj	Geometric mean chord
Osk	Aerodynamic mean chord
Osn	Quarter chord point
Osq	Aerofoil sections, Aerofoil profiles
Oss	Camber
	Rotating wing
Oub	Tilt
Oud	Disc area
Ouf	Solidity
Ouh	Diameter
Oup	Pitch (Rotors)
Our	Collective pitch
Out	Cyclic pitch
Ouv	Fore-aft cyclic pitch
Ouw	Lateral cyclic pitch

Appendix G (Continued)

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A 533.695.12	COMBINATIONS, WING-FUSELAGE — Lift
B 533.693.35	" " " — Centre of pressure
C 533.693.6	WINGS, CRUCIFORM — Lift
D 533.693.92	" " — Centre of pressure
E 533.6.013.13	WINGS, TRIANGULAR — Lift
F 533.69.048.2	" " — Centre of pressure
ADBE BE DE	WINGS, RECTANGULAR — Lift
ADBF BF DF	
ADCE CE	" " — Centre of pressure
ADCF CF	

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RECTANGULAR: TRIANGULAR:	0508	
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	0951	
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FIGURE 1. FRONT AND REVERSE OF INDEXING MASTER CARD

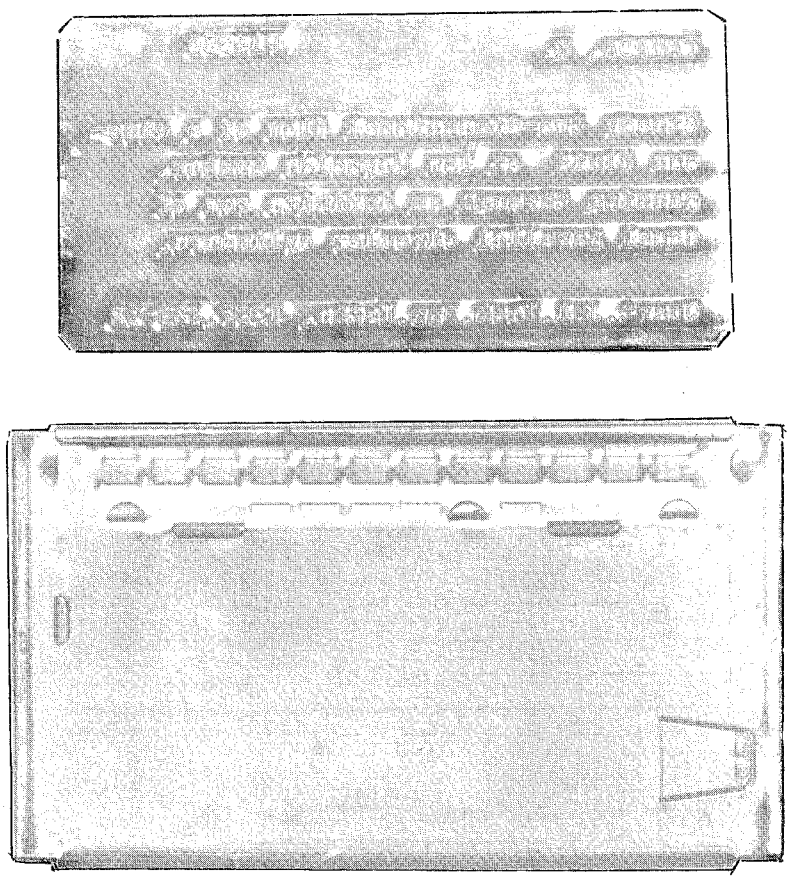

FIGURE 2. PLATE AND HOLDER FOR ADDRESSOGRAPH

TAMADA, K. P14536

Steady two-dimensional flow of a viscous fluid at low Reynolds number, passing through an infinite row of equal parallel circular cylinders.

Quart.Jnl.Mech.App.Maths, 1957,425-32

FIGURE 3. LAYOUT OF CATALOGUE CARDS