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ASLIB

CRANFIELD RESEARCH PROJECT

REPORT ON THE TESTING AND ANALYSIS 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

G. M. Keen.

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Cranfield

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PREFACE

This volume continues the account of the Aslib-Cranfield project as given in the "Final Report of the First Stage of an Investigation into the Comparative Efficiency of Indexing Systems". The major portion of the two years spent on this present stage has been involved with the analysis of the considerable amount of data which was obtained from the main test programme. A difficulty in this work was in deciding on the type of analysis which would be most likely to yield valuable information. In order to keep this volume within reasonable limits, it has been necessary to select from the analysis that was done, and even so in many cases only brief examples are given. The major emphasis has been placed on the reasons for failure to retrieve source documents, for this is considered to give some of the most interesting results of the project and has not, to our knowledge, been previously attempted. Of possible equal importance, but certainly more difficult to evaluate, is the reason for the retrieval of non-relevant references. This analysis has not been attempted within the present work, but will be one of the matters to be investigated in the continuation of the project.

The interest in this work has been widespread, and a large number of people either personally or in correspondence, have made many interesting and useful comments. To all these, as well as many others who have taken an active part in the work, I would acknowledge my debt. In particular, however, I would express my sincere thanks to the National Science Foundation for their support which alone made the project possible, and in particular to Dr. B. Adkinson and Mrs. Helen Brownson for their co-operation, advice and encouragement. I am also indebted to the Principal and Senate of The College of Aeronautics for their permission for the work to be undertaken at Cranfield and to Mr. L. Wilson, Director of Aslib, for coping so admirably with the administration of the project.

Cranfield, September 1962.   Cyril W. Cleverdon.

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CHAPTER 1

INTRODUCTION

In July, 1957, the National Science Foundation awarded a grant to Aslib (Association of Special Libraries and Information Bureaux) for an investigation to be made into the comparative efficiency of four indexing systems. The work was to be undertaken at the College of Aeronautics, Cranfield, under the direction of the Librarian, Mr. Cyril Cleverdon. The grant was to cover the first stage of the investigation which consisted of the preparation of four separate indexes, for which 18,000 documents were indexed by the Universal Decimal Classification, an alphabetical subject index, a special facet classification and the Uniterm system of co-ordinate indexing. Various controls were included in the work, and these, which are discussed in detail in the Report on the First Stage (Ref. 1), may be summarised as follows:-

1. Indexing staff were selected for their different experience
2. The time for indexing each document was strictly controlled and varied from 16 minutes to 2 minutes
3. Working with batches of 100 documents, the documents in each group were divided equally between
    (a) Papers dealing with high speed aerodynamics and general aeronautical subjects
    (b) Research reports and periodical articles
    (c) American papers and papers from other countries.
4. A complete cycle of indexing variables covered 6,000 documents, and by repeating this sub-programme three times, there was the possibility of assessing the learning factor.

To permit testing to be done, it was necessary to compile the indexes in a physical form that could be used in searching. The methods used were conventional card catalogues for U.D.C., Alphabetical and Facet and aspect cards posted with document numbers for Uniterm. The reasons for these decisions are explained in detail in Reference 1, and here it is only necessary to re-emphasise that the investigation was not basically concerned with the physical form of the indexes but concentrated on the characteristics and performance of the descriptor languages.

The three individuals concerned with the indexing were Mr. J. Sharp, Miss B. Warburton and Mr. J. Hadlow. Mr. Sharp was a Fellow of the Library Association and had previous experience both as regards indexing and as regards the subject matter, since he had been a technical librarian with a large aircraft firm. Miss Warburton, an Associate of the Library Association, had previous indexing experience as Librarian of the United Steel Co. Ltd., but the subject field was new for her. Mr. Hadlow had joined the project staff direct from work in a public library, and therefore had no previous experience of the type of indexing involved, nor of the subject field.

Mr. Sharp left the staff at the completion of the indexing and took no part in the testing. Mr. Hadlow joined the staff of the library of the College of Aeronautics and was able to do some testing until his resignation in February, 1961. Miss Warburton, who remained on the project staff until her marriage in July, 1961, and returned afterwards on a part-time basis, did much of the testing and was responsible for most of the analysis described in Chapter 5. Mrs. J. Aitchison joined the staff in May 1961, and took part in the third round of testing and assisted with the analysis. She was also mainly concerned with the work involved in the test on the W.R.U. index described in Chapter 7. Other testing was done by the Director and Miss A. Scott of the College Library staff. In addition five graduate students of the College, Lt. A. Ashmore, R.N., Mr. W. Elder, Flt. Lt. E.J. Whitehead, Flt. Lt. B. Jewell and Mr. P. Young, spent periods of from six to ten weeks making searches during the summer vacation of 1960.

An Advisory Committee consisting of Mr. B.C. Vickery, Deputy Director of the National Lending Library, Mr. J. Farradane, Information Officer, Tate & Lyle Ltd., Mr. R.C. Wright, Librarian, Royal Aircraft Establishment, Mr. R.A. Fairthorne, Royal Aircraft Establishment and Mr. C.W. Hanson, Aslib, met on a number of occasions to discuss the progress of the work.

The Report on the First Stage of the Investigation (Reference 1), deals with all aspects concerning the indexing of the documents and the preparation of the four indexes. It includes a number of tables relating to this stage of the project, but Tables 1.1, 1.2, 1.3 and 1.4 are repeated here in that they have a particular bearing on the matters considered in this report.

U.D.C.	4052	headings in alphabetical index
	2350	different notational elements
ALPHA	2864	main headings
	1560	*see* references
	592	subheadings
FACET	1686	notational elements
* UNITERM	3174	terms

* (including 607 Proper names and 267 numbers)

TABLE 1.1

NUMBER OF HEADINGS OR NOTATIONAL ELEMENTS USED DURING THE INDEXING PROGRAMME

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	458	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 1.2

TOTAL POSTINGS FOR DIFFERENT TIME ALLOWANCES DURING FINAL SUB-PROGRAMME

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.

Time in minutes	U.D.C.		ALPHA.		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 1.3

AVERAGE POSTINGS PER DOCUMENT FOR REPORTS AND JOURNAL ARTICLES

	U.D.C.	ALPHA.	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 1.4

AVERAGE POSTINGS BY SERIES AND JOURNALS

CHAPTER 2

MAIN TEST PROGRAMME

The basic requirement for the test programme was to have a method which would enable an assessment to be made of the effects of the variables which had been built in to the indexing. Each group of 100 documents had some unique characteristics, and ideally it was desirable that it should be possible to evaluate the performance of each such group. In practice it was considered that, since the original main objective of the investigation was to compare the efficiency of the four systems under test, it would be reasonable to concentrate most of the testing on the final sub-programme of 6,000 documents, since it might be expected that these would have been indexed more efficiently than the 12,000 documents in the two earlier sub-programmes, due to the greater experience of the indexers in using the descriptor languages.

The only previously known work in this field of testing retrieval systems was an investigation known as the ASTIA-Uniterm test, which was made in 1953. Unfortunately this work was never fully written up, and the only generally available account is that given by D. Gull (Ref. 2). This is mainly concerned with analysing the results, but from this paper it can be gathered that some 15,000 documents were indexed by two separate teams, one being the indexing staff of the Armed Services Technical Information Agency while the other team were indexers of the staff of Documentation, Inc. The former group used alphabetical subject headings taken from the authority list established by ASTIA, while the latter group used the uniterm system, the commercial exploitation of which was at that time an important part of the work of Documentation, Inc. Having different groups of indexers, with no comparable controls of how the indexing was being done or how long was being spent on the work, the test could not do more than assess the relative merits of two dissimilar indexes, where the only connection was that the indexers covered the same group of documents. It was therefore possible for the test programme to be relatively simple. A number of questions, reputed to be 93, which had been sent to ASTIA in the normal course of their activities, were selected and both organisations carried out searches in the indexes which they had compiled. It would appear that when the searches were completed, each organisation then looked at the documents which had been retrieved and decided on those which were relevant to each particular question. The two groups then met to compare results. Immediately they came up against the problem of deciding what was relevant and found that they were quite unable to agree on this point. Each group had its own interpretation of the question and therefore its own views as to the relevance of the documents. It appears that after some lengthy discussion, the decision was taken that each group should compare the retrieved documents and make its own analysis. The report prepared by Documentation, Inc., as discussed in the paper by Gull, would appear to indicate that the uniterm system was more successful than the alphabetical indexing of ASTIA. It also seems that the ASTIA group, as a result of their analysis, were of the opinion that the position was the reverse.

In considering the results of this test, it can be seen that even if it had been successful, in the sense that the two groups were able to produce a single joint report, the value of the work would have been limited to showing merely that the index compiled by Documentation, Inc. was superior to the index compiled by the ASTIA staff or vice versa. There having been no controls on the method of indexing or the method of searching, any such results would have had doubtful practical significance. It was the intention of the present investigation to produce some results that had more validity, which was the reason for the controls which were built in to the indexing part of the programme. However, it was the failure of the two groups to produce any kind of joint result which strongly influenced the decision on the main method of testing the four indexes which were compiled. It was quite obvious that, whatever other weaknesses the test might have, it was essential that it should not get bogged down in the quagmire of arguments concerning relevancy. Further test programmes could be used to clear up those points which the basic method of testing failed to answer satisfactorily.

In such an investigation as this, an important requirement is that the results which are obtained should be capable of being shown as being statistically valid. This matter is discussed in more detail in the next chapter, but it was considered that it might be necessary to use as many as 1,600 questions. Since searches were to be made in each of the indexes with all questions, it would have been an exceedingly large and difficult task to attempt to evaluate the relevancy of every document that might be retrieved in this multiplicity of searches. The simplest and most practical method of deciding this question of the relevant document appeared to be by using questions which were based on documents that were in the collection. Thus it would always be known that there was at least one document which would be relevant to each question. Using this technique, it was also possible to control the compilation of questions in such a way that the documents on which they are based (now known as the source documents) were distributed throughout the collection in the required manner. Since, as mentioned previously, the testing was to concentrate on the final sub-programme of 6,000 documents, it was necessary to have 75% of the questions based on these documents with the remaining questions spread over the documents in the first two sub-programmes. The 75% of the questions based on documents in the last sub-programme had to be evenly distributed over the sixty groups of 100 documents which made up this sub-programme, so that it would be possible to find the results of different persons doing the indexing at varying time allowances, as well as the effect of different types of documents and of the other controls which had been built in to the indexing.

It will be recollected from the report of the First Stage that a number of individuals and organisations were invited to take part in the investigation by indexing documents. At the same time their assistance was also requested in compiling questions. The procedure for obtaining these questions was that, to each organisation or individual who had expressed a willingness to help, a collection of twenty sheets was sent. On each sheet was listed a minimum of twenty references. These references represented a selection of documents which was taken from a complete group of 100 documents. In Appendix 2A is given a sample group of 100 documents, the relevant sheet of selected documents which were to be used for the compilation of questions and examples of the resulting questions. A copy of the letter sent to those compiling questions, who were mainly scientists or engineers, is also included in this appendix. As will be seen from this letter, they were required to select a single document from each of the twenty sheets which had been sent to them. They then consulted the resulting documents and framed twenty questions, each of which could be satisfactorily answered by one of the selected documents. Therefore for each question which was to be used in the testing there was at least one document, i.e. the source document, which it was known would have provided, in the opinion of the compiler of the question, a satisfactory answer to that particular question. Sixty lists of references were prepared to cover the final sub-programme of 6,000 documents and a further twenty lists to cover the documents in the first two sub-programmes. Different sets of lists were sent to each person so that the questions ranged over the total collection in the desired way.

Altogether some 1,500 questions were received. Although this was slightly less than the number originally thought necessary, no immediate steps were taken to increase the number, since it was known that there would be no difficulty in obtaining further questions if the need should arise. As will be discussed later it was found that the requirements were satisfactorily met by using only 1,200 questions. There were cases where the same document had been selected by more than one person, with the result that there were two or more questions which were based on the same document. It was interesting to note the variety of questions which a single document could generate, and there was no strong reason against using a question simply because the source document was also the source document for a question previously used. However, in some cases there was a strong similarity between questions which had been based on the same document, and in this case not more than one of these questions was used.

Some form of comparable results were required at the earliest possible stage and therefore the first round of testing was limited to 400 questions. 300 of these questions were spread over the earlier sub-programmes. This meant that in each group of 100 documents there would be five source documents to answer the five questions covering that particular group. The questions for this round of testing were selected so that half of the questions covered the subject field of aerodynamics while the remainder were on other subjects. An attempt was also made to see that there was a reasonable agreement between the number of source documents which were reports and those which were periodical articles.

Before the questions were used for searching, they were submitted to a panel of three persons, Mr. T. Aitchison of English Electric Aviation Ltd., Mr. J. Rosser of Hawker Siddeley Nuclear Power Group and Mr. R. Wall of A. V. Roe & Co. Ltd., Guided Weapons Division. These gentlemen, all of whom had had several years experience in aeronautical information work, were asked to consider the questions from the viewpoint of whether they were reasonable, that is of a type which they might expect to have put to them in the course of their normal duties. As a result of their scrutiny, only one question was rejected on the grounds that it was a question which could have been more reasonably answered by consulting a scientific dictionary.

The intention was to carry out searches with these questions in all the indexes. Search would be carried on to the stage where the source document was retrieved or alternatively the searcher was unable to devise any further reasonable search programmes. Apart from the variables which were included in the indexing, it was also desired to investigate the ability of different persons as searchers. However, for the first round of testing only staff who had been working on the project were used, namely Miss Warburton, a full time member of the project staff, Mr. J. Hadlow, who had been an indexer on the project but had at the completion of the indexing stage of the work, joined the College of Aeronautics Library and C. W. Cleverdon, the Director of the project. Full records had to be kept of all the searches and for this purpose master search cards were printed. These were in four different colours, one colour for each system being tested. The 400 questions were entered on each pack of search cards so that with four search cards for each question there was a total of 1,600 search cards for all four systems (see Figs. 1 and 2). For convenience, each question was given a code number, and in addition on each search card was entered the project code reference of the source document on which the question had been based.

At this stage there was no idea of what the results were likely to be or how this technique of testing would work. It was, in fact, originally envisaged that this first round of testing might be considered as purely experimental, so that the more suitable methods could be developed. A matter of concern was whether memory would come into the searching. Hadlow and Cleverdon, in this round of testing, each did 400 searches, so by making 100 searches in each system it was possible to avoid searching for any question more than once. Miss Warburton did a total of 800 searches, 200 by each system, so the result of this was that she searched for all the questions in two different catalogues. The work was spread out so that there was at least a month between the same question being used for a second time, and we were satisfied that the results were not affected.

The search procedure varied slightly with each system but the endeavour was always as far as possible to simulate a real life situation. This was taken to be as in a normal information service where an enquirer comes in with a request for certain information. Based on this request, the librarian will formulate a search programme by deciding on the concepts and translating these into the terminology of the index.*

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* The matter of formulation of search programmes is considered in more detail in Chapter 5. The approximation given here is sufficient for the present argument.

Irrespective of the descriptor language and irrespective of whether it is being used with a card catalogue, with peek-a-boo cards or any other physical form, this action is essential, and the resulting search will bring about one of three situations:-

(a) No references are retrieved which are of value to the enquirer

(b) The search is partially successful, in that at least one of the references retrieved is to a document which partially meets the needs of the enquirer

(c) A sufficient number of references (which may be one or more depending on the type and purpose of the question) are retrieved to meet fully the needs of the enquirer.

If (c), the search has been successful; if either of the first two situations result, a second search programme must be formulated and a further search made. This again will result in one of the three situations outlined above and if necessary further searches are made until either the position is reached where:-

(i) the search is successful and the enquirer is satisfied

(ii) no further search programmes can be devised

(iii) the librarian and/or the enquirer lose their patience.

Basically the same procedure would be followed if the enquiry came by telephone or letter, or if the enquirer carried out his own search in the indexes. The only difference in the latter case is that one person would carry out both roles outlined above.

It is true that, in a real life situation, there tends to be with difficult questions a further elucidation of the question by the enquirer, thus helping the librarian in devising further useful search programmes. Alternatively, experience shows that in finding some references of slight relevance, the enquirer is able to re-phrase his question in a more precise manner and also thus help in the search. In the project this was not the situation, for the question as submitted was all that was available and there was no possibility of the project staff going back to the enquirer to find whether he could clear up any doubtful points or give a useful lead.

Apart from this latter point, which was to the disadvantage of the project group, the attempt was made to simulate a real life situation as far as possible. The basic procedure was to consider the question and devise a search programme. This was then entered on to the master card. The appropriate index would be searched and the cards bearing the particular notation or subject headings as recorded would be consulted. If a card bearing the project code number of the source document was there, then the search was considered successful and would be entered as such, with the record of the number of other references which bore the same heading as the source document. If the search did not reveal the reference to the source document, a note was made of the number of references which were at that heading and a further search programme was then devised. The process was repeated as outlined, with records being made of the search programme and the result. This continued until finally the question could be marked as a success, stating the total number of search programmes required, or as a failure.

It might appear at first sight that this was a somewhat doubtful method of carrying out a search, in particular with regard to the fact that there was a certain card in the catalogue which could always be immediately recognised as being the required reference. To return to a real life situation, when the first search has been made, the enquirer will look at the resulting references, and form a judgement as to whether any are likely to be of value to him. This judgement will be based on a number of factors which the index card can reveal such as the name of the author, the originating organisation, the title and date of the paper and possibly the abstract. Normally the enquirer would reject some of the references and decide that other references were sufficiently interesting to justify his asking to see the actual documents. On obtaining the documents, the enquirer will then carry out a further search through these documents to find whether the required information is contained in any one or more of them. This will result in one of the three situations, (a), (b) or (c) as given above and the decision is taken either to call off the search as being successful or to make further searches. If the latter, the procedure is repeated with a new search programme, and so on until situations (i), (ii), (iii) are reached. Our method of doing the searches short-circuited this procedure, which would have been quite impracticable to carry out, and an immediate decision as to whether the search had been "successful" could be made by looking at the project number of the references retrieved.* It must be emphasised however that although it was known to the searcher

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* This claim that a search could be considered "successful" by finding a single relevant document would appear to presuppose that the enquirer does not require <u>all</u> available information on a subject. This aspect is considered in Chapter 6 .

that a card which bore a number such as P16327 was the card which had to be located, nothing was known about where in the catalogue this card might be found.

As had been expected, difficulties soon arose in this first round of testing but it was completed so that the necessary experience could be obtained. Certain minor problems were satisfactorily solved but two major difficulties remained. In the first place it was necessary to decide exactly what constituted a single search and what changes in the search programme meant a new search; secondly there was the decision to be taken as to how long one was justified in continuing a search. This latter problem was particularly difficult because, in that it was known that there must be a satisfactory answer somewhere in the index, it would have been possible for the searches to be broadened until every card in the index had been seen. This was not being done, but it was essential that the search procedure should be levelled as between the differing systems and between the different searches.

Two new rules were therefore devised to cover the second round of testing. For the first, a search programme was defined as being any permutation of a given set of elements, and a new search would be when any element was omitted from the original search programme or when one or more elements were changed.* Regarding the second point, it was decided that a search would not be continued beyond the stage where more than one of the basic elements that were originally considered necessary had been dropped. These two rules, while forming a basis for the later testing, could not be applied without descrimination to all four systems and can probably best be explained by giving examples of the method of application as shown by some actual test workings. Figure 1 shows the search cards in connection with question 25-07 "Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading". With the Universal Decimal Classification, the search programme was devised as being 669.715 (Aluminium alloys) and 620.178.3 (Fatigue testing). The original search was made in the catalogue at 669.715:620.178.3 and was unsuccessful in that the source document was not found, although there were twelve other references having this notation. The second search was made with the figures reversed round the colon, that is to say 620.178.3:669.715, and in this case the reference to the source document was located in addition to 31 other references. It is recorded on the search card that the full notation of the source document was 669.715:620.178.3:621.884.057.2. This second search was not, under the new rule, considered as being a new search, for the same notational elements were being used. Therefore the result is given as a success on the first

* See Appendix 2B

search, penalised to a certain extent by the fact that it was necessary to do an extra sub-search and also recorded that 43 documents were retrieved. With the alphabetical subject catalogue, the first search programme here was given as "Sheets, aluminium alloy - fatigue". This proved unsuccessful, as did the second search under "Sheets, aluminium" and the third, fourth and fifth searches. Finally for the sixth search the programme was devised as "Joints, riveted, aluminium alloy - fatigue" and in this case it proved successful. Altogether there were six searches which resulted in the retrieval of 34 other documents before the source document was retrieved. Since with each of the search programmes either new terms had been introduced or had been dropped, each search programme was counted as a new search.

With the facet system, the original search programme asked for four elements, namely Peal-a "Aluminium alloys", Rkm "Fatigue", Hvd "Rivets, Fsb "Sheets". It is shown that the first search was made in the chain index under the latest element in the notation, namely "Fatigue". The index showed that the classified catalogue did have a reference with the four notational elements requested but on looking in the classified catalogue, there was found only one reference which was not to the source document. A second search was made, this time it being decided that the first three elements could be accepted without requiring anything concerning Fsb "Sheets". Here again the chain index directed the searcher to one place in the classified catalogue and there the source document was found together with one other document. The actual location of this required reference was at Hu Hvd Peal-a Rkm Rp Vi.

With the uniterm system, the first element searched was "Aluminium". Here the source document reference number was found and the search then went to the card for "Sheets". This term had not been indexed so the search was switched to "Riveted". This being successful the next card looked for was "Alclad", this was a failure and so the search went on to "Fatigue" which was successful, then to "Strength" which was also successful. The searcher felt that we would be better if it was possible to have found something for "Plates". This could not be found but the search was adjudged as being successful, in that there had been obtained a reference covering "Fatigue strength of aluminium". The search was therefore marked as taking three separate searches in that there were two failures to find required entries during the search up to the time a satisfactory result was reached.

Comparison of document numbers on the aspect cards showed that eight references were retrieved in the course of these searches.

Figure 2 shows the search cards in connection with question 28-07, "Theoretical calculation of the performance of half-delta wing-tip controls on the tips of delta wings". The programme devised for U.D.C. was 533.693.31 "Delta wings" and 533.694.5 "Control surfaces". It is interesting to note in this case however, that the searcher agreed from the start that she would accept any further breakdown of 533.694.5. By this she gave herself more flexibility in the search but there was the probable penalty of retrieving more irrelevant documents than if she had been able to specify the search more precisely. In the event, searching under 533.693.31:533.694.5 the card for the source document was found with 25 other cards, the actual place for the source reference being 533.693.31:533.694.512 "Moving wing tip ailerons". With the alphabetical subject catalogue, the first search programme was for "Wing tips, moving"; although 14 cards were found at this heading, none of them related to the source document so further series of programmes were devised. First there was "Wings, delta - control", followed by "Wings, delta, supersonic - control", and then "Wings, delta, transonic - control". These proved unsuccessful so a further search was made under these headings with the sub-heading "Performance". The search was still unsuccessful and was at this stage abandoned.

The facet search was devised as Id "Tips", Cd(Ij) "Wings, delta" and Cp "Control surfaces". The first search was made in the chain index under "Tips", and led directly to the source document which was at this particular place with the addition of four other references. Finally, with uniterm, the first two searches for "Wings" and "Delta" were successful; "Tips" was a failure but then an entry was found under "Control". In an attempt to refine it rather more a search was made under "Performance" but there was no reference on this card. The search was considered successful, it having taken two separate programmes to reach the required stage. In addition to the source document, five other references were also found.

To go back to the two basic rules, it will be seen that it was necessary to interpret them somewhat freely. For instance, a single U.D.C. number may well be the equivalent of two or more uniterms. For this reason it was necessary to check the results between different systems to ensure that no one system had been penalised by too strict an interpretation of the basic rule. In this respect, it quickly became obvious that the alphabetical subject catalogue was usually the yardstick. For instance, the person searching the uniterm index for the second question considered above, originally felt doubtful as to whether it was reasonable to mark the uniterm search as being successful when it was only possible to find "Wings", "Delta" and "Control". However on comparing the card with that of the alphabetical catalogue search, it was clear that it would have been accepted as a legitimate subject heading. This comparison of markings between one system and the other had to be carefully checked throughout and it made a difference to the results which were given in the original report on this first round of testing at the annual conference of Aslib (Ref. 3).

Regarding the question of the number of searches, while the decision appeared satisfactory concerning the U.D.C., alphabetical and uniterm systems, it raised some doubts in the matter of the facet system. This was due to the double nature of the search in either the classified catalogue or the chain index. A situation which frequently arises is with a question which generates a search programme such as Ncd "Laminar flow", Nfk "Boundary layer" and Ocd "Suction", the question itself being, "The calculation of the laminar boundary layer having distributed suction". It would have been possible to have added the further terms to the programme of Ya "Calculation" or (Zf) "Distribution", and it was doubtless a deliberate policy not to do this, for "Calculation", if sought in the chain index, would have involved searching through a file of approximately 1,200 cards, and it is a term that might well not have been indexed as being redundant. To a lesser extent, the same reasoning applied to "Distribution", for in this case one would have had to search through a file of approximately 400 cards. The term "Suction" was therefore taken as the entry to the chain index and in this case there were 97 cards to search. However of these there were 9 cards which included the three sought terms, these being:-

Suction: Boundary layer: Laminar flow	Ncd Nfk Okb
S.: B.L.: L.F.: Clyinders	Fq Ncd Nfk Okb
S.: B.L.: L.F.: Discs	Fqd Ncd Nfk Okb
S.: B.L.: L.F.: Flat: Plates	Ffe(Is)Ncd Nfk Okb
S.: B.L.: L.F.: Slots: Aerofoils	Cc Ct Ncd Nfk Okb
S.: Control: B.L.: L.F.: Flat: Plates	Ffe(Is)Ncd Nfk Oa Okb
S.: Distribution: Velocity: B.L.: L.F.: Flat: Plates	Ffe(Is)Ni(Zf)Okb
S.: Profile Drag: B.L.: Incompressible Flow: L.F.	Ncd Nfh Nfk Nrb Okb
S.: Skin Friction Drag: B.L.: L.F.	Ncd Nfk Nrf Okb
S.: Skin Friction Drag: B.L.: L.F.: Flat: Plates	Ffe(Is)Ncd Nfk Nrf Okb

In this particular search, the correct programme was found and, by searching under "Suction", there was the clue of "Distribution" because in the seventh entry it happened to have been brought in to qualify "Velocity" which notationally is earlier than "Suction". To have searched under "Distribution" in the chain index would have revealed a number of entries which included "Laminar flow", "Boundary layer" and Suction", but which would not have in fact revealed the source document.

Another similar situation did not work out so well. The question was "Velocity profile, heat transfer and skin friction data for turbulent boundary layers". Entering the chain index at "Heat transfer" there were over 200 cards to be searched. One card contained the four required elements in combination on their own but there were 14 other cards where the elements were combined with other terms to form such combinations as

Fm Nbm Ncf Nfk Nrf Nvf Oi St
Fu Nbm Ncf Nfk Ngc Nvf Oi St
Nbm Ncf Nfk Nrf Oi St

This involved 15 different places which had to be looked at in the classified index and in the event the source document was not retrieved. The second search programme substituted Nrf "Skin friction" for St "Heat transfer". From the chain index on this occasion ten possible locations were found, and under Fm Nbm Ncf Nfk Nrf, the required reference was found on the seventh of these sub-searches. At first it appeared somewhat difficult to justify marking this question as being successful with only two searches, seeing that it had been necessary to sort through over 300 cards in the chain index and to look at 22 different places in the classified catalogue. However to have done anything but this would have been to extend the range of our work into the physical form of the index. If facet had been used as a post-co-ordinate system,* then it would only in fact have required two

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* The term 'post-co-ordinate' is used in contrast to 'pre-co-ordinate'. Certain descriptor languages have become known as forms of co-ordinate indexing, but in fact all but the simplest descriptor languages 'co-ordinate'. The difference is that some do the co-ordination at the time of indexing, e.g. an alphabetical subject heading such as WINGS, DELTA, SUPERSONIC - Stability, longitudinal, or the equivalent U.D.C. number of 533.693.1.011.5:533.6.013.412. Others do it at the time of searching, e.g. Uniterm, where the separate elements "WINGS", "DELTA", "SUPERSONIC", "STABILITY", "LONGITUDINAL" would be co-ordinated. While some descriptor languages may be more convenient to use in one way than the other, yet all can, in fact, be used in a pre-co-ordinate or post-co-ordinate manner. The facet schedules as used in the project test were particular adaptable to either method.

search programmes to find the necessary reference.

Using these new rules, a second round of testing was carried out, again with 400 searches being made in each system. In this round the searching was carried out by the same three people as in the first round of testing with the addition of Miss A. Scott, an assistant in the College of Aeronautics Library, who had not taken any active part in the work of the project. In addition, five post-graduate students of the College spent an average of six weeks each in doing searches. The questions which they used were the same as those which had been used by the project staff in the first and second rounds of testing, and the main purpose of having such persons doing the searching was to discover whether any particular system was more or was less satisfactory when used by persons who were skilled in the subject content of the documents indexed but who had little practical experience of searching for information.

The second round of testing by the project staff proceeded quite satisfactorily and calls for no particular comment.

A minimum amount of guidance was given to the students, and consisted of merely explaining the rules of operation, what was required of them in keeping records and showing them the various catalogues and ancillary aids. While they all had a certain amount of experience in retrieving information for their own purposes prior to this test, none of them could, at the start of the test, be considered to have any special experience or qualifications which would make them unrepresentative of the normal scientist or engineer using an index.

At the conclusion of the second round the results of the searches were tabulated, and from the overall picture of the way the work was going, it appeared unlikely that more than one further round of testing would be required. Before this was done, a very detailed analysis was made of all searches which ended in failure to find the source document. This matter is discussed in detail in Chapter 5, but is mentioned here to explain the change in procedure which was adopted for the third round of testing.

As discussed earlier, the test was intended to discover something concerning the ability of various people to carry out searches. By the time that the second round of testing was completed, it was considered that reliable information had been obtained and that it was not necessary to investigate this particular matter any further. However, the analysis of the failures had shown that there were many cases where the search had been successful in one system but had failed in another system. In such cases the reason for the failure had nothing to do with the system or the indexing but was entirely due to the fact that the person making the search in that system had not found the correct search programme, which had been used by the searcher in another system.

Also, even when searches had been successful, it appeared often a matter of chance whether the correct programme was used on the first or fifth searches.

The third round of searching, which again consisted of 400 questions in all systems, was therefore done in such a way as to eliminate as far as possible the variable of searching. To do this, Miss Warburton first searched for all questions in the alphabetical subject catalogue, keeping the usual records. The searches were then repeated in the U.D.C. catalogue using the same programmes in the same order as with alphabetical. That is to say that if, for instance, with alphabetical, the first three search programmes had proved unsuccessful, but the document had been found on the fourth search, then the searches by U.D.C. had to go through the same stages in so far as this was practical with the terminology and structure of the different descriptor languages. On the other hand, when a source document was located in the alphabetical subject catalogue by the first search programme, there would be no necessity for further possible search programmes to be generated. If in the search in the U.D.C. this single search programme failed, then further search programmes were tried, and these formed the basis when the searches were repeated in facet and later in the uniterm system.

Mrs. J. Aitchison worked on these subsequent searches and in some cases was able to generate further search programmes in cases where Miss Warburton had failed. In such cases these new programmes would be tried with all systems, so that in the end all systems had been equally treated in regard to search programmes.

CHAPTER 3

TEST RESULTS

While there are many reasons which may (and no doubt will) be adduced for doubting the validity of the results given in this chapter, it is certain that the figures can only be considered statistically correct within a range which varies according to the number of searches on which they are based. In comparison with some other investigations which have been reported, the test programme has been large, and this enables the standard error to be correspondingly lower.

The basic equation which is used to ascertain the standard error is given as:

$$\sigma_p = \sqrt{\frac{PQ}{N}}$$

in which P equals the probability of success, Q equals 100 - P and N equals the size of the sample. For the overall results, (e.g. Table 1) the standard error comes out at around 2.5%, and this probably is a reasonable figure at which to aim. However, as soon as one breaks down into the various groupings, such as the indexer or the indexing time, there are a number of complications. The figures assume pure binomial variability; if this is not to be accepted as reasonable, it is doubtful if the figure for the standard error can be significantly reduced without a large increase in the test programme. However, with all the tables given in this section, what is believed to be the correct standard error is shown for the actual situation in which the tables have been compiled.

A more detailed statistical analysis of the validity of the test results was made by Mr. J. T. Harris, Lecturer in Mathematical Economics at the College of Aeronautics and is included as Appendix 3A.

	Total Searches	Success	Failure	% Success
U.D.C.	1157	875	282	75.6
ALPHA	1154	941	213	81.5
FACET	1047	773	274	73.8
UNITERM	1146	940	206	82.0

TABLE 3.1

COMBINED RESULTS OF ALL SEARCHES
BY PROJECT STAFF (s.e. 2.6% approx.)

U.D.C.	82% (179)	80% (173)	74% (180)	77% (174)	72% (176)
ALPHA	89% (179)	85% (173)	77% (180)	85% (174)	73% (176)
FACET	76% (179)	79% (173)	71% (180)	71% (174)	71% (176)
UNITERM	89% (179)	85% (173)	83% (180)	88% (173)	75% (176)

TABLE 3.2

RETRIEVAL FOR VARIOUS INDEXING TIMES FOR SEARCHES
BY PROJECT STAFF IN FINAL SUB-PROGRAMME
(DOCUMENTS 12001 - 18000) (s.e. 5% - 6%)

(Figures in brackets indicate number of searches on which percentage figure is based)

	Hadlow	Warburton	Sharp
U.D.C.	73.8	81.0	76.9
ALPHA	79.6	85.4	82.7
FACET	71.4	77.9	71.1
UNITERM	84.0	83.0	86.0

TABLE 3.3

PERCENTAGE RETRIEVAL ACCORDING TO INDEXER FOR SEARCHES BY PROJECT STAFF IN FINAL SUB-PROGRAMME (s.e. 4% approx.)

	Aerodynamics	General
U.D.C.	72.7	78.6
ALPHA	78.9	84.2
FACET	70.3	77.3
UNITERM	81.6	82.2

TABLE 3.4

PERCENTAGE RETRIEVAL ACCORDING TO SUBJECT FOR SEARCHES BY PROJECT STAFF IN FINAL SUB-PROGRAMME (s.e. 3.5% approx.)

	1 - 6000	6001 - 12000	12001 - 18000
U.D.C.	63.9	74.2	77.2
ALPHA	74.7	80.3	82.5
FACET	-	74.5	73.7
UNITERM	69.9	76.6	86.4

TABLE 3.5

PERCENTAGE RETRIEVAL ACCORDING TO INDEXING SUB-PROGRAMME FOR SEARCHES BY COLLEGE STAFF (s.e. 3% - 8%)

	1st Round	2nd Round	3rd Round
U.D.C.	78.2	74.2	76.1
ALPHA	81.7	78.4	84.5
FACET	72.7	69.3	79.3
UNITERM	77.6	80.9	87.3

TABLE 3.6

PERCENTAGE RETRIEVAL FOR SEARCHES BY PROJECT STAFF IN THE THREE ROUNDS OF TESTING (s.e. 5% approx.)

	Warburton	Hadlow	Cleverdon
U.D.C.	77.2	75.5	76.3
ALPHA	80.1	83.8	76.9
FACET	73.9	71.4	70.1
UNITERM	83.2	78.5	82.4

TABLE 3.7

PERCENTAGE RETRIEVAL BY SEARCHING FOR PROJECT STAFF IN FIRST TWO ROUNDS OF TESTING (s.e. 4% - 6%)

	Success	Failure	% Success
U.D.C.	520	132	79.6
ALPHA	501	183	73.3
FACET	335	167	66.7
UNITERM	297	619	81.1

TABLE 3.8

RESULTS OF ALL SEARCHES BY TECHNICAL STAFF (s.e.3.2% - 4.1%)

	16 mins	12 mins	8 mins	4 mins	2 mins
U.D.C.	84	86	78	78	76
ALPHA	81	78	74	76	63
FACET	62	73	66	55	70
UNITERM	85	83	73	87	85

TABLE 3.9

PERCENTAGE RETRIEVAL FOR VARIOUS INDEXING TIMES FOR SEARCHES BY TECHNICAL STAFF IN FINAL SUB-PROGRAMME (s.e. 6.2% - 11.6%)

	Hadlow	Warburton	Sharp
U.D.C.	81	77	83
ALPHA	76	70	78
FACET	63	69	64
UNITERM	78	85	82

TABLE 3.10

PERCENTAGE RETRIEVAL FOR INDEXERS FOR SEARCHES BY TECHNICAL STAFF IN FINAL SUB-PROGRAMME (s.e. 5.1% - 9%)

	Aeronautical	General
U.D.C.	77	82
ALPHA	72	74
FACET	62	72
UNITERM	81	81

TABLE 3.11

PERCENTAGE RETRIEVAL ACCORDING TO SUBJECT FOR ALL SEARCHES BY TECHNICAL STAFF (s.e. 4.3% - 5.4%)

CHAPTER 4

STATISTICAL ANALYSIS

In addition to the results as given in tables in Chapter 3, there is the possibility of doing a considerable amount of detailed analysis, aimed at finding the effect of various factors. The difficulty in doing this lies in pre-assessing what is likely to be significant, and the danger is that effort will be wasted in carrying such analysis to unnecessary and useless limits. The result is that in this chapter certain matters will be considered, but any conclusions will be based on a varying amount of analysis. Where something of interest appears, to ensure that the results are valid more analysis has been done than in those cases which appear to be producing negative results.

First is considered the question of language and this is done in a simple way by comparing the correlation between the words of the questions and the titles of the documents. Appendix 4A lists 100 questions numbered 20-06 to 20-10 through to 39-06 to 39-10. Appendix 4B lists 100 documents on which these questions are based and which are therefore the objects of the searches. The titles and questions have been compared and the correlation figure varying from 0 to 10 has been given for each question. This has been done by marking with 10 any question where all the key words in the question were found in the title and grading down to 0 where there was no correlation. Table 4.1 shows the 100 questions sorted and grouped into correlation order, with the search results for the four systems.

Correlation Figure	Question Number	SEARCH RESULT UDC	ALPHA.	FACET	UNITERM
0	21-10	f	f	f	f
	29-09	f	f	f	f
	30-06	f	f	f	f
	30-09	s	s	s	s
	30-10	s	s	s	f
	35-06	s 3-3	s 3-3	s 3-3	s 2-4
1	20-09	s	s	s	s
	23-07	f	s	s	f
	26-07	f	s	f	s
	33-10	s 2-2	s 4-0	s 3-1	s 3-1
2	20-06	s	f	s	s
	22-06	s	s	s	s
	22-07	s	s	s	s
	22-10	s	s	s	s
	26-09	s	s	s	s
	26-10	f	s	s	s
	33-09	s	s	f	s
	39-07	f 6-2	f 6-2	f 6-2	s 8-0
3	21-08	s	f	s	s
	23-08	s	s	s	s
	24-10	s	s	s	s
	27-10	f	s	f	s
	29-07	s	f	f	s
	30-07	f	f	f	s
	31-09	f	f	s	f
	32-09	s	s	s	f
	32-10	s	s	s	f
	35-08	s	s	f	s
	36-06	f	s	s	s
	37-08	s	s	f	s
	38-09	s 9-4	s 9-4	s 8-5	s 10-3
4	21-06	s	s	s	s
	21-07	f	s	s	s
	21-09	f	s	f	s
	22-09	s	s	s	s
	23-09	s	s	s	s
	25-09	f	s	s	s
	25-10	s	s	s	s
	27-06	s	f	s	s
	28-07	f	s	s	s
	21-06	s	s	f	s
	38-06	f	f	f	s
	38-10	s 7-5	s 10-2	s 9-3	s 12-0

TABLE 4.1

RESULTS OF SEARCHES GROUPED ACCORDING TO CORRELATION OF LANGUAGE OF TITLE AND QUESTION

s = successful search
f = failure

Continued.....

Correlation Figure	Question Number	UDC	ALPHA.	FACET	UNITERM
		SEARCH RESULTS			
5	20-07	s	s	s	s
	22-08	s	s	s	s
	25-06	s	s	s	s
	25-07	s	s	s	s
	25-08	f	f	f	s
	28-09	s	s	s	s
	29-06	s	s	s	s
	31-10	f	f	f	s
	32-08	s	s	s	s
	34-08	f	s	s	s
	34-10	s	s	s	s
	36-07	s	f	f	s
	38-08	s	s	s	s
	39-09	s 11-3	s 11-3	s 11-3	s 14-0
6	20-10	s	f	f	s
	23-10	s	f	s	s
	24-06	f	s	s	s
	27-08	f	s	f	s
	28-08	s	s	s	s
	28-10	s	s	s	s
	33-06	s	s	s	s
	34-07	s	s	f	s
	34-09	s	s	f	s
	35-07	s	s	s	s
	35-09	f	s	s	s
	36-09	s	s	s	s
	39-06	s	f	f	f
	39-10	f 10-4	s 11-3	s 9-5	s 13-1
7	24-07	s	s	s	s
	24-08	s	s	s	s
	24-09	s	f	f	s
	26-08	s	f	f	f
	27-07	s	f	f	s
	32-07	s	s	s	s
	33-08	s	s	s	s
	34-06	s	s	s	f
	35-10	f	s	f	s
	36-08	s	s	s	s
	36-10	s	s	s	s
	38-07	s	s	s	s
	39-08	s 12-1	f 9-4	s 9-4	s 11-2

TABLE 4.1 (Continued)

Correlation Figure	Question Number	SEARCH RESULT UDC	ALPHA.	FACET	UNITERM
8	20-08	s	f	f	s
	26-06	s	f	s	f
	28-06	s	s	s	s
	29-10	s	s	s	s
	33-07	s	s	f	s
	37-06	s	s	s	s
	37-09	s	s	s	s
	37-10	f 7-1	s 6-2	s 6-2	s 7-1
10	23-06	s	s	s	s
	27-09	s	s	s	s
	29-08	f	s	s	f
	30-08	s	s	f	f
	31-06	s	f	s	f
	31-07	s	s	f	s
	31-08	f	s	f	s
	37-07	s 6-2	s 7-1	s 5-3	s 5-3

TABLE 4.1 (Continued)

This type of analysis was extended to cover a total of 600 searches, and Table 4.2 gives the percentage success rate for each correlation figure together with the accumulated total.

Correlation	UDC	ALPHA.	FACET	UNITERM
0	48 (48)	45 (45)	52 (52)	44 (44)
1	60 (53)	74 (53)	65 (58)	70 (52)
2	72 (60)	70 (58)	63 (59)	85 (63)
3	69 (64)	73 (63)	74 (62)	79 (65)
4	66 (65)	84 (69)	67 (63)	89 (72)
5	77 (68)	74 (70)	71 (65)	83 (74)
6	72 (67)	79 (72)	68 (65)	91 (77)
7	88 (72)	85 (74)	75 (67)	92 (80)
8	84 (74)	90 (77)	80 (70)	87 (82)
9	81 (76)	89 (79)	78 (72)	90 (84)
10	82 (77)	92 (82)	77 (73)	89 (86)

TABLE 4.2

PERCENTAGE SUCCESS RATE FOR SEARCHES WITH VARYING DEGREES OF CORRELATION BETWEEN TITLE AND QUESTION

(Figures in brackets represent accumulated percentage figure)

Leading on from this, a test was made independently, of the retrieval figure which would be obtained by using a form of key-word-in-context title indexing, but as will be appreciated this in effect duplicated the work of the term correlation test, for it was found that 97% of the source documents could be retrieved by this technique. This figure corresponds with the 3% of source documents not located when there was zero correlation, and also corresponds to the figure of 3% of the questions which (as considered in Chapter 5) were considered to be misleading or bad. Not quite so explicable is that whereas the maximum recall efficiency by any single system was 85%, yet by one system or another the source document was obtained in 97 out of every 100 cases. The fact that 97% retrieval was obtained by KWIC indexing is not so much an argument in favour of this technique as an interesting commentary on the effectiveness of the titles of the reports and papers used in the project. To achieve the figure of 97% would have been equally possible by Uniterm if the search rules had been relaxed in such a way as to accept as a success any search where a single correlating term was found. The penalty in this case, as with KWIC indexing, would have been the increased number of irrelevant documents that were also retrieved. This aspect is considered in more detail in Chapters 9 and 10.

It can be argued that some questions were too easy or obvious, and that a more realistic result might be given by eliminating such questions from the analysis. It is difficult to decide exactly which question is easy, but an arbitrary choice would be to consider as such all questions where the source document was retrieved by the four systems. This was done for 300 searches and Tables 4.3. and 4.4. show the general figures and the figures when broken down by indexing times.

UDC	54%
ALPHA.	58%
FACET	43%
UNITERM	63%

TABLE 4.3

PERCENTAGE RETRIEVAL EFFICIENCY FOR SEARCHES BY PROJECT STAFF AFTER ELIMINATING QUESTIONS WHERE SOURCE DOCUMENTS WERE RETRIEVED BY ALL SYSTEMS

	16 mins	12 mins	8 mins	4 mins	2 mins
UDC	49	60	54	58	54
ALPHA.	66	67	58	67	52
FACET	38	52	39	44	46
UNITERM	70	69	62	76	45

TABLE 4.4

PERCENTAGE RETRIEVAL EFFICIENCY BY INDEXING TIMES FOR SEARCHES BY PROJECT STAFF AFTER ELIMINATING QUESTIONS WHERE SOURCE DOCUMENTS WERE RETRIEVED BY ALL SYSTEMS

As would be expected, the figures represent a departure from those in the main test, but it is noteworthy how they repeat the general relationship between the systems and, in particular, the way in which the efficiency of 4-minute indexing time is emphasised.

In the first stage of the work, the indexing decisions were partly controlled by time, and the effect that this had on the number of entries for each document is shown in Table 1.2. (page 4). This variation might be expected to appear in the results when broken down by time (Table 3.2, page 22), but from this it would appear that many of the additional entries made when indexing at 16 minutes were redundant, since there was such a small increase in efficiency of recall. This problem of redundant indexing was considered in the W.R.U. Project (Chapter 7), but a comparison of the effect of number of postings on success or failure is given in Table 4.5.

Appendix 4C gives the results of 100 searches shown against the number of entries made in indexing the source document, and the analysis has been carried to a further 200 searches within this document group. The resulting figures, broken down by indexing time are given in Table 4.5, but would appear to show little of significance.

	minutes	General Average	Search Average Success	Search Average Failure
U.D.C.	16	5.8	6.0	4.3
	12	4.0	4.9	2.9
	8	4.2	4.5	3.8
	4	3.7	4.7	2.8
	2	3.5	3.4	3.8
ALPHA.	16	3.8	4.1	2.7
	12	3.5	3.8	3.1
	8	3.2	3.5	2.7
	4	2.2	2.3	2.0
	2	2.4	2.5	2.2
FACET	16	6.8	6.8	6.8
	12	6.8	6.7	6.9
	8	6.8	6.0	7.7
	4	4.7	4.8	4.3
	2	5.0	5.2	4.3
UNITERM	16	13.0	13.0	13.0
	12	9.2	9.9	7.8
	8	10.6	12.3	7.4
	4	8.5	8.8	7.7
	2	8.5	8.6	8.2

TABLE 4.5

COMPARISON OF AVERAGE POSTINGS BY INDEXING TIMES FOR DOCUMENTS P12001 to P14000 FOR SUCCESSFUL AND FAILED SEARCHES BY PROJECT STAFF

A more interesting set of figures is produced by the analysis of the terms used in indexing source documents and the terms used in searching for these documents. The complete lists of terms in the four systems are given in Appendix 4D, and Table 4.6 shows the comparative count for the use of the terms.

	UDC	ALPHA. Main Headings	ALPHA. Sub-Headings	FACET	UNITERM
Terms used in indexing Total	381	272 -	155	396	582
Indexing and searching	252	141 -	86	240	347
Indexing only	129	131 -	69	156	235
Terms used in searching Total	408	259 -	107	343	458
Indexing and searching	252	141 -	86	240	347
Searching only	156	118 -	21	103	111

TABLE 4.6

USE OF TERMS IN INDEXING 200 SOURCE DOCUMENTS AND MAKING 200 SEARCHES

A general comment on these figures is the high number of non-indexed terms used in searching and particularly that with U.D.C. the total of terms used only in searching is greater than that used only in indexing. It is, however, in the more detailed analysis of the figures presented in Appendix 4D that useful work could be done, although no attempt has been made to exploit this possibility within the present project. As an example, one can consider the matter of redundant terms, of which some are set out in Table 4.7.

	UDC	ALPHA.	FACET	UNITERM
Tests	14-3	59-5	46-4	48-17
Wind tunnel tests		42-1	24-2	
Calculations		62-11	52-1	36-14
Analysis		15-2	10-0	16-0
Design	9-1	18-8	12-3	22-16

TABLE 4.7

POSSIBLY REDUNDANT TERMS SHOWING NUMBER OF TIMES USED IN INDEXING AND SEARCHING

It is practically certain that none of these terms assisted in locating a source document which would otherwise not have been retrieved, and all that these terms could do would be to limit the number of irrelevant documents. An analysis of the point could be made by checking the catalogues, and would probably confirm the view that such terms were, in the context of the work, redundant.

As another example, there was a category of terms (notation 'I') in the Facet schedules covering Spatial Properties. Most of these terms are not available in U.D.C. 6 such terms were used in the indexing of the sample 200 documents, with a total of 65 uses. 20 of these terms were also used in searching on 37 occasions. This shows a slightly lower average use than for the terms throughout the schedules, but is high enough to justify the inclusion of this category. The category General Properties (Z) had 16 terms which were used on 34 occasions in indexing, but only 5 terms were used in searching on 6 occasions, and this category appears of more doubtful value. Analysis of this nature would appear to have possibilities of providing information for the design of systems, and it is hoped that it will form the subject for an independent thesis.

As was discussed in Chapter 2, note was taken of the number of separate programmes which were necessary to retrieve the source document. Appendix 4E shows the results for 100 searches and indicates how many search programmes were involved by each system. This analysis has been extended to cover the 400 searches in the second round of testing, and the results are given in Table 4.8.

No. of searches	UDC	ALPHA	FACET	UNITERM
1	36%	40%	51%	54%
2	39%	33%	36%	25%
3	8%	13%	9%	16%
4	10%	5%	1%	2%
5	6%	4%	1%	3%
6 or more	1%	5%	2%	0

TABLE 4.8

PERCENTAGE OF NUMBER OF SEARCHES REQUIRED IN SECOND ROUND OF TESTING

These cover the second round of testing, when the searches generated their own programmes. In the third round of testing, as has been explained, the search programmes were standard for all systems, so a further check was made of the searches in this round. As will be seen from Table 4.9, this did not show any significant difference, apart from a slight general improvement.

The number of searches which retrieved the source document with the first or second programmes indicates that, with the techniques and levels of indexing used in the project, the formulation of a successful programme is not particularly difficult, but other aspects of this point will be considered in the discussion on the failures in Chapter 5.

No. of programmes	UDC	ALPHA.	FACET	UNITERM
1	42	42	50	57
2	39	36	39	26
3	10	14	8	15
4	7	4	1	1
5	2	2	1	1
6 or more	0	2	0	0

TABLE 4.9

PERCENTAGE OF NUMBER OF SEARCHES REQUIRED
IN THIRD ROUND OF TESTING

CHAPTER 5

ANALYSIS OF FAILURES

On the completion of the second round of the test programme, a complete analysis was made of all cases where the source document, within the range P12001 - 18000, had not been retrieved. As a result of this analysis, some changes were made in the rules for the third round of testing (as discussed in Chapter 2), and further analysis was done of all failures in the third and final round of testing. This work was done mainly by Miss Warburton; Mrs. Aitchison assisted in the later stages but her work was checked by Miss Warburton to ensure consistency. All doubtful cases were also considered by the Director.

The procedure involved obtaining in each case the source document, the master indexing card, the question and the master search card. These were then considered in relation to each other and a decision taken as to the factor or factors responsible for them. The reasons fall under four main headings, namely:

1. Question
2. Indexing
3. Searching
4. System

Within these headings there are a number of divisions and the complete set are shown in Tables 5.1, 5.2 and 5.3. These tables include the figures relating to each division in the second and third rounds of testing and also the cumulated total for the two rounds.

329 documents and questions were involved in this analysis, while the number of failures by one system or another amounted to 495. The average time to complete each analysis was about an hour, although in some complex cases the time went up to two hours.

The complete summary of the analysis of failures by project staff, of which the following pages give a precis, is contained in Appendix 5A while some examples of the complete analysis of the individual documents are given in Appendix 5B.

		UDC	ALPHA.	FACET	UNITERM	TOTAL
1.	QUESTION					
a.	too detailed	2	2	2	2	8
b.	too general	5	4	6	4	19
c.	not easily understood	1	1	1	1	4
d.	misleading	1	3	3	2	9
e.	incorrect	3	2	3	2	10
		12 16%		15	11 27%	
2.	INDEXING					
a.	insufficient indexing:-					
(i)	personal errors	8	9	11	6	34
(ii)	time allowance	8	8	10	10	36
b.	overdetailed indexing	1	1	1	1	4
c.	incorrect:-					
(i)	personal errors	3	0	1	0	4
(ii)	time allowance	3	2	3	0	8
d.	insufficient number of entries	7	0	1	0	8
e.	careless indexing:-					
(i)	personal errors	6	11	15	6	38
(ii)	time allowance	7	3	3	1	14
f.	lack of entry in indexes to schedules	0	0	1	0	1
g.	lack of cross references	0	1	0	0	1
		43 57%	35		24 59%	
3.	SEARCHING					
a.	lack of understanding	2	5	6	2	15
b.	failure to use all concepts	3	3	4	0	10
c.	chain indexing	0	0	12	0	12
d.	failure to search systematically	1	2	5	0	8
e.	incorrect searching	3	1	2	0	6
f.	insufficient searching	2	7	3	2	14
		11	18 25%	31%	10%	
4.	SYSTEM					
a.	number of places for same subject	2	2	4	0	8
b.	lack of place in schedules	4	3	5	0	12
c.	lack of subdivisions causing placing to be too general	3	0	0	0	3
d.	bad choice of heading	0	1	0	0	1
e.	synonyms	0	0	1	2	3
f.	inability to combine particular concepts	0	1	0	0	1
		9	7	10	2 5%	
		75 12%	72 10%	10%	41	

TABLE 5.1

REASONS FOR FAILURES IN SECOND ROUND OF TESTS BY PROJECT STAFF

		UDC	ALPHA.	FACET	UNITERM	TOTAL
1.	<u>QUESTION</u>					
a.	too detailed	4	3	3	3	13
b.	too general	0	0	2	0	2
c.	not easily understood	2	2	2	2	8
d.	misleading	3	3	4	4	14
e.	incorrect	1	0	0	1	2
		/10 12%	/8 15%	/11 16%	/13 22%	
2.	<u>INDEXING</u>					
a.	insufficient indexing:-					
(i)	personal errors	7	8	4	3	22
(ii)	time allowance	8	6	9	5	28
b.	overdetailed indexing	3	3	1	0	7
c.	incorrect:-					
(i)	personal errors	4	3	4	0	11
(ii)	time allowance	2	2	3	1	8
d.	insufficient number of entries	11	0	0	0	11
e.	careless indexing:-					
(i)	personal errors	16	8	14	12	50
(ii)	time allowance	8	2	8	5	23
f.	lack of entry in indexes to schedules	5	1	0	0	6
g.	lack of cross references	1	1	1	1	4
		/65 76%	/32 63%	/44 66%	/27 60%	
3.	<u>SEARCHING</u>					
a.	lack of understanding	4	4	4	5	17
b.	failure to use all concepts	0	0	0	0	0
c.	chain indexing	0	0	0	0	0
d.	failure to search systematically	0	0	0	0	0
e.	incorrect searching	1	1	1	0	3
f.	insufficient searching	1	2	2	1	6
		/6 7%	/7 13%	/7 10%	/6 13%	
4.	<u>SYSTEM</u>					
a.	number of places for same subject	1	1	1	0	3
b.	lack of place in schedules	2	2	3	0	7
c.	lack of subdivisions causing placing to be too general	1	0	0	0	1
d.	bad choice of heading	0	1	0	0	1
e.	synonyms	0	0	1	2	3
f.	inability to combine particular concepts	0	1	0	0	1
		/4 5%	/5 9%	/5 7%	/2 4%	
		85	54	67	45	

TABLE 5.2

REASONS FOR FAILURE IN THIRD ROUND OF TESTS BY PROJECT STAFF

		UDC	ALPHA.	FACET	UNITERM	TOTAL
1.	QUESTION					
a.	too detailed	6	5	5	5	21
b.	too general	5	4	8	4	21
c.	not easily understood	3	3	3	3	12
d.	misleading	4	6	7	6	23
e.	incorrect	4	2	3	3	12
2.	INDEXING					
a.	insufficient indexing:-					
(i)	personal errors	15	17	15	9	56
(ii)	time allowance	16	14	19	15	64
b.	overdetailed indexing	4	4	2	1	11
c.	incorrect:-					
(i)	personal errors	7	3	5	0	15
(ii)	time allowance	5	4	6	1	16
d.	insufficient number of entries	18	0	1	0	19
e.	careless indexing:-					
(i)	personal errors	22	19	29	18	88
(ii)	time allowance	15	5	11	6	37
f.	lack of entry in indexes to schedules	5	1	1	0	7
g.	lack of cross references	1	2	1	1	5
3.	SEARCHING					
a.	lack of understanding	6	9	10	7	32
b.	failure to use all concepts	3	3	4	0	10
c.	chain indexing	0	0	12	0	12
d.	failure to search systematically	1	2	5	0	8
e.	incorrect searching	4	2	3	0	9
f.	insufficient searching	3	9	5	3	20
4.	SYSTEM					
a.	number of places for same subject	~~2~~ 3	~~2~~ 3	~~4~~ 5	0	~~8~~ 11
b.	lack of place in schedules	~~4~~ 6	~~3~~ 5	~~5~~ 8	0	~~12~~ 19
c.	lack of subdivisions causing placing to be too general	~~3~~ 4	0	0	0	~~3~~ 4
d.	bad choice of heading	0	~~1~~ 2	0	0	~~1~~ 2
e.	synonyms	0	0	~~1~~ 2	~~2~~ 4	~~3~~ 6
f.	inability to combine particular concepts	0	~~1~~ 2	0	0	~~1~~ 2

TABLE 5.3

TOTAL REASONS FOR FAILURES IN SECOND AND THIRD ROUNDS OF TESTS BY PROJECT STAFF

PRECIS OF SUMMARY OF ANALYSIS

1. QUESTION

The analysis has divided the failures because of questions into five main types:-

(a) Too detailed:- in which the information the questioner required was hidden in a short paragraph and consisted of only a small part of the whole paper. (21 failures).

(b) Too general:- in which the search would have retrieved large numbers of documents, any of which may have given the information required. (21 failures).

(c) Not easily understood:- with which the answer might have been forthcoming if the enquirer had been at the librarian's elbow whilst the search was being made. (12 failures).

(d) Misleading:- again if the searcher had been able to talk to the enquirer, the difficulty in finding the document would probably have been eliminated. (23 failures).

(e) Incorrect:- where the questioner appeared not to have understood the subject of the article, and compiled a question which was inaccurate. (12 failures).

2. INDEXING FAILURES

(a) Insufficient indexing:- These are divided into (i) the errors caused through the indexer's lack of judgement, and (ii) the failures caused by shortage of time allowance. The latter will not be discussed, on the assumption that the indexer would have made the necessary additions to his entries had time allowed.

(i) Personal errors:- Under this heading have been placed fifty six failures. This total comprises the single failures under each system, but they are grouped in this analysis under the causes of failure and not the systems.

(α) Omission of an important concept:- In 16 cases, the indexers' failure to include an important concept has caused the document to remain untraced.

(β) Too general indexing:- In 12 cases, the indexer did not index particular concepts in as much detail as he could have done, and so placed them at a more general number or heading.

(γ) Failure to recognise practical applications:- In 2 failures, the indexer omitted to index the applications of the subject of the paper. In each paper, the theory was indexed in sufficient detail, but the practical applications, usually referred to in the summary, introduction or conclusions, were ignored.

(δ) Lack of technical knowledge: - In only 5 cases was it apparent that a particular concept was missed because of the indexer's lack of technical knowledge.

(ε) Effect of one concept on another: - In one failure, it was clear that the indexer, although he had indexed the principal part of the paper, ignored the effect of a single concept on another concept. As the document was approached by a question based on the second concept it remained untraced.

(b) Overdetailed indexing: - 11 failures have been classed under this heading, emanating from 4 documents. In each of these documents, the indexer indexed the examples given in the test, but did not index the general purpose of the article, in each case expressed by the title. As the questions were based on the titles, the searchers were not able to trace the documents from the specific headings and entries given, without checking whole sections of the catalogue.

(c) Incorrect indexing: - Again, only section (i) under which have been placed the failures caused by personal errors not affected by time allowance, are considered.

There were 7 failures under this heading, in the U.D.C. system, 3 by Alphabetical and 5 in the Facet system. The failures in U.D.C. are not easily explained, for a rule that had been fully understood by the three indexers had, on these occasions, been ignored. Possibly fatigue of the indexer, or some slight forgetfulness was responsible.

The errors in Facet were due to carelessness or lack of memory. The indexer remembered an element of notation incorrectly, but it was used so frequently that it was not checked in the schedules. Although the documents were not traced in three systems, there were sufficient Uniterms found to consider the searches successful.

(d) Insufficient number of entries: - The failures falling under this heading are from two systems only, U.D.C. and Facet.

The 18 failures with U.D.C. are due to lack of permutation. The indexer had, in each case, chosen the correct U.D.C. number, but had not made sufficient entries from those numbers. Also, on occasions, the indexers coloned four U.D.C. numbers for one entry. It was found in the searching programme that a searcher rarely used more than two notational concepts with which to start his search programme.

The one failure in Facet was traced to the indexer's use of one long entry, of nine elements, which would have made necessary a long search via the chain index to trace the particular document. This was because the question was more general than the indexing entry, which with the addition of extra elements separated those required by the searcher.

(e) Careless indexing:- A total of 88 reasons for failure fall under section (i) Personal errors. Again, only these are considered useful to discuss, as the remainder are due to shortage of indexing time allowance.

Of these 88 reasons for failure, 22 documents were not traced in U.D.C., 19 in Alphabetical, 29 in Facet and 18 in Uniterm. There is no apparent reason, apart from carelessness, for the high numbers in Facet or Alphabetical, or U.D.C. Possibly the failures in Uniterm were due to the fact that code numbers and not terms were entered on the master indexing card, so that the indexer could not readily assess which Uniterms he had included. It is true that numbers are used for the notation of U.D.C., but these would be fewer in toto and were more familiar to the indexers.

73 documents are included in this total of 87 failures, showing that normally the indexer used the necessary elements for success in most of the systems, but through lack of thought or carelessness, did not include the elements in all the systems. In each case considered, the inclusion of the same elements in each system would have traced the document.

(f) Lack of entry in indexes to the schedules:- 7 failures can be attributed to this reason, 5 in the U.D.C. system, one each in Alphabetical and Facet.

The failures in U.D.C. were caused by the use of a new number without the appropriate entry being entered in the alphabetical index. Thus the searchers for these documents were unable to find their way to the correct part of the catalogue.

The single failure in Alphabetical was also due to a new heading being used. Later, the form of the heading was altered to bring it into line with the other entries, but no reference was made from the first heading to the second.

(g) Lack of cross reference:- 5 failures are included under this heading, 4 from the same document. A particular term was used in the title and question which was not known to either the indexer or searcher. If, in the alphabetical lists to all systems, an entry had been made from the unknown term to that in each system under which the document had been placed, there would have been no difficulty in searching. One failure in the Alphabetical can be attributed to the searcher failing to check a heading with which she was not familiar, due to the fact that there was no cross reference from the general heading to the more specific.

3. SEARCHING FAILURES

(a) Lack of understanding:- Some failures where, if the questioner had been available, the searcher might have been able to formulate the search programmes correctly, are included here as well as in Section 1(c). There are also the failures in which if the searchers had given a little more thought to the problems, the documents should have been traced without difficulty.

Three questions failed in all four systems because the searching programme did not include a concept which should have been understood, and used from the question. A fourth question failed in Alphabetical, Facet and Uniterm, because of the same reason but, as the particular concept could not be expressed in the U.D.C. code, it cannot be counted as a reason for failure. Also, a fifth question failed in U.D.C., Facet and Uniterm, but, as the particular concept omitted in the searching programme was used as a subheading in Alphabetical, the reason for failure is due to another cause.

(b) Failure to use all the concepts given in the question:- Under this heading fall 10 documents, 4 failing in the search of the Facet catalogue, and 3 each in the Alphabetical and U.D.C. catalogues. In every case, the searcher failed to include in the search programme all the concepts given in the question. If these had been included, the required documents would have been traced.

Three of the failures in the searches of the Facet catalogue were because the searchers were frightened away by the number of cards under the single concept they had chosen. If they had also used one or more other concepts, the number of necessary searches in the classified catalogue would have been greatly reduced, and the search would have become realistic.

(c) Chain index:- 12 documents remained untraced in the Facet catalogue because of the searchers refusing to continue with a search. In each case, all possible concepts were taken from the question, and used in the search programme, yet still the searches involved too many entries into the classified section of the catalogue from the chain index. The questions concerned can be divided into two; either they were too general to enable the chain index to be used satisfactorily, or there was no single adequate place for entry via the schedules, but several possible places, each of which would need to be checked in the chain index.

For the third round of testing, this heading does not apply, as physical search in the classified catalogue was obviated by the searchers listing, from the chain index, the entries containing the required elements and checking these against the master card.

(d) Failure to search systematically:- Under this heading are included cases where the document was not traced, because the searcher did not take the search to the limits allowed by the decision of the project staff. For instance, if a search programme included three concepts, only one could be dropped, although each could be dropped in turn, leaving two concepts remaining for the next search programme. This limitation was made so that the searchers would not let their searches become too general. In these particular cases, this limitation was not reached, although if it had been, the documents would have been traced.

Also included under this heading are the failures in the Facet system, where the searcher has tried a place in the classified catalogue, yet not checked under the translation of that element of notation in the chain index.

Another reason for failure in the Facet scheme was when the searcher did not check under the sub-divisions of a concept, which could easily be found from the printed schedules.

One failure in U.D.C., two in Alphabetical, and five in Facet comprise the 8 failures.

(e) Incorrect searching:- 5 failures, two in the U.D.C. scheme, and one each in Alphabetical and Facet, were due to the searcher checking an incorrect place in the catalogues. In the U.D.C. failures, the searcher probably through carelessness, checked the entry next to the correct entry in the alphabetical index.

One question in U.D.C., Alphabetical and Facet, failed because the searching programme was incorrect. The document was traced in the Uniterm system because of sufficient additional Uniterms traced to constitute a success.

(f) Insufficient searching:- Under this section fall 20 causes of failure from 13 documents. 3 failures were from the U.D.C. catalogue, 9 from the Alphabetical, 5 from Facet and 3 from Uniterm. In most cases the searcher did not formulate sufficient search programmes, or check in all the possible places in the catalogue.

One question failed in Alphabetical and Facet for the same reason, but was traced in U.D.C. because of the ability to combine two numbers and yet make a general search through the second. i.e. 533.6.013.129: 533.692+. In the Uniterm system, sufficient Uniterms were traced to consider the search successful.

4. SYSTEM

(a) Number of places in the schedules for the same aspect:- In the U.D.C. searching, it was discovered that one failure was due to a number of entries in the alphabetical index for the same aspect, although each entry was described by the containing heads. Thus it was possible to sort the number of places into order of relativity. In another case, there were four possible places in which to index or search, and the searcher did not try them all.

In the Alphabetical searching, two failures were caused by there being two entries for similar concepts. A cross-reference from one to the other, or the inclusion of both under the same heading, would have eliminated the difficulty.

The Facet searching brought out two failures attributed to the fact that in both cases there are two or more possible ways of indexing and searching for the same concept. With each failure, the indexer used one method and the searcher another.

In another case, the failure showed up the ability of the indexer or searcher to use terms which, with adjectival terms, build up expressions with the same or similar meanings. Some decision should be made as to which is the more suitable, and the material placed under one heading, with a see reference in the chain index from the other.

(b) Lack of place in the schedules:- 12 searches were unsuccessful because there was no obvious place to which the searcher was directed by the indexes to the classification schemes. One of the three documents was not traced in either the U.D.C., Alphabetical or Facet systems. Of the other failures, 3 were in the U.D.C. system, 2 with Alphabetical and 4 with Facet.

In each case, as the question was a fair one for the subject of the document concerned, it also applies that the indexer could find no satisfactory place in which to classify the document.

(c) Lack of sub-division, causing the placing to be too general:- Three failures, all in U.D.C., were assessed to have been caused by a lack of sub-division in the printed schedules, thereby causing the place chosen to be too general. In one case, the place provided in the aerodynamic schedules was too general for such an aerodynamic collection, but in a second failure, it is the indexers' use of the schedules that is criticised, not the printed schedules themselves. There was provision for sub-division by alphabetical arrangement, but the indexers chose not to use it. Hence, the section was very full and searching time was increased because of the size of the section.

(d) Bad choice of heading:- One failure in the Alphabetical catalogue was due to a bad choice of heading. The heading, which was adjectival, was a general one, whereas the use of the particular adjective implied that a more specific heading should have been used. The searcher therefore, did not lead to the correct place in the catalogue.

(e) Synonyms:- Three failures were caused by synonymous terms, one in the Alphabetical system and two in Uniterm.

With one question, there was a failure to trace the required document in both Alphabetical and Uniterm, yet the searches were successful in the other two systems, solely because the two particular terms were included under one heading or number.

The third failure, in Uniterm, was caused by three similar Uniterms which should have been combined under one Uniterm, with references from the others.

(f) Inability to combine particular concepts:- One failure was caused by the inability in the Alphabetical systems to combine two concepts. To search each concept individually, would have made the search too general.

In the three other systems, the document was traced because the two particular concepts could be combined.

Table 5.4 gives the reasons for failure by the four main headings of Question, Indexing, Searching and System, and from this will be noted the major part due to indexing, and the small percentage which can be shown to have been caused through any weakness of the indexing system. The basic figures are rearranged in Table 5.5. to bring out the effect of personal errors and the time allowance for indexing. While the latter was adjudged to be responsible for 22% of the failures, personal errors in either indexing or searching caused over half of the failures.

	UDC	ALPHA.	FACET	UNITERM	TOTAL
QUESTION	22 (13%)	20 (17%)	26 (16%)	21 (25%)	89 (17%)
INDEXING	108 (70%)	69 (56%)	90 (54%)	51 (60%)	318 (60%)
SEARCHING	17 (11%)	25 (21%)	39 (24%)	10 (12%)	91 (17%)
SYSTEMS	~~9~~ (6%) 13	~~7~~ (6%) 12	~~10~~ (6%) 15	~~2~~ (3%) 4	~~28~~ ~~(6%)~~ 44 (8%)

TABLE 5.4

REASONS FOR FAILURES (PROJECT STAFF)

	UDC	ALPHA.	FACET	UNITERM	ALL SYSTEMS
PERSONAL ERRORS					
Indexing	66 (43%)	43 (36%)	52 (32%)	28 (34%)	189 (36%)
Searching	17 (11%)	25 (20%)	27 (16%)	10 (12%)	79 (15%)
TIME ALLOWANCE	36 (23%)	23 (19%)	36 (21%)	22 (26%)	117 (22%)
QUESTION	22 (13%)	20 (17%)	26 (16%)	21 (25%)	89 (17%)
ALL OTHER REASONS	~~15~~ (10%) 19	~~10~~ (8%) 15	~~24~~ (15%) 29	~~3~~ (3%) 5	~~52~~ (10%) 68

2 a;b,c;d,e;
3 abdef not c
a ii, c ii, e ii INDEXING
2 fg K all K
3c

TABLE 5.5

BREAKDOWN OF REASONS FOR FAILURES (PROJECT STAFF)

In addition, an analysis was made of the cases where the technical staff had failed to retrieve the source documents and Tables 5.6 and 5.7 summarise the results of this analysis. These show a greater proportion of failures due to searching by Alphabetical and Facet, but a much smaller change in this respect for U.D.C. and Uniterm.

	UDC	ALPHA.	FACET	UNITERM	TOTAL
QUESTION	20%	15%	16%	25%	17%
INDEXING	53%	32%	34%	53%	42%
SEARCHING	23%	49%	43%	20%	37%
SYSTEM	4%	4%	7%	2%	4%

TABLE 5.6

REASONS FOR FAILURES (TECHNICAL STAFF)

	UDC	ALPHA.	FACET	UNITERM	TOTAL
PERSONAL ERRORS					
Indexing	40%	28%	24%	33%	33%
Searching	17%	32%	33%	18%	24%
TIME ALLOWANCE	15%	16%	14%	20%	17%
QUESTION	20%	15%	16%	25%	17%
ALL OTHER REASONS	8%	9%	13%	4%	9%

TABLE 5.7

BREAKDOWN OF REASONS FOR FAILURES (TECHNICAL STAFF)

CHAPTER 6

SUPPLEMENTARY TEST PROGRAMMES

The whole emphasis of the basic test programme was concerned with recall, based on the retrieval of source documents. Relevance of the documents retrieved had in other investigations proved to be too difficult a problem to be satisfactorily solved, for relevance is, in the present state of the art, a purely subjective assessment. It will vary with the interests of the different individuals who make the assessment and it can also vary for the same individual at different times. In fact, the only person who can truly assess the relevance of a document to a question is the person who asks the question, and then only at the time when he actively requires the information. Even under these conditions, the high or low relevance of a particular document can obviously be influenced by any other documents retrieved. It was to side-track temporarily these difficulties that the particular test technique of the basic programme was used, and the intention was to make tests of a different nature which would enable more information to be obtained on other matters such as relevance.

A first task was to find exactly what was being measured, exactly what was implied when it was said that Uniterm, for instance, had an efficiency of 85%. At the time of the first public discussion of the preliminary results (Ref. 3), we affirmed that this did, in fact, mean that the searches were retrieving 85% of all the documents in the system which had a degree of relevance which was higher than or at least equal to the document on which the question was based. To this statement there was one qualification, namely that the figure of 85% might be too high due to the fact that there was an unnatural correlation between the document and the question as compared to a true life situation. If it were shown that this correlation resulted in the efficiency being, say, 15% higher than it would otherwise be, then it might be expected that the figure of 70% would represent the real efficiency of recall.

The supporting argument for this view was as follows. It is known that amongst the total collection of documents there is a group of 100 documents which will provide relevant answers to 100 questions, namely the documents which were used by the compilers of the questions. This was the situation in the main test programme, and the result of searches for 100 questions was that with Uniterm for instance, on an average 85 of this known group of relevant documents was recovered. Assume that there had been another group of 100 equally relevant documents for the same collection of questions; it is not unreasonable to presu me that 85% also of these would have been retrieved. Assume a further 100 relevant documents, with the same search result. Continue this to a stage where there is a collection of 10,000 documents, with 100 documents being relevant to each question. The result of a single search would then be expected to be that 85 of the known 100 documents were retrieved.

The above argument has not been shown to be false or illogical, but further tests were required to show how valid it could be considered. The method of attempting to do this was to select 100 questions. The selection was made in such a way as to ensure that half the questions covered aerodynamic subjects, while the remainder dealt with the other more general subjects in the collection. These were sent in groups to the librarian or information staff at different organisations working in the appropriate subject fields. They were requested (see Appendix 6A) to prepare as complete as possible bibliographies for each question. In particular it was emphasised that a bibliography was not intended to be critical, but that it should include any reference which it appeared might be relevant to the question. We received bibliographies covering 88 questions, and 18 questions had duplicate lists from different organisations. On being received at Cranfield, each bibliography was checked to ascertain which items were included in the documents covered by the index. Eight bibliographies did not include any references to such documents, so there were left bibliographies to 80 search questions. The total number of references in these bibliographies to papers which had been indexed in the project came to 359, varying from one to a maximum of fifteen. The source documents were not to be included in this test, so whenever they appeared in a bibliography, they were crossed out. Each of the 359 documents were then assessed in relation to the appropriate question, with the source document being used as a guide to determine relevance. The assessment rating was '1' for documents as useful as the source document, '2' for documents of some interest and '3' for documents of no interest.

As a result of this assessment, there were 53 documents which had a rating of '1', and 67 documents with a rating of '2', the remainder not being considered of any interest. The number of questions which were covered by documents of top relevance was 35, and 6 other questions had documents of lower relevance.

The breakdown of these questions and documents is shown in the first two columns of Table 6.1. Searches were then made for these 41 questions, but in this case, contrary to the main test programme, the searcher did not know the document numbers of the relevant documents and the search continued until the searcher had covered all reasonable possible programmes. The results of these searches are given in the final column of Table 6.1 and Table 6.2 gives the total figures.

	No. of relevant documents		Number of relevant documents retrieved			
			UDC	ALPHA	FACET	UNITERM
	1	2	1 - 2	1 - 2	1 - 2	1 - 2
PQ1	1	2	1 - 1	1 - 2	1 - 2	1 - 2
PQ3	1	1	1 - 1	1 - 1	1 - 1	1 - 1
PQ6	1	1	0 - 1	1 - 1	1 - 1	1 - 1
PQ9	2	2	1 - 2	1 - 2	0 - 1	1 - 2
PQ10	1	2	1 - 1	1 - 1	1 - 1	1 - 1
PQ13	0	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ14	2	1	2 - 1	2 - 0	1 - 0	2 - 0
PQ15	1	0	0 - 0	0 - 0	0 - 0	0 - 0
PQ18	3	3	3 - 2	2 - 2	2 - 2	3 - 2
PQ21	1	1	1 - 1	1 - 1	1 - 1	1 - 1
PQ26	1	2	1 - 1	0 - 1	0 - 1	1 - 1
PQ27	1	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ28	1	0	1 - 0	1 - 0	1 - 0	1 - 0
PQ33	0	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ35	3	5	2 - 3	2 - 4	2 - 3	3 - 4
PQ39	1	1	1 - 1	1 - 1	1 - 1	1 - 1
PQ41	1	3	1 - 2	1 - 2	1 - 2	1 - 3
PQ45	1	2	0 - 2	0 - 1	0 - 1	0 - 2
PQ48	1	2	1 - 1	1 - 2	1 - 1	1 - 1
PQ50	2	2	2 - 1	2 - 1	1 - 1	2 - 1
PQ53	1	1	1 - 1	1 - 1	1 - 1	1 - 1
PQ56	1	1	0 - 1	1 - 0	1 - 0	0 - 1
PQ59	0	2	0 - 2	0 - 2	0 - 1	0 - 2
PQ61	6	5	4 - 4	4 - 3	3 - 3	4 - 3
PQ64	1	1	1 - 1	1 - 0	1 - 0	1 - 1
PQ65	1	2	0 - 1	0 - 1	0 - 1	0 - 1
PQ68	2	3	1 - 2	1- 2	1 - 1	2 - 1
PQ70	1	1	1 - 0	1 - 0	1 - 0	1 - 0
PQ72	1	0	0 - 0	0 - 0	0 - 0	0 - 0
PQ79	4	3	4 - 2	4 - 2	3 - 2	3 - 2
PQ80	2	3	2 - 1	2 - 2	1 - 2	2 - 2
PQ82	1	0	1 - 0	0 - 0	0 - 0	0 - 0
PQ84	0	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ87	0	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ88	2	3	1 - 3	1- 2	1 - 2	1 - 3
PQ90	1	1	1 - 0	1 - 0	1 - 0	1 - 0
PQ91	1	1	1 - 1	1 - 0	1 - 0	1 - 1
PQ92	1	2	1 - 2	1 - 2	1 - 1	1 - 2
PQ94	1	1	0 - 1	0 - 1	0 - 1	0 - 1
PQ96	1	1	1 - 1	1 - 1	1 - 1	1 - 1
PQ99	0	1	0 - 0	1 - 1	0 - 1	0 - 1
			39 - 49	40 - 47	32 - 41	40 - 51
			74% - 73%	75% - 70%	60% - 61%	75% - 76%

TABLE 6.1

RESULTS OF SEARCHES FOR RELEVANT DOCUMENTS FROM BIBLIOGRAPHIES

	RELEVANCE 1	RELEVANCE 2
U.D.C.	39 (74%)	49 (73%)
ALPHA	40 (75%)	47 (70%)
FACET	32 (60%)	41 (61%)
UNITERM	40 (75%)	51 (76%)

TABLE 6.2

SUMMARY OF RESULTS OF SEARCHES FOR RELEVANT DOCUMENTS FROM BIBLIOGRAPHIES

While it is the case that, because of the relatively small number of documents concerned with this test, the standard error is high, it would seem probable that there has been a slight but definite reduction in the efficiency as compared with the main test. Possibly significant is that Uniterm shows the largest drop for the figures in the basic test.

This test involved a great deal of effort, not so much for the project staff as for those who voluntarily co-operated by compiling the bibliographies and it is doubtful if the more valid information that could be obtained by a larger programme would be commensurate with the effort involved. It was a disappointment to find so few relevant documents amongst those which had been indexed in the project. Unfortunately this test was under way before the relevance assessments (discussed later in this chapter) had been carried out; had the latter been completed first, it would have been no surprise to find that the large majority of documents listed in the bibliographies were of no interest and it would certainly be unreasonable to criticise those who gave generously of their time.

If it is agreed that 85% efficiency in the main test is equivalent to retrieving 85% of the relevant documents, it is still necessary to make some qualifying statement concerning the operating conditions. The 85% efficiency of Uniterm was achieved using the search rules as considered in Chapter 2. These permitted the searcher to drop one, but not more than one, of the basic concepts originally considered necessary. If the search programme requiring ABCD proved unsuccessful it was permissible to search ABC, ABD, ACD or BCD but not permissible to search AB or any other two-concept term, much less A or B or C or D on their own. As stated earlier, with KWIC indexing and also with Uniterm, if a single concept had been accepted, the efficiency would be 97%. Obviously, if it had not been possible to accept something less precise than the original requirement, it is certain that the recall efficiency would have been lower. The result is that there is the possibility of quoting three different performance figures, those with Uniterm as an example being:

65% when all concepts are required

85% when one less concept than the required is accepted

97% when a single Uniterm is accepted.

The only practical method of showing these varying points is by plotting them against relevance ratio, that is the percentage of the retrieved documents which have an agreed relevance. This matter is considered in more detail in Chapters 9 and 10, and mention is only made here in connection with the analysis that was made. Sufficient now to make the point that as the recall figure (i.e. the percentage of potentially relevant documents in the collection) rises, the relevance ratio (i.e. the percentage of relevant documents amongst the total of those retrieved) must fall and conversely as the recall figure drops, so the relevance ratio will improve.

In order to find the relevance ratio, an assessment was made of the number of documents which had been retrieved in the course of the searches. For this purpose a random sample was taken of 79 questions spread over all indexing variables. From the master search cards there was obtained a list of all the references found in the course of the searches. This showed that the total number of documents obtained in the searches was as in Table 6.3.

	Total	Average per search
U.D.C.	3171	40
ALPHABETICAL	2122	27
FACET	1910	24
UNITERM	1527	19

TABLE 6.3

TOTAL DOCUMENTS RETRIEVED IN SAMPLE OF 79 SEARCHES

These numbers may seem large, but in every case were swollen by very heavy retrieval in certain searches and if the twelve searches with the highest retrieval figures were deducted in each case, the figures for the remaining 67 searches would read as in Table 6.4.

	Total	Average
U.D.C.	1346	20
ALPHABETICAL	940	14
FACET	1060	16
UNITERM	895	13

TABLE 6.4

DOCUMENTS RETRIEVED IN SAMPLE OF 67 SEARCHES

A sample was taken of the documents retrieved by each system. The intention was that an assessment analysis of approximately 400 documents should be made for each system. Care had to be taken not to bias the sample by using documents which had been retrieved by all systems, as this would have tended to include those which had a strong probability of being relevant. Naturally, however, there was some duplication and the sample finally involved a total of 759 documents, which were assessed in the same manner as described for the previous test. From this random sample, it was found that a total of 59 documents with the top relevance rating had been retrieved, in addition of course, to the source documents. These were in many cases retrieved by more than one system, but they turned up in the analysis of the different systems as set our in the first column of Table 6.5.

	a	b	b + source	Relevance ratio
U.D.C.	19	150	229	7%
ALPHA.	32	165	244	12.5%
FACET	16	85	164	7.5%
UNITERM	28	101	180	12%

TABLE 6.5

RELEVANCE RATIO OF DOCUMENTS RETRIEVED IN 79 SEARCHES

a. Relevant documents in sample assessed
b. Assumed relevant documents in total retrieved

To find the total number of relevant documents retrieved, the total in this sample was multiplied by the appropriate factor depending on the total number of documents retrieved by each system (as shown in Table 6.3). This figure is shown in the second column, while the third column gives the total when the number of source documents have been added to the figures in column 2. Finally the relevance is obtained by finding the percentage of relevant documents against the total number of documents retrieved, (as given in Table 6.3).

As will be seen, the results showed a suspiciously large variation regarding relevance ratio, so a further check was made. This consisted of finding exactly how many of the 59 top-relevance documents had in fact been retrieved by each system as against those which had happened to be included in the assessed sample. The result of this check is given in the second column of Table 6.6 and shows a major change, for Alphabetical, which had originally disclosed the most non-source relevant documents, now dropped to the bottom, while the other three systems were all very level. The third column shows the percentage retrieval from the known collection of 59 non-source relevant documents, and this should be compared with the final column of Table 6.2. It does not, however, tell the full story, for the non-source relevant documents included in this analysis were only those retrieved by the successful programme for the particular system. To explain this point, it will be recollected that in the main test, the search was only carried to the stage where the source document was located. This might, in some cases, have involved many different programmes with one system, but only a single programme with another system. Normally the more searches, the more documents retrieved, and this would usually result in more relevant documents being retrieved, with the penalty that more irrelevant documents will also be brought out. Since the non-source relevant documents were only those that had been retrieved in the course of possibly limited searches, a check on this was made by going back to the master search card and indexing card for all the failures to retrieve these non-source relevant documents, and attempting to assess whether an extended and complete search programme would have retrieved them. The result of this analysis was that the figures in the second and third columns should be improved to those given in columns 4 and 5 of Table 6.6, and represent a considerable increase on the figures for Table 6.2 and even an increase on the searches for source documents in the main test programme.

	a	b	c	d	e
U.D.C.	19	43	71%	46	78%
ALPHABETICAL	32	36	61%	48	81%
FACET	16	41	68%	50	85%
UNITERM	28	42	70%	53	90%

TABLE 6.6

NON-SOURCE RELEVANT DOCUMENTS RETRIEVED IN 79 SEARCHES

a. Relevant documents in sample assessed
b. Known relevant documents retrieved
c. Percentage of known relevant documents retrieved
d. Known relevant documents which could have been retrieved by improved searches
e. Percentage of known relevant documents which could have been retrieved by improved searches

This somewhat tortuous analysis serves to emphasise nothing more than the extreme danger of placing too much credence on any of the figures which are not otherwise corroborated. To recap, there is the known figure of recall as given in the main test. Of this figure the claim has been made, earlier in this chapter, that it represents not only the recall figure for source documents, but also the recall figure for all relevant documents in the collection. The two supplementary tests have shown that this statement is probably true with one proviso. It appears doubtful if an equal percentage of the total of non-source relevant documents were actually retrieved, but it does appear from the final column of Table 6.6 that an equal figure could have been obtained with extra reasonable search programmes. On the other hand, the final column of Table 6.2 indicates a general lowering of the main test figures for recall and this could be taken to indicate that the questions were slanted towards the source documents.

In point of fact, the documents being assessed in these two further tests numbered only 53 and 59 respectively, and this is too small a figure to have any real validity. To have increased this figure materially would have involved a large amount of extra work and would still only produce figures whose basis would be the unprovable assumption that the relevance assessment was correct. It was quite impossible to go back to the originators of the questions for them to determine the relevance, and even if this had been possible, it would, in view of the lapse of time, have been impractical to do so.

The present investigation was not geared to carry out this refinement of operation, and it was decided that it was unwise to spend much further time in trying to make fine measurements with a crude instrument. However, the ratio of relevant documents to irrelevant documents in the operation of this test can be said with some certainty to lie between 6% and 14%. Whereas it is, at this level, a very wide range, it does indicate, possibly for the first time, the region in which information retrieval systems are conventionally working. Crude as these further tests were, they did give pointers to the more valuable analysis described in Chapter 7 and the further programme considered in Chapter 10.

A further test was made in an attempt to find what improvement could be obtained by combining the specialised knowledge of the technical staff and the project staff in searching. For this purpose, in each system 60 searches which had been unsuccessful both by technical and project staff were repeated. These failures were all in the first two rounds of testing, when the search programmes had not been co-ordinated between the four systems, and the test was done prior to the analysis of failures described in Chapter 5. The result of this collaboration between technical and project staff was that a further five source documents were located in U.D.C. and Facet, six in Alphabetical and four in Uniterm.

FACET

Another test, which falls into a different category, was made with Facet. The results for Facet had been disappointing, for they were markedly lower than the other systems. Personal observations of the searchers, reinforced by the analysis of failures, was that the main weakness of Facet lay in the fixed order and chain index. This difficulty was forecast in the section written by Mr. J. Sharp in Chapter 4 of Ref. 1, and it was contemplated that it might be worth testing Facet by using it in a post-co-ordinate manner. It was, however, first decided to try the effect of using it as one does with U.D.C., ignoring the fixed order andpermitting the free co-ordination of terms in any order which the indexer considered reasonable and possibly useful for retrieval.

2,000 master indexing cards were taken, and from these Miss Warburton regrouped the notation as made in the original indexing. A typical example of this was document P14287 which was originally given the single entry: Cd(Zqv)Juy Ncd Nfj Nfk Of Yas, with the chain index entry "Solution: Stagnation: Boundary layer: Compressible flow: Laminar flow: Angle of Yaw: Infinite: Wings". When re-indexed, this involved entries which were as follows:

Juy Cd(Zqv)
Of Nfk Nfj Ncd
Cd(Zqv)Ncd Nfk
Cd(Zqv)Nfk Ncd
Cd(Zqv)Juy

The instructions were that an average of 4 - 5 entries should be made for each document, so as to maintain the level used in the U.D.C. and Alphabetical catalogues. On completion of this task, 400 searches were made again using the elements requested in the original search programmes. The successful searches using this method came to 332, an average of 83%. This was 8% higher than Facet had achieved by the use of chain index and fixed order, and was higher than either U.D.C., Alphabetical or Uniterm in the main test.

CHAPTER 7

TESTING OF EXISTING SYSTEMS

Whereas the main investigation had attempted to simulate as far as possible normal operating conditions, yet it had artificialities, some of which were inevitable, others which were imposed by the requirements of the programme. Even if in the indexing it had been practical to simulate exactly a normal operation, the results of the work would inevitably be subject to the limitations that are inherent in any single system, such as the operators of the system, the subject field, the purpose of the system, etc. There would, therefore, be at the conclusion of the investigation the dual requirements of attempting to find to what extent the results of the investigation had been influenced by the inherent artificialities and also to what extent the results could be considered applicable to other operating conditions of the type mentioned above.

From the commencement it had been hoped that it would eventually be found practicable to do these two separate tasks with only a small amount of the effort and expenditure involved in the present project. When the first set of analyses had been made (as discussed in Chapter 5), it seemed that it would be possible to make a test which, in addition to providing information on these points, would also be of some value to the system being tested.

At the request of the Director, the Library of the English Electric Co. Ltd., at Whetstone, kindly agreed to allow the Project staff to carry out a test on their catalogue. From our viewpoint this was to be an experiment designed to show whether such a technique of testing could produce valid results, and at the same time it was hoped that the co-operation of the library staff would to some extent be repaid by providing data which would assist in the operation of the catalogue.

On the completion of this test in June, 1961, a report was prepared for private circulation amongst the libraries of English Electric Group of companies, and the following account is largely taken from this report, which was prepared by Miss Warburton of the Project staff and Mrs. J. Aitchison, Librarian at Whetstone.

The English Electric Library at Whetstone, now the Central Library Service for the Group, developed a faceted classification scheme in 1958, the third edition of which was issued in March, 1961. The system is used at the Whetstone and Bradford libraries of The English Electric Company and has since been adopted by newly established libraries at the Stafford and Liverpool Works. The facet scheme is also used in certain library publications, the most important of which is the monthly Reports Abstract Bulletin indexing English Electric reports. The catalogue at Whetstone, which was tested between January and April 1961, contained cards for approximately 36,000 documents.

The schedules were constructed according to facet principles as understood from the writings of members of the Classification Research Group. The subject field, the whole of engineering, was divided into the basic categories, plant and machines, components, materials, physical phenomena, operations and instruments, and within these categories terms were further analysed and grouped according to clearly defined characteristics. The schedules, like those of the Cranfield Facet Schedules, are short compared with enumerative schemes since only basic terms are listed, from which the classifier must himself synthesise class numbers for complex subjects.

The orthodox method of preferred order and chain index technique is used in the Whetstone Catalogues, but care is taken to ensure that the scatter of subsidiary terms inherent in preferred order does not render the catalogue unworkable as a speedy retrieval tool. The number of concepts used in combination are kept within limits and it is recognised that there should be consistency in omission and addition of terms during synthesis. In certain parts of the schedules there are rules disallowing certain combinations of terms so that scatter is reduced. Also, when adding new material, the classifiers check both chain index and classified sequence so that like documents are kept together and not separated by slight inconsistencies in combination of terms. As a result, the average number of terms used in combination is three as compared with the five used in the Facet catalogue at Cranfield. At the time of the test the catalogue contained 76,000 cards of which 48,000 cards (63%) were in the class sequence and 28,000 cards (37%) in the chain index. The average number of cards in the catalogue for each document was 2.05.

The first requirement in a test of this nature is to have relevant information concerning the indexing and it was fortunate that this was already available in that, as a matter of routine, records were maintained of the indexing of each document. 200 references were chosen at random from those documents which had been indexed, and the selected documents were divided out amongst a number of technical staff at Whetstone. They were asked to compile questions of a kind which they might expect to put to the library in the normal course of their work. These questions were to be such that one of the documents which they had been given would provide a satisfactory answer to a question. These questions were collected and transferred to search cards.

Altogether there were 186 questions, and Miss Warburton, with some small assistance of a former member of the project staff, made searches for all these questions. In addition, members of the English Electric Library staff repeated 68 searches. As in the main project the searches were continued until the source document had been located or until no further search programmes could be devised, and the searches were considered on this basis as being either successes or failures. The results are as shown in Table 7.1.

	Searches	Success	Failure	% Success
Project staff	186	144	42	77.4
E.E. Library staff	68	50	18	73.5

TABLE 7.1
SEARCH RESULTS IN ENGLISH ELECTRIC CATALOGUE

The average time for carrying out a complete search was $5\frac{2}{3}$ minutes; for failures only, it was nearly 11 minutes, while for successes it was only 4 minutes.

The first point of importance arising from this test was to find that the recall efficiency fell within the range of the systems tested in the Cranfield Project. As explained earlier, the English Electric staff normally used less elements in notation than had been Cranfield practice, this resulting in a lower number of cards for the chain index. In addition, the indexer was in the habit of checking previous indexing of similar documents, and this achieved greater consistency in notation. One result of these factors appeared to be a decrease in retrieval time compared with the Cranfield facet index.

An interesting point arose in the searching by Miss Warburton. It had been thought that there might be difficulty for her in searching a system where the classification scheme was unfamiliar and where many of the questions dealt with a subject field (nuclear engineering) in which she had no practical experience. In fact, her first fifteen searches were all successful and this, combined with the final success rate, shows that for an experienced librarian neither an unfamiliar indexing system nor a relatively strange subject field present too serious problems.

	E.E. Test	Facet Cranfield Test
Poor Question	12%	4%
Indexing	43%	47%
Searching	32%	33%
System	13%	16%

TABLE 7.2

REASONS FOR FAILURE IN ENGLISH ELECTRIC CATALOGUE

The comparison of failures (Table 7.2) showed remarkable consistency. For instance, assessed indexing failures were 47% against 43%. Within this, the figure for insufficient indexing was 22% as against 20%. The errors due to the system were in both cases mainly concerned with difficulties caused by the chain index.

As has been discussed earlier, the preferred order with a chain index had appeared to be a major weakness of the project facet catalogye, so it was interesting to have this confirmation with the English Electric catalogue. It was this which made us decide to retest the facet catalogue as discussed on page 59 , and the results of this test were sufficiently conclusive for the new systems subsequently set up at two other English Electric plants to be without preferred order.

It had been the hope that it would be possible to make an assessment of the relevance of other documents retrieved in the searches, but due to staff changes, this proved impracticable. Although, in this respect, the test cannot be considered as complete, it still served to show a number of interesting points. Most important, it showed that this method of testing was comparatively straightforward and provided a considerable amount of data for analysis, some examples of which are given in Appendix 7A. Further it appeared to confirm at the Whetstone library, it was found necessary to expand and make additions to the schedules in order to cope with the concentration of documents in the comparatively narrow subject field. This in itself was an interesting and useful exercise and will be considered in detail in the report on this work; here it is sufficient to say that little difficulty was found in accommodating the new concepts.

Instructions to the indexer at Cranfield were that the indexing should be as thorough as was reasonable, and should for preference err on the side of over-indexing rather than under-indexing. As can be seen from the sample indexing card, (Fig. 4), the indexing was recorded in three stages. First the concept indexing was done; this is to say that the indexer wrote down those concepts in the document which were considered to be sufficiently important to merit indexing. The second stage was to translate the concept indexing into the notational elements of the descriptor language and the final stage was to decide on the suitable combinations of the separate notational elements which would serve as index entries. This last sentence shows that the use of the chain index was abandoned, a decision which appeared to be justified in the light of the results obtained in the project and in the English Electric test.

It was desired to simulate as far as possible the conditions under which the W.R.U. index would be tested. In a conventional card catalogue, the searcher has, at the time and in the course of the search, the advantage of being able to read the titles, the references and possibly the abstracts of the documents retrieved, and this might well be of assistance in devising further search strategies, or the eye might alight, by chance, on an entry under a heading that might not otherwise be searched. With a computer, however, the searcher will not have any such assistance. Therefore in the card catalogue prepared for the Cranfield indexing, the cards contained nothing more than the notational heading and a code number which identified the individual article.

The assistance of a group of twelve metallurgists in ten different organisations was enlisted for the preparation of the questions to be used for the test searches. Each person was sent a number of the marked title pages and allowed to make a personal selection of articles dealing with subjects of his particular interest. These articles were then used as the basis for questions of a kind which he might expect to make in the course of his normal duties. A total of 137 questions were obtained in this way, and were sent to W.R.U. There the questions were programmed, searches made in the computer, and the references retrieved in the course of these searches sent to Cranfield. Each search was checked to ascertain whether the source document had been retrieved; if so, the search was considered successful and W.R U. were advised which had been the source document. When the search was unsuccessful in this respect, W.R.U. were not given the reference to the source document, and so were able to make a fresh search.

The questions were also given to members of the project staff to search in the Cranfield facet catalogue. The difference between these searches and those done in the main project test was that in this case the searcher did not know when or whether the source document had been retrieved. This meant the search was continued until no further reasonable programmes could be devised, and since, as described above, the catalogue cards only contained the notation and a document code number, the searcher had no information to assist in deciding whether a satisfactory reference had been found.

Following the searches, a sample was taken of the other documents which had been retrieved in the searches, and these were sent to the individual who had originally prepared the questions. They were asked to make an assessment of those other documents in relation to the questions in the scale of 1 to 5, these representing:

1. A document more useful than the source document
2. A document as useful as the source document
3. A document of some interest
4. A document of no interest
5. A false drop.

In practice it was found difficult for different persons to be consistent in their assessments between 4 and 5 and in the statistical analysis it was decided to group these assessments together.

The results of the tests on the two indexes are given in Table 7.3. There is no sinister reason for the fact that not all the figures are given; it is merely that they are not at present available. Some preliminary discussion of these results and analysis of some of the W.R.U. failures is contained in papers by J. Melton and A. Rees (Refs.6 and 7), and further comment can await the final report on this test. It is, however, already apparent that the method of organising this test has made considerable advances beyond those adopted in the test of the

English Electric catalogue. This is partly due to the fact that in this case there was a control provided by the indexing done at Cranfield, which was made possible because the test collection had been restricted to 1,300 documents at the request of W.R.U. who would have had major problems in searching by the computer through their whole collection. Originally a collection of only 1,300 documents might have seemed too small to give valid results but now that the main project has given so much basic data concerning the performance of retrieval systems, it is practical to make further subsidiary tests with relatively small effort.

It was frankly a surprise to find that the W.R.U. system was not particularly effective either from the viewpoint of recall or relevance. The use of roll indicators should in theory have improved the relevance by eliminating irrelevant documents and the very detailed indexing as practiced by W.R.U. would be expected to result in a high recall. In fact neither with recall or relevance did it equal the performance of the Cranfield index and various hypotheses can be formulated as to why this should be.

If there have been clerical errors with the computer, these will be easily revealed by the analysis. More likely is that the fault will lie with the intellectual processes of concept indexing or in the formulation of the search programmes. To check these factors and to find the exact effect of the descriptor languages, it is intended that there shall be an exchange between W.R.U. and Cranfield of these two sets of data. W.R.U. will use the Cranfield programmes for searching in their index, while we will use the W.R.U. programmes for the facet catalogue. Then we shall pass to W.R.U. the concept indexing done at Cranfield to be translated into their system and retested both with W.R.U. and Cranfield programmes, while we shall do the same with the W.R.U. concept indexing. When this is done, it is certain that a considerable amount of additional information will be available on the strengths and weaknesses of the two systems and still more on the methods in which they have been used.

Further information has already been obtained from the Cranfield indexing, where the instructions were that every reasonable concept should be indexed and there should not be any inhibitions concerning the number of entries through concern regarding the size of the resulting catalogue. The intention was to do "exhaustive" indexing, so that it would be possible to find the effect of reducing the number of entries. Originally, as will be seen from Table 7.3, on an average

	W.R.U.	Cranfield
No. of documents indexed	1300	1150
Average No. of elements per document		7
Average No. of entries in catalogue		$12\frac{1}{2}$
Average indexing time		
Concept indexing		4.4 mins.
Notational indexing		4.5 mins.
No. of questions searched	125	129
No. of source documents retrieved	91	116
Percentage success	79%*	90%
Average No. of documents retrieved per search	15	7.4
Average search time		7.3 mins.
No. of source documents found in:		
1st programme	79	47
2nd programme	12	38
3rd programme		16
4th programme		8
5th programme		1
6th programme		6

TABLE 7.3

RESULTS OF SEARCHES IN WESTERN RESERVE UNIVERSITY AND CRANFIELD INDEXES

* After the searches had been made, it was found that due to clerical errors, 9 source documents had been omitted from the W.R.U. search file. This percentage figure has therefore been adjusted accordingly.

7 notational elements were used for each document with $12\frac{1}{2}$ entries in the catalogue.

No. of entries	% Source Documents Retrieved
$12\frac{1}{2}$	90%
8	89%
5	82%
3	74%

TABLE 7.4

RECALL FIGURE FOR SOURCE DOCUMENTS AS AFFECTED BY NUMBER OF ENTRIES

This resulted in a recall figure of 90%. The entries were then re-assessed and approximately one third were eliminated, so that an average of only 8 cards were in the catalogue for each document, (Table 7.4). On re-searching with the original search programmes on this basis, it was found that the recall efficiency remained at 89%, which shows that the eliminated entries nearly all represented redundant indexing, at any rate in so far as the search questions used in the test were concerned. The next stage was to reduce the entries to an average of 5 per document; this had the effect of bringing the recall figure down to 82%. The final stage was to bring the entries to an average of 3, resulting in a recall figure of 74%.

Further analysis of the search results is based on the 120 questions which were searched both at W.R.U. and at Cranfield.

In order to obtain a complete picture of the position regarding recall and relevance, an assessment was made not only of the documents retrieved, but of all the documents in the collection in relation to every question. For discussion of this, it is necessary to define the meaning given to the two terms, 'recall ratio' and 'relevance ratio'.

'Recall ratio' equals $100\,\frac{R}{C}$ where C equals the total number of documents in the collection which have an agreed standard of relevance to a given question, while R equals the number of those relevant documents retrieved in a single search. On the other hand, 'relevance ratio' equals $100\,\frac{R}{L}$ where L equals the total number of documents retrieved in a single search. As an illustration, presume that in a given collection of documents, ten are known to have an agreed satisfactory standard of relevance. In a single search, six of these documents are retrieved, plus another twelve documents which were irrelevant. In this situation recall ratio equals

$100 \times \frac{6}{10} = 60\%$ while the relevance ratio would be $100 \times \frac{6}{18} = 33\%$.

The results of the analysis showed that a rating of relevance 2 applied to 175 documents, made up of 120 source documents and 55 non-source documents. In addition there were 307 documents of relevance 3, that is documents of some interest. Table 7.5 illustrates the effect which decreasing the number of entries has on both recall and relevance. It will be noted that the recall figures for relevance 2 documents are lower than those given in Table 7.4. The latter referred only to retrieval of source documents, whereas the figures in Table 7.5 include the 55 non-source documents that were assessed as relevance 2, and the recall figure for these was lower than for source documents.

It can be seen from Table 7.5 and the accompanying graph (Table 7.6) that, as recall falls quite sharply, there is a slight improvement in relevance. Within the range in which we were operating, it appears that 1% improvement in relevance results in a 3% drop in recall, this applying both to relevance 2 documents and to all documents of relevance 2 or 3. It should be mentioned that this graph represents performance as influenced by indexing, and not by searching. By this it is meant that in all cases the same level of search requirement was maintained, namely that references would only be accepted if the notation contained a minimum of one less concept than originally demanded (see page 14 and Appendix 2B). It will be noted that increasing the entries per document from 3 to 5 and then from 5 to 8 resulted in an increase in recall ratio of 9% and 7%, but by increasing from 8 to $12\frac{1}{2}$ entries only gave an increase in recall of 2.4%. From this it is assumed that no further increase of indexing entries is likely to result in any material changes in the recall ratio, in other words we have probably come quite close to the maximum recall figure that can be obtained by indexing. If, however, the search rules were relaxed, then it would certainly be the case that the recall ratio would improve, and the upper dotted line in Table 7.6 is a probable extension of the performance curve. Alternatively if the search programme had been made stricter, so that no reference would be accepted unless it fulfilled the requirement of containing all the concepts of the question, the recall ratio would decrease as shown in the lower continuation of the dotted line.

Another family of curves could also be produced by varying the search conditions as given in the preceding paragraph but holding steady the indexing with regard to number of entries. This is an investigation which still has to be done.

No. of entries	No. of documents retrieved	Relevance 1		Relevance 1 & 2	
		Recall Ratio	Relevance Ratio	Recall Ratio	Relevance Ratio
12½	958	84.1%	15.7%	74.3%	34.1%
8	890	83.6%	16.6%	71.3%	35.2%
5	697	75.1%	19%	61.1%	38.5%
3	539	65.6%	21.6%	50.9%	41.7%

TABLE 7.5

RECALL AND RELEVANCE RATIO IN FACET CATALOGUE OF W.R.U. TEST AT VARYING INDEX ENTRIES

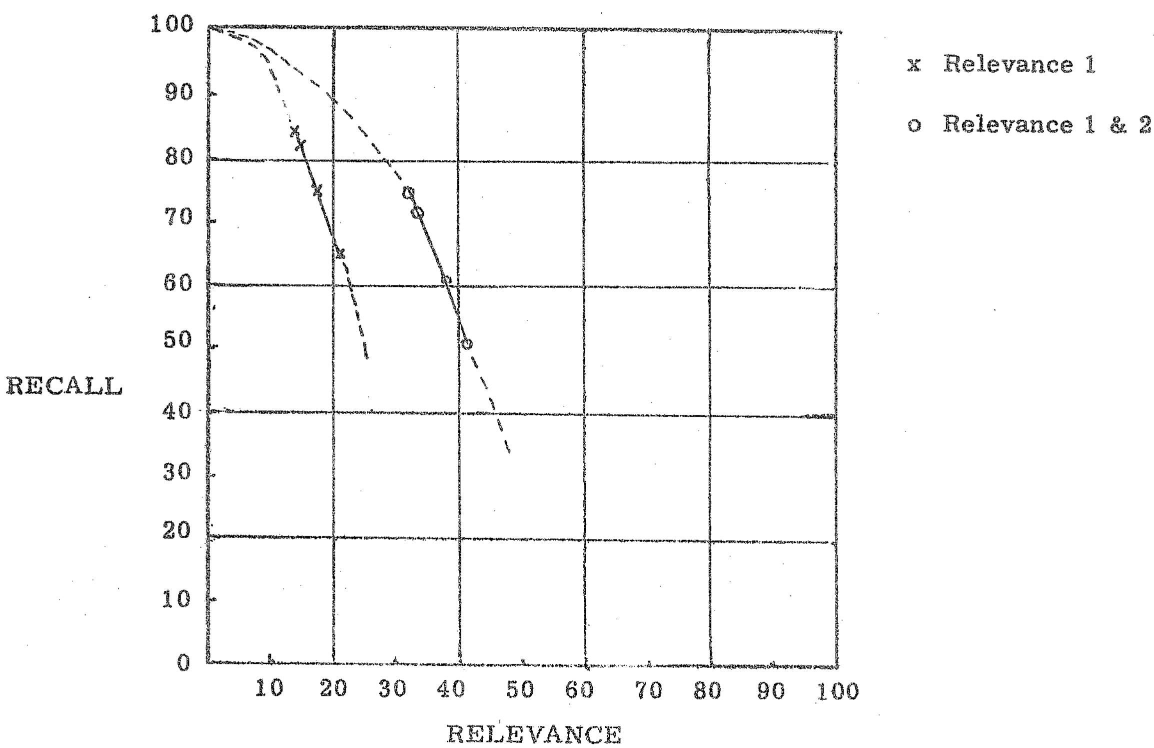

TABLE 7.6

PERFORMANCE OF FACET CATALOGUE OF W.R.U. TEST

An analysis of failures has been made for the Cranfield indexing and some of the more interesting are included in Appendix 7B. Summarised, the reason for 13 failures are shown to be as in Table 7.7.

Question	Too broad	1
Indexing	Insufficient indexing (concepts)	6
	Incorrect indexing (concepts)	2
	Omission of index entry into term in schedules	1
	Failure to translate concept indexing into class number	4
	Lack of permutation elements	6
Searching	Failure to search systematically	1
	Insufficient searching	3
System	More than one place in schedules for single subject	2
	Inability to permute in parts of schedules	1

TABLE 7.7

REASONS FOR FAILURE IN FACET CATALOGUE OF W.R.U. TEST

These reasons in total exceed the number of failures because the assessments often showed more than one aspect as responsible for the failure. Breaking down the analysis in another way gives the following reasons for failures:-

Indexing alone	6
Indexing and question	1
Indexing and searching	3
Indexing, searching and system	2

One aspect of this work which has been the cause of comment concerns the questions which are used for searching. There is a feeling that these questions are not typical and are in some way different from "true" questions. The problem has been well put by Alan Rees in his paper dealing with the W.R.U. test, and the following paragraphs are extracted from his report: (Ref. 7)

"The Synthetic Nature of the Questions.

"It is difficult to state explicitly how these differ from natural questions. Their artificial nature is obvious at once to all of our programmers. A synthetic question is based upon an association of concepts often peculiar to the document described and is therefore derived from an artificial environment. A real question, on the other hand, is derived from a wide background of associated ideas and represents concepts which a questioner feels are likely to be found in a document or documents. Such questions can be formulated in many ways due to the difficulty of individuals in real question asking situations in expressing their information needs.

"I have two points which I wish to make in relation to the synthetic nature of the questions-

"First, since a synthetic question is based upon one document, the formulation of the question reflects the individual, subjective interpretation of the questioner of the significance of the document. It is, therefore, analogous to the problem of indexing a document which is dependent upon point-of-view, subject background and insight of the indexer.

"I raise this point here since a preliminary check reveals that although some questions are based upon the title or author abstract of the source document, at least one question asks for concepts of minor importance in the text and, more seriously, another asks for "Processes available for producing sound, contamination free welds in titanium and its alloys" (Q21) while examination of the text of the source document by several members of our staff reveals nothing beyond an oblique mention of titanium in an eight page article. In the text there is no indication that contamination free welds have been achieved for titanium.

"The subjective judgement of our indexers is, therefore, to be balanced against the subjective judgement of Mr. Cleverdon's question compilers. Or, to put it in another way, the language of the question and the language of the indexing are not equidistant from the document.

"Second, since in many instances the association of concepts in the question is peculiar to the document from which it is derived, being perhaps an inverted statement drawn from the text, the relevance of any items identified, other than to source document, is artificial and it is to be questioned whether we are discussing the same kind of relevance as found in searches based on real questions.

"Third, the synthetic nature of the questions naturally precluded any negotiation with the question asker as to their precise meaning. Our experience in the analysis and machine searching of some six hundred questions now permits us to identify those questions where further clarification is needed prior to final definition of search strategy.

"In at least ten cases in the present series of test searches we were able to predict failure prior to searching. If the same requests were received from real question askers a concerted effort would have been made to clarify them. We have found that the degree of success achieved in searching is directly proportional to the amount of insight possessed into the nature, purpose and environmental origin of the requests. It is particularly difficult to plan an effective search on the face value of a written request."

While we would not necessarily agree with all these comments, at present there is little point in arguing the matter, for there is not sufficient evidence either way. It is reasonable to assume that the test figures are affected in some way or another by the use of special questions, but it does not necessarily follow that this affects the validity of the test. More work requires to be done on this specific point to decide exactly what correction factors should be built into the results, and we await with interest more detailed analysis of the questions from this viewpoint, which the experienced staff at W.R.U. will be making. In addition it is the intention to search the two catalogues with a number of questions that are put to W.R.U. in the course of their normal service to The American Society of Metals and this should help to a better appreciation of this problem.

It would be unwise to be over-confident on the general applicability and acceptance of this test technique, but the results so far are sufficiently encouraging to justify making a series of such tests in other subject fields. It is capable of extension by any organisation which is seriously interested in, for instance, achieving maximum economic efficiency. A short series of tests covering documents indexed under varying time allowances would permit the optimum to be selected. As has been done with the Cranfield-W.R.U. index, the effects of exhaustive indexing can be investigated, and the decision as to whether to include more or less cards in a catalogue or whether to use 10 or 50 uniterms can be based on something more logical than hunches.

CHAPTER 8

SUPPLEMENTARY INDEXING

At the same time as we were arranging for the compilation of questions, we invited those who were co-operating in this task to index documents by any of the systems being used in the project. The purpose of doing this was in order to have some data which would provide a comparison with the indexing done by the project staff. Those who agreed to help (see Appendix G of Ref. 1) were sent selected lists of documents which had been indexed in the project, and relevant indexes to the particular system or systems which they were using. Those indexing by U.D.C. received the alphabetical index to U.D.C. numbers which had been compiled by the project staff of all terms used in the indexing of the first 10,000 documents, together with information concerning the printed schedules which were being used. A list of the alphabetical subject headings or a list of the uniterms used in indexing the first 10,000 documents was sent to those indexing by Alphabetical or Uniterm, and a set of the schedules, the alphabetical index and indexing rules were sent to those using Facet. Each person also received a set of master indexing cards. (see Apprendix 8A).

A total of 3,793 items were indexed, and Table 8.1 gives relevant data on this indexing.

	No. of documents indexed	Average Indexing Time	Average entries
U.D.C.	1,115	10.8	3.6
ALPHABETICAL	902	11.3	1.1 (with 5 elements)
FACET	775	10.8	12
UNITERM	1,001	8.0	3.6

TABLE 8.1

DATA ON SUPPLEMENTARY INDEXING

Comparison with the indexing done by project staff showed that the average time fell near the middle time level used in the project, and that the average number of entries for each document was very close to that requested by project staff when indexing at 8 minutes. Further statistical data on the supplementary indexing is given in Chapter 7 of Ref. 1.

It was originally contemplated that the indexing entries would be incorporated in the project catalogues, but this was not done, partly because it would have caused extra complications but mainly because it was found that checking of the efficiency of the indexing could be done more simply.

Many of the documents which had been indexed could not be included in the test because no questions had been received for those documents, but altogether it was possible to test the indexing of 1772 documents. The method of testing was to take the master search cards which had been used in the main test. One person (A) would have this search card while a second person (B) had the appropriate master indexing card, examples of which are shown in Figure 3. 'A' called out the first search programme and 'B' checked the master indexing card to see if the programme fitted the indexing. If successful, that completed the operation; if unsuccessful, 'A' called at the second search programme for 'B' to check, and so on. In cases where, in the project the search had been successful at an early stage but the supplementary indexing search had not succeeded, then 'A' would, whenever possible, devise further search programmes, but without knowing the indexing decisions entered on the master card. The results of this testing are given in Table 8.2 where comparison is made with the results for the source documents achieved by the project indexing. The reason for the total number of documents not agreeing is because many documents were indexed by two or more organisations. From this table project staff would appear to be superior in both U.D.C. and Alphabetical, but not so successful by Facet or Uniterm.

Table 8.3 breaks down the supplementary indexing by countries, and the results cannot, in view of the comparatively small number involved, be taken to show any marked national differences of the kind which might be expected to appear because of the popularity of different methods in England and the United States. Table 8.4 continues this breakdown to cover different organisations.

	SUCCESS		FAILURE		% SUCCESS	
	Project	Supplementary	Project	Supplementary	Project	Supplementary
U.D.C.	263	430	51	135	83.8	76.1
ALPHABETICAL	306	389	51	121	85.7	76.3
FACET	142	248	50	65	73.9	79.2
UNITERM	225	337	55	47	80.4	87.8

TABLE 8.2

COMPARISON OF RESULTS OF PROJECT STAFF AND SUPPLEMENTARY INDEXERS

	United States	United Kingdom	Canada	Holland
U.D.C.				
Success	44	370	-	16
Failure	14	112	-	9
% Success	76%	77%	-	64%
ALPHABETICAL				
Success	165	156	57	11
Failure	52	57	5	7
% Success	76%	73%	92%	61%
FACET				
Success	46	190	-	12
Failure	8	51	-	6
% Success	85%	79%	-	67%
UNITERM				
Success	206	115	-	16
Failure	23	21	-	3
% Success	90%	85%	-	84%

TABLE 8.3

SUPPLEMENTARY INDEXING RESULTS BY COUNTRY

Key
a. Indexing Time in Minutes
b. Number of Documents
c. % Success

	U.D.C.			ALPHA.			FACET			UNITERM		
	a	b	c	a	b	c	a	b	c	a	b	c
UNITED STATES												
1.	-	-	-	15	5	80%	-	-	-	-	-	-
2.	-	-	-	9	20	85%	-	-	-	12	29	83%
3.	-	-	-	-	-	-	-	-	-	105	11	100%
4.	-	-	-	17	9	67%	19	7	43%	9	69	91%
5.	9	12	92%	8	13	85%	9	7	100%	5	12	92%
6.	-	-	-	12	9	78%	-	-	-	11	6	100%
7.	-	-	-	7	112	69%	-	-	-	-	-	-
8.	-	-	-	-	-	-	8	5	80%	5	13	85%
9.	-	-	-	13	11	91%	-	-	-	-	-	-
10.	-	-	-	6	4	100%	-	-	-	5	5	80%
11.	-	-	-	6	32	88%	-	-	-	-	-	-
12.	13	46	72%	-	-	-	12	35	91%	7	51	90%
13.	-	-	-	6	2	50%	-	-	-	7	13	85%
14.	-	-	-	-	-	-	-	-	-	8	20	95%
UNITED KINGDOM												
15.	36	27	89%	-	-	-	-	-	-	8	24	88%
16.	11	14	86%	-	-	-	-	-	-	-	-	-
17.	-	-	-	-	-	-	8	5	60%	-	-	-
18.	-	-	-	-	-	-	26	7	86%	19	11	64%
19.	21	11	82%	15	14	71%	15	7	86%	12	13	100%
20.	-	-	-	-	-	-	-	-	-	8	14	100%
21.	3	6	50%	-	-	-	4	6	83%	-	-	-
22.	14	18	61%	-	-	-	-	-	-	-	-	-
23.	-	-	-	-	-	-	6	29	79%	-	-	-
24.	11	13	85%	-	-	-	-	-	-	-	-	-
25.	-	-	-	3	67	70%	-	-	-	-	-	-
26.	10	30	77%	13	33	85%	24	17	94%	15	28	75%
27.	-	-	-	-	-	-	13	21	86%	-	-	-
28.	10	10	90%	-	-	-	-	-	-	-	-	-
29.	7	10	90%	-	-	-	-	-	-	-	-	-
30.	8	10	90%	-	-	-	-	-	-	-	-	-
31.	7	61	84%	8	28	50%	14	9	80%	5	10	80%
32.	19	9	67%	-	-	-	-	-	-	-	-	-
33.	-	-	-	-	-	-	14	41	83%	-	-	-
34.	10	21	71%	9	23	83%	-	-	-	-	-	-
35.	1	28	57%	1	25	76%	2	22	68%	1	27	85%
36.	8	54	65%	-	-	-	7	38	76%	-	-	-
37.	9	11	82%	-	-	-	-	-	-	-	-	-
38.	-	-	-	-	-	-	14	14	79%	-	-	-
39.	-	-	-	-	-	-	8	16	63%	-	-	-
40.	10	10	70%	-	-	-	9	7	72%	-	-	-
41.	7	14	79%	-	-	-	-	-	-	-	-	-
42.	5	13	69%	-	-	-	-	-	-	-	-	-
43.	14	16	88%	12	16	81%	-	-	-	-	-	-
44.	10	73	80%	-	-	-	-	-	-	-	-	-
45.	11	6	83%	-	-	-	-	-	-	-	-	-
46.	29	10	90%	8	7	86%	10	2	100%	2	9	89%
CANADA												
47.	-	-	-	5	53	90%	-	-	-	-	-	-
48.	-	-	-	8	9	100%	-	-	-	-	-	-
HOLLAND												
49.	29	25	64%	16	18	61%	23	18	67%	14	19	84%

TABLE 8.4

SUPPLEMENTARY INDEXING RESULTS OF INDIVIDUAL ORGANISATIONS

An analysis was made of all those cases where there had been failures with the supplementary indexing but where the project indexing had been successful. Not all the grouping included in the analysis of failures in Table 5.1 are appropriate, but they have been followed in Table 8.5, with some additional headings that were necessary. Table 8.6 groups these into the three main categories of indexing, searching and system, and it is not unexpected to find that indexing is the main cause of the failures.

	UDC	ALPHA	FACET	UNITERM	TOTAL
INDEXING					
2a. Insufficient indexing	40	48	16	14	118
b. Overdetailed indexing	1	6	1	1	9
c. Incorrect indexing	2	1	2	0	5
d. Lack of permutation	10	0	0	0	10
h. Lack of knowledge of indexing practice	14	12	1	0	27
SEARCHING					
3g. Insufficient searching	10	12	2	1	25
SYSTEM					
4a. No. of places for same subject in schedules	6	0	4	0	10
b. Lack of places in schedules	0	0	4	0	4
f. Bad choice of heading	0	10	0	0	10
g. Synonyms	0	0	0	3	3
h. Inability to combine headings	0	13	0	0	13
j. Lack of subject grouping of headings	0	4	0	2	6

TABLE 8.5

ANALYSIS OF REASONS FOR FAILURES WITH SUPPLEMENTARY INDEXING

	UDC	ALPHA	FACET	UNITERM	TOTAL
Indexing	67	67	20	15	169
Searching	10	12	2	1	25
System	6	27	8	5	46

TABLE 8.6

REASONS FOR FAILURES IN SUPPLEMENTARY INDEXING

From Table 8.5 has been extraced information relating to the efficiency in relation to the time spent on indexing, with the results shown in Table 8.7. In that the indexing times used by the project staff are estimated to have been at least 50% less than the equivalent time in a real-life situation, the breakdown of times in this analysis has been so adjusted to correspond as far as practical to the indexing times used in the project. This table shows that the large majority of documents by all systems were indexed in the range of 7 - 12 minutes, and also emphasises again the higher efficiency of Uniterm at the shortest indexing time.

Time	UDC		ALPHA.		FACET		UNITERM	
Minutes	a	b	a	b	a	b	a	b
1 - 3	34	56%	92	67%	22	68%	36	87%
4 - 6	13	69%	91	89%	35	80%	40	85%
7 - 12	356	80%	237	74%	115	80%	239	91%
13 - 18	80	73%	90	77%	92	83%	47	79%
19 - 24	20	75%	-	-	42	74%	11	64%
25 +	62	79%	-	-	7	86%	11	100%

TABLE 8.7

EFFICIENCY AT VARYING INDEXING TIMES FOR SUPPLEMENTARY INDEXING

(a) Number of documents indexed in group

(b) % Successful retrievals

CHAPTER 9

COMMENTS ON THE RESULTS

This test has produced a large mass of data, and even for those who have been actively engaged in the project, it is not always easy to separate that which is significant from that which is of little value. In this report and appendices, the attempt has been made to present at least examples of everything that might be of interest to serious readers so that they may have the opportunity of making their own assessments, and it has been the endeavour to keep to a minimum personal expressions of opinion. In the course of the work, the staff obtained a number of impressions concerning the various systems being used. These cannot be expressed as figures or percentages, but will, to a certain extent, influence the interpretation of the results as given in this chapter.

At first glance, the results as given in Table 3.1 show an unexpected level of performance, particularly if allowance is made for the possible standard error. Including this in the percentage results would produce the following figures:-

U.D.C.	73.1%	-	78.1%
ALPHABETICAL	79%	-	84%
FACET	71.3%	-	76.3%
UNITERM	79.5%	-	84.5%

Taking these at their highest or lowest ranges shows that all four systems could be within the range of 3.2%, and it is doubtful if a claim that this is significant in an investigation of this nature could be substantiated. However, the figures at the other extremes would give a difference of 13.2% and this would be a worthwhile figure.

More logical is to consider the figure for the result of the searches which were based on documents in the final sub-programme of documents P12001 - P18000 (Table 3.5), for these represent the work of the indexers when they were operating at their highest efficiency. The figures here give Uniterm with a superiority of 3.8% over Alphabetical which is in turn 5.3% above U.D.C., with Facet a further 3.5% behind.

The breakdown according to system and time, as shown in Table 3.2, is subject to a larger standard error of between 5 and 6%. This can be reduced by ignoring the system and grouping the indexing by time only, and results in the figures as shown in Table 9.1.

Indexing Time Minutes	Percentage Retrieval
2	72.9%
4	80.2%
8	76.2%
12	82.7%
16	84.3%

TABLE 9.1

EFFICIENCY BY TIME FOR ALL SYSTEMS

These figures show an expected increase from the short time of two minutes to the longest time of sixteen minutes, with the exception of eight minutes. In the view of the indexers, there is a possible explanation as to why the efficiency showed a drop at this middle time. When working at the short times of two minutes and four minutes, they knew that there was little time to spare, and concentrated on making entries for the essential concepts. When working at the eight minute level, they felt free to study the whole document more closely before making any indexing decisions. In fact the time allowance was not really sufficient for this to be done thoroughly, so the end result was that the standard of the indexing decreased. This is not a statement that can be substantiated and might appear to be contradicted by the figures given in Table 1.2. This shows that there was an increase in the number of entries in the catalogue according to indexing time, and it could be assumed that, when recall was the only factor being measured, extra entries in the indexes would result in an improvement. On the other hand there is slight support for the argument, in that analysis of the failures showed a greater proportion of errors in indexing at eight minutes than at the other time allowances.

While the figures indicated that two minutes was probably too short an indexing time, four minutes gave results which by all systems are only slightly inferior to the indexing times of twelve minutes and sixteen minutes. By Uniterm the four minute time was within 1% of the figure for sixteen minutes, and with a collection of documents such as used by the project it appears that there would be no justification in spending more than four minutes indexing. With sixteen minutes indexing, not only would the indexing costs be four times as great, but also there would be the increased posting cost occasioned by having an average of 12.4 Uniterms per document as against 7.7 at four minutes.

The indexing times given in the project were governed by the use of a stop watch, and represent real time spent on actual work. As discussed in Ref. 1, pages 24-25, to translate them into a real life situation would require adding 60% to the basic times, so that the four minute indexing time would thus become about $6\frac{1}{2}$ to 7 minutes. This brings it within the range of indexing time that was most generally used by the supplementary indexers, as shown in Table 8.7, and is also very close to the average time found necessary by Mrs. Aitchison when indexing documents in connection with the W.R.U. test.

The breakdown by indexer (Table 3.3, page 23) shows no significant differences between the three members of the staff, but worthy of comment is the ability shown by Mr. Hadlow to index with an efficiency equal to that of the more experienced members.

The assumption is commonly made and frequently asserted that scientific or technical documents can only be satisfactorily indexed by a person having detailed subject knowledge of the field. This may be true in certain subject fields, but all the results of the investigation show that it cannot be substantiated for such subjects as physics, engineering or metallurgy. In the main test analysis (Chapter 5) it is shown that only with two of the 1200 source documents could lack of subject knowledge be considered a contributory factor in failure to retrieve. The librarian indexers certainly had difficulties with many of the documents, and frequenctly had recourse to scientific and technical dictionaries, but they were very successful in dealing with a wide range of research papers, particularly considering that Mr. Hadlow came direct from a public library, with no experience either of the subject or of doing indexing of this type. In addition it has to be remembered that, during the two years, neither he nor the other indexers received any feedback as would be the case in a more normal true life situation, where the probability would be that they would not only be indexing documents but would also be helping to answer enquiries, and thus acquiring knowledge both of the type of questions put to the system and of the ability of the indexing to meet the requirements.

Table 3.4 considers the results of searches based on the subject matter of the question. There is a possibly significant difference in favour of general questions. This was to be expected, since the major concentration on documents in a narrow subject field resulted in a multiplicity of alternative locations, whereas in the wider, more general field, there would be less difficulties in selecting the appropriate headings. It was interesting, and in view of other results, possibly significant that the difference does not appear with Uniterm.

Table 3.5 (page 24) indicates that there was an improvement of 17.5% for Uniterm in the last sub-programme as compared with the first, 13.3% for U.D.C. and only 7.8% for Alphabetical. It was surprising to find such a large improvement in Uniterm. It might appear to be accounted for by the fact that the number of Uniterms posted in the final sub-programme was 32% higher than in the first sub-programme (see Ref. 1, Table 5A). This difference in posting, however, is lower than the difference of 60% when indexing at the different times of four minutes and sixteen minutes. Since in this latter case there was an insignificant increase in the efficiency, it would seem that there must have been a greater definite improvement in the standard of indexing by Uniterm than by the other systems. Table 5.5 (page 49) gives some information on this matter. It is a rearrangement of the figures as set out in Table 5.4 (page 49), being the reasons for failure of all searches covering documents in the final sub-programme, with emphasis on the human error involved. There is shown to be an average for all systems of 35% of failures due to bad indexing, ranging from 42% for U.D.C., to 32% for Facet. The number of searches made using questions based on the two first sub-programmes was limited, so the failures are so few that there is doubt as to whether they can be considered sufficient in number to permit of the detailed breakdown of reasons for failure as has been done for the main programme. With this reservation, Tables 9.2 and 9.3 have been compiled in an attempt to show the particular point concerning learning rate for the different systems.

	U.D.C.	ALPHA.	FACET	UNITERM	TOTAL
Personal Errors					
Indexing	15 (43%)	10 (40%)	-	13 (52%)	38 (41%)
Searching	4 (11%)	2 (8%)	-	1 (4%)	7 (8%)
Time Allowance	6 (16%)	4 (16%)	-	3 (12%)	13 (17%)
Question	5 (15%)	5 (20%)	-	4 (16%)	14 (17%)
All Other Reasons	5 (15%)	4 (16%)	-	4 (16%)	13 (17%)

TABLE 9.2

BREAKDOWN OF REASONS FOR FAILURE ON DOCUMENTS INDEXED IN FIRST SUB-PROGRAMME (DOCUMENTS 1 - 6000)

	U.D.C.	ALPHA.	FACET	UNITERM	TOTAL
Personal Errors					
Indexing	20 (43%)	13 (38%)	12 (28%)	14 (35%)	60 (37%)
Searching	5 (11%)	4 (13%)	8 (19%)	3 (8%)	20 (13%)
Time Allowance	8 (18%)	6 (17%)	6 (14%)	10 (25%)	30 (18%)
Question	6 (13%)	5 (15%)	5 (12%)	6 (15%)	22 (14%)
All Other Reasons	7 (15%)	6 (17%)	11 (27%)	7 (17%)	30 (18%)

TABLE 9.3

BREAKDOWN OF REASONS FOR FAILURE ON DOCUMENTS INDEXED IN SECOND SUB-PROGRAMME (DOCUMENTS 6001 - 12000)

In comparing the tables with Table 5.5, the only significant change in percentage occurs with Uniterm, where from 52% of the personal errors for indexing in Table 9.2, there is a change to 34% in Table 5.5. This, in so far as anything is likely to do in the present investigation, appears to substantiate the view that it was not any inherent difficulties which made Uniterm originally difficult to operate that were the cause of the increase in efficiency, so much as the chance of human error.

Considering the searching, it will be seen from Table 3.7 that the three project staff concerned with making the searches in the first two rounds of testing did not have any significant variation in their efficiency. A check was also made on the results for Warburton and Hadlow when searching for documents which they had themselves indexed, but this revealed no difference from their general figures. Some more interesting figures are given in Tables 3.8, 3.9, 3.10 and 3.11, as these deal with the searches made by technical staff. These repeat the results obtained by the project staff with the exception that U.D.C. had a superiority of 5.7% over Alphabetical as compared to an inferiority of 5.9% with the searching by project staff. The figure for U.D.C. was also the only system where technical staff returned a higher figure than the project staff, and the result would, to say the least, appear to cast considerable doubt on the oft repeated argument that the notation of U.D.C. is too cumbersome to be mastered by technical staff.

A problem that is attracting much interest at present is the formulation of search programmes. This is particularly the case in organisations which are attempting to use some form of mechanised retrieval, for an incorrect search programme will result in severe time and cost penalties due to the comparative inflexibility of computer searching. Allied to this, a criticism of the project programme as originally proposed was that it would not be dealing with the physical act of retrieval from the store. The reason for our not attempting to cover this point was that the investigation was concerned with what was thought to be the intellectual aspects of information retrieval rather than the clerical. The formulation of the search programme, the decision as to which concepts or which combination of concepts to search first, is the intellectual part of the work, whereas the physical act of locating these items which have been marked with the appropriate tags is a clerical routine. In spite of the fact that there was no controlled test on this latter point, the experience of the project staff may be of some interest. It is clear that we were not prepared to spend the length of time in physical searching which some organisations appear willing to do. This came up in particular with the original Facet catalogue, as can be seen from the comments in the analysis of failures, where several times the conclusion is reached that the searcher considered that the number of different places to be searched in the course of a single programme was more than could be tolerated. It was this point, more than anything else, which caused the comparatively low retrieval figure for Facet, and led us to the decision that fixed order and chain indexing were not suitable for the type of indexing done in the project.

The most reliable figures which can be produced are those given with the W.R.U. test (Table 7.3), where the average search time is shown to be 7.3 minutes. This compares with the general opinion of staff searchers that they would expect to make from seven to ten searches an hour in the U.D.C. and Alphabetical card catalogue. Concerning Uniterm, we knew that posting document numbers on cards was a relatively archaic method that was inferior to other techniques such as peek-a-boo cards, and the only comment on this point is that our experience proved what we already knew.

The decision as to what is a reasonable search time is a matter for each organisation to consider in the light of its own circumstances, but it has been a matter of surprise to find the time delay which many organisations appear willing to tolerate for the doubtful benefit of using some form of mechanical retrieval. In the field of applied science and technology, the position in England seems to be that most librarians expect to be able to supply some references within five to ten minutes of receiving the enquiry. No-one would suggest that in such a time they would be able to obtain every relevant reference. However, experience again indicates that frequently the requester is satisfied with some documents relevant to his enquiry, and does not, in the first place, require a complete collection of all relevant documents. Naturally, there are occasions when this is required, but an I.R. system which cannot meet the necessity for supplying some relevant documents within a few minutes would fall short of the ideal for many organisations.

This being the case, the formulation of such programmes must be a reasonably straightforward matter, and this was the position with the project searches. The majority of source documents were retrieved by the first or second search programme and it can be seen from Tables 5.4 and 5.5 that searching was only responsible for 17% of the failures, and of this 15% was adjudged to be due to human errors. The analysis of failures which has been made in Chapter 5shows most decisively that the failures were, for more than all other reasons together, due to mistakes by the indexers or the searchers, and that a third of the failures could have been avoided if the project staff had indexed consistently as well as they were capable of doing. Put another way, this means that in every hundred documents, the indexers failed to index adequately five documents, the failure usually consisting of the omission of some particular concept. They might legitimately plead that the conditions under which they worked for two years, such as the monotony of the work or the continuous re-adjustments of indexing times, were not conducive to that concentration which is required to obtain perfection. In fact, they have no reason to plead, for the analysis of the supplementary indexing and of other systems has shown tnat their performance was above average.

As has been emphasised in Chapter 6, the emphasis in the main test was on recall, and other tests had to be developed in order to put the figures in perspective. To do this with any real precision turned out to be impractical, but these further tests, together with the tests on other systems, have shown that the general working level of I.R. systems appears to be in the general area of 60% - 90% recall and 10% - 25% of relevance, the shaded area of Table 9.4. This is a considerable distance away from the oft-made assertion that systems are operating in the general area of the top right-hand corner.

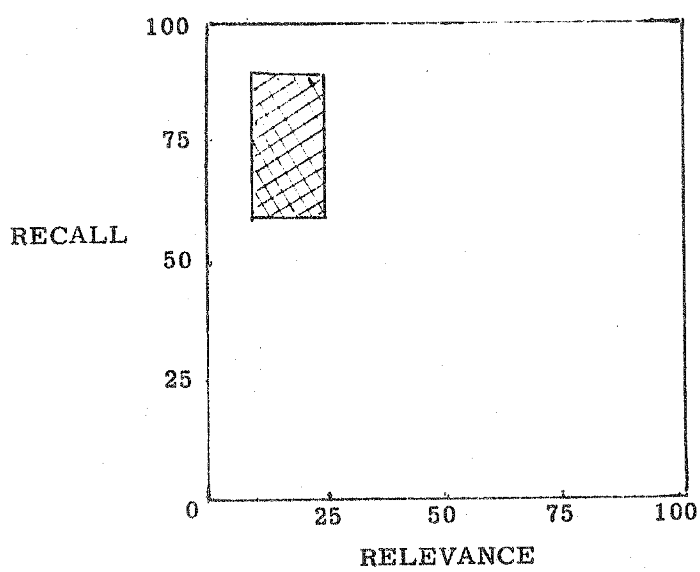

TABLE 9.4

PROBABLE OPERATING AREA OF I.R. SYSTEMS

Further, it can now be said that the inverse relationship between recall and relevance has been conclusively shown, and it should be now possible to design and operate systems that will satisfy, in the most economic way, stated requirements. There will be situations where the emphasis must be on the highest possible recall level, and the resulting penalty of the low relevance figure will be accepted. In other cases recall is less important, and greater emphasis will be placed on improved relevance. It must be stressed that the relevance figures depend entirely on the references which have been retrieved by the programmes used in the search, and no attempt has been made to weed out the irrelevant documents. It must not, therefore, be imagined that there is necessarily a severe time penalty by the librarian or the searcher having to look through a number of useless documents. It would be dangerous to be too definite on this point, but it would not be unreasonable to suggest that, in the conditions prevailing in the systems tested, a rapid visual check of the titles and in some cases of the abstract would enable the large majority of the useless references to be eliminated straight away. To express this in figures, one might say that of every hundred documents retrieved in the W.R.U. test, fifty could be quickly and safely eliminated as being of no possible interest.

The problems arising in indexing by the four systems have been dealt with in detail in Chapter 4 of Ref. 1., and the following comments should be regarded as supplementary to the earlier statements.

Universal Decimal Classification

In that most of the professional staff searchers were reasonably familiar with this system, it is difficult to record fresh opinions. Most striking, perhaps, was the great value and importance of the alphabetical index for the schedules, which was of a higher standard than any of us had previously used. It completely justified the considerable amount of effort which was entailed in its compilation, and was clearly responsible for the high level of success achieved by the technical searchers.

It soon became obvious that the indexing was more specific than the searching could possibly be. More than half the entries in the catalogue consisted of notations having three or four coloned elements, e.g. 533.6.013.412: 533.6.057: 533.6.011.35, but it was only in approximately one search out of ten that the searcher felt justified in using more than two elements.

The main advantage in the classified arrangement appeared to be in being able to combine in alternate searches specific and broad concepts. The question, for instance, might be "Buckling stresses of circular fuselages". The specific heading would be 629.13.012.213.1:531.224.4, which represents a literal translation of the two concepts in the question. If this failed, each concept could be broadened in turn, searching first under 629.13.012.213.1:531.2+ (Stresses plus any subdivision of 531.2) and then 531.224.4:629.13.012.2 (Fuselages) or even 531.224.4:629.13.012+ (Aircraft structures plus any sub-division of 629.13.012). Such searches frequently resulted in success without paying too high a penalty in retrieval of irrelevant information. It was not always possible to do this type of search in Alphabetical, due to the restriction on combined headings that is discussed later, and even when practical, it involved far more search effort. It would have been possible to do it with Facet, but the effort would have been prodigous. With Uniterm it presented few difficulties.

Alphabetical

This system was far more effective than had been expected, and met with the general approval of the technical searchers. The main frustration came in searches where it was desired to combine two main headings, which is another way of saying that the headings were not sufficiently specific. This point received critical comment from the technical searchers, who also felt that there was inconsistency in certain headings, in particular the terms that could be associated with 'Boundary Layer'. This was because of the basic rules which we had compiled to cover the types of terms that could be used as main headings or sub-headings (see Appendix 8A), and can be considered more a defect of the authority list than of the method of indexing.

As explained in Ref. 1, no "see also" references were used in the main testing, and it was surprising to find that such a small percentage of failures were considered to be due to this. The technical staff had, as might be expected, more difficulty in this respect, and found that they tended to "go all round the subject" before alighting on the heading used by the indexer.

Facet

Most of the comments concerning Facet have been made in the earlier chapters. Its weakness undoubtedly lay in the insistence on the use of a fixed order combined with chain indexing, and from our experience it appears unlikely that this technique could have been successfully applied in this investigation. There are indications throughout the test results that the more elements making up the complete notation, the greater the difficulty in locating the source document, but even with less specific indexing, the use of the chain index would have resulted in difficult and tedious searches.

As a classification covering the subject field of the investigation, the schedules were considered to be very satisfactory by the indexers, a view which was not changed by the sear ching. This was particularly shown in the subsequent test (see page 59), when the fixed order was abandoned and entries made by logical combinations of the elements.

The notation of the Facet scheme, consisting of upper and lower case letters, was most unsatisfactory, for there were frequent cases of confusion caused by insufficient difference between letters. This could have been largely avoided if certain letters and combinations of letters had been omitted. As it was, an eight letter notation was more awkward to handle than a numerical notation twice its length.

Uniterm

Uniterm, as a descriptor language, can be given a high rating on many counts. It achieved the best overall figures in the test, it presented no serious difficulties for the technical searchers, it was the highest scoring system in the supplementary indexing, both for indexers in the United States and in England, and was notably successful with short indexing times. It appears to have as good a relevance figure as any other system, and Table 6.6 (page 58) indicates that it did not compare unfavourably in the recall of non-source relevant documents.

It was deliberately operated in the simplest possible form, and, as discussed in Ref. 1, p 74, it took, compared to the other systems, very little time to prepare.

The project originally began as an investigation into the comparative efficiency of four indexing systems, and it might appear to be shirking the issue if no attempt was made to answer the question that is so often put to us, "What system is recommended ?" This is impossible to answer without qualification, for no system which has been investigated has shown itself to be so markedly superior as to justify its use in all conditions. The size of the collection, the number of users, obviously the subject matter; these are the type of considerations which would influence a decision.

To take a personal case first, an academic organisation where all the students are working on research theses. By discarding older references, the collection remainds fairly constant at 40,000 - 50,000 documents. At certain times of the day there may be a dozen or more people wishing to consult the catalogues. The majority of the search questions will be for background material but many requests are for specific information. A card catalogue is, in these circumstances, the most practical store. Indexing is at a level of an average of five entries per document, with an alphabetical arrangement of the cards in the catalogue. The general use of inverted headings in the alphabetical subject list gives a measure of classification, to a level which appears to be most useful to the searchers. Combined with the list of headings is given a set of classified schedules to enable the searchers to find the appropriate and related headings.

As a different environment, we consider an information service in a research organisation where the staff of the library would normally carry out the physical search. In this case a post-co-ordinate system would appear most effective. Possibly the quickest and cheapest store would be peek-a-boo cards, which are certainly effective for a collection with an annual intake of up to 20,000 documents. The alphabetical subject index to the facet schedules would be perfectly satisfactory for the list of terms; the facet schedules would enable the terms to be used more effectively in indexing and searching.

If, however, the catalogue was to serve a number of different establishments within a large organisation and covered many different subject fields, then there would appear to be reasonable grounds for deciding to use a standard system such as the Universal Decimal Classification. On the other hand, if the subject field is reasonably concentrated, then facet analysis is (to quote from Mr. Sharp's comments in Ref. 1) "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". The facet schedules used in the project and in connection with the W.R.U. test were completely effective when the original principle of fixed order was abandoned.

However, our own predilection (a word which we use in its precise meaning, for we can produce little data to substantiate it) would be that, where a large computer and high speed print out was available, printed indexes should be made available to as many individuals as required them. To do this effectively, simply and relatively cheaply, each document would be given a serial number and a list of these, either titles and references or with the addition of abstracts, would form the basic permanent store, to be supplemented with additional entries as required. The documents would be indexed by a special facet classification designed for the purposes of the organisation, with the separate elements being combined as required, and an average of eight such combinations being allocated for each document. A master classified card catalogue could be maintained if desired, but the entries would be entered on tape, so that print-out would give a copy of the classified card catalogue, except that it would not be necessary to repeat the notation for all the separate entries that might have that notation. To take a sample from the facet catalogue in the W.R.U. Test, it would read:

Nu Jg Dk	11799
Nu Ldr	11247, 11396
Nu Mahf Nbi Ok	11209
Nu Nbe Mahp	11514, 11632, 11895
Nu Nbe Vls	11516, 11732
etc.	

In a small collection, as was used in the W.R.U. Test, the number of different notations will be large in relation to the number of documents, but will decrease as the collection grows. To up-date such a file would be relatively simple, and it would also be possible to subdivide the printed classified index so that individuals received only those sections which covered their main interests. It is estimated that for a collection of 100,000 documents, the classified index would contain about 400 pages, if printed in a double-column layout such as Chemical Titles. With KWIC indexing, a similar collection would require an index five times the size, and would not be amenable to subdivision.

We await with keen interest news of any such application.

CHAPTER 10

BASIC PROBLEMS OF INFORMATION RETRIEVAL

In this concluding chapter, an attempt will be made to survey the basic problems of information retrieval. Many of our statements will have been made before, and much of it may appear to be in the nature of a "child's guide" to the subject. Certainly, however, for many of our assertions it would be easier to find contradictory statements rather than supporting statements, but it is hoped that the experimental results obtained in the investigation will provide supporting evidence that has previously been lacking.

The discussion can be grouped into three main aspects. First there are the requisites needed for an I. R. retrieval system. Secondly there are the essential operations to be carried out and thirdly there is the question of system performance. Inevitably, due to the interaction between these various aspects, it will not be possible to maintain these divisions throughout the discussion.

The basic requisites for an I. R. system are that there should be a group of potential users and a collection of documents, (which we will define as being a general term to cover any item bearing intelligible marks) that can potentially meet some or all of the information requirements of the users. There must be a physical environment to store the documents in whatever form they may be, and so far we have come to the stage of describing a 'library' in the classical sense of being an unexploited collection of documents. To turn this into an information retrieval system, we require that the useful information content of the documents should be recorded in a descriptor language and that a store should be available for these records. The descriptor language may be basically simple or have a complex structure and may be operated at a shallow or deep level. The store may be one of many different kinds, such as a printed volume, a conventional card catalogue, a collection of edge- or centre- punched cards or a computer.

The essential operations of the information retrieval system which we wish to consider are limited to those which have been covered in this investigation and which are considered to form the core of the whole problem. There are a number of important actions concerned with acquisition which precede the first operation, but whatever these may be, eventually they lead to the stage where a document has to be indexed. The six operations from thereon consist of:-

(1) concept indexing of the documents,

(2) translating the concept indexing into the descriptor language,

(3) entering coded information into the store,

(4) concept analysis of the question,

(5) translating the concept analysis into descriptor language,

(6) extracting coded information from store.

Later operations cover straightforward clerical matters such as obtaining the original documents, but these are likewise outside the scope of our work. Nor are the methods of assessing relevance of retrieved documents considered here, since it is not essential for this to be carried out within an I. R. system.

The performance of an I. R. system can be considered from a number of aspects. Basically there is the efficiency in regard to recall and relevance. Its performance in these matters will be affected by the indexing, the formulation of the search programme and the specificity of the request. The decision as to the descriptor language and the store will determine the time and cost performance of the system, although this can also be influenced by the efficiency which is demanded.

Having summarised the three groups of problems to be discussed, we will now attempt to show their inter-relationship in the light of the results of the investigation. The most difficult, most onerous task in I. R. is indexing, the plain hard slog of indexing; on how well this is done will depend more than any other factor the efficient performance of an I. R. system. To quote Fairthorne, "Indexing is the basic problem, as well as the costliest bottle-neck of information retrieval".

Indexing, in the sense in which it is conventionally used, is a two-stage process, even though many indexers will merge these two stages into a single process. The first task of indexing is to decide on the subject content of the document which is worthy of inclusion in the index. This we term 'concept indexing' and is in all present conditions an intellectual process. There are attempts to turn it into a pseudo-clerical process, and it might be argued that this has been done with key-word-in-context indexing, and that it is being attempted in a more sophisticated manner by statistical indexing (e.g. Ref. 8). This is to some extent true, but to do this is to make the decision as to what subject concepts should be included in the index according to some pre-arranged plan. A human indexer will also probably try to work to a plan, but is able to alter his requisites in the light of special circumstances; the penalty for the ability to do this is the probability of human error, as has been demonstrated in the analysis for reasons for failure in the various tests.

However, for the purpose of this discussion, we will assume that the decision concerning the concepts to be included is made by human indexers, and is therefore an intellectual process. The second aspect of indexing is translating the selected concepts into the descriptor language. As has been said, most indexers tend to merge this operation with the previous process of concept indexing, for they will think of their concept in the terms of the descriptor language, but these are two distinct processes, and the second part, the translation into the descriptor language is, or should be, purely a clerical process.

Consider a document which is being indexed. The decision is taken that the document's subject content which is related to the purpose of the index is represented by concepts A, B, C, D and E. This is the basic operation of concept indexing and more than any other matter will determine the resulting efficiency of the system. No document can be retrieved under a given concept unless its concept has been included at this stage. Equally important, if the concept is correctly translated into the descriptor language, it is capable of being retrieved whatever descriptor language is used. To illustrate this latter point, consider four descriptor languages such as were used in the project.

	Descriptor Language			
Concept	I	II	III	IV
A	A_1	A_2	A_3	A_{4a} $_{4b}$
B			B_3	B_4
	$(BC)_1$	$(BC)_2$		
C			C_3	C_4
D	D_1	D_2	D_3	D_{4a} $_{4b}$
E	E_1	E_2	E_3	E_4

TABLE 10.1

TRANSLATION OF CONCEPTS INTO DESCRIPTOR LANGUAGES

Translating the concept indexing into the descriptor language I results in the indexing terms A_1, $(BC)_1$, D_1, and E_1. For descriptor language II, the indexing terms become A_2, $(BC)_2$, D_2 and E_2. Similarly for descriptor languages III and IV, from which it is obvious that the four resulting indexes will contain exactly the same information concerning the document.

This matter obviously raises some further points, and to deal with these it is necessary to consider the nature of descriptor languages in terms of the basic types rather than in terms of examples of types, such as U.D.C. or a particular alphabetical subject heading list. In doing this we would stress the similarity rather than the differences, for it has been the belief that descriptor languages essentially differ from each other which has caused so much confusion.

All practical descriptor languages have common ground in their necessity to have

(a) an alphabetical arrangement,

(b) an arrangement showing relationship between terms.

This is not to say that every example of an actual descriptor language has these two parts, for many simple Uniterm installations or the Keywords index of U.S. Government Technical Reports only have the alphabetical arrangement. It can hardly be denied, however, that they would improve their efficiency if the user had the further assistance of readily being able to locate related terms. Further, assume in an alphabetical subject catalogue, the not uncommon position that a new term is required. Either from memory (if keen enough) or by a visual check, the indexer must go through the other terms already in the system to find whether a new term should be entered as such or whether it should be directly cross-referenced to another term. If "see also" entries are used, then the process must be repeated to find which terms to "refer to" or to "refer from". Failure to do this at the indexing stage would merely transfer the operation to the search stage, where if there were a failure to find required information under a certain term heading, the searcher would have to make his own personal classification or grouping of other terms in the system which might be useful for his purpose.

In practice, certain descriptor languages use the alphabetical arrangement for the entries in the store, while in other cases the alphabetical arrangement is used as an index to some form of classified grouping of entries in the store. To simplify discussion on this point, we would here confine discussion to systems using pre-co-ordination, such as were, in the project, U.D.C., Alphabetical and Facet. Assume that these three systems are represented by descriptor languages I, II, and III in Table 10.1. It has been shown that into each descriptor language has been fitted the basic concepts A, B, C, D and E. In one case the coding is represented by decimal notation, in the second case by words and in the third case by letter notation, and these will determine the filing orders of the entries in the store. What exactly is the purpose of the different filing orders ? Each system has had exactly the same amount of information put in to it, and therefore each system is potentially capable of retrieving the same amount of information irrespective of the order in which the entries are filed. The only valid reason that can be given for any particular filing order is the convenience of the users of the catalogue. The conventional reason in favour of a classified filing order is that similar subjects are brought in proximity with each other, with the implication that this is not the case with Alphabetical. In favour of an alphabetical filing order is that the searcher can go direct to the store, with the implication that the searcher finds difficulty in using an alphabetical index leading to an unfamiliar notation.

In the project not one of these or of other points was shown to be of any real importance. The technical staff found no difficulty with the complex U.D.C. numbers used in the project, and scored better than with Alphabetical. An analysis of the search programmes showed that U.D.C. searches involved just as many different places in the catalogue to look as with Alphabetical. The analysis showed no significant difference between alphabetical and classified systems for failures which could be in any way put down to the filing order. Convenience for users is, therefore, the predominant consideration.

Whereas we have been considering so far the descriptor languages of a type which are normally used in a pre-co-ordinate manner, the position is, within the context so far considered, exactly the same with post-co-ordinate systems, but before arguing this matter, it is necessary to discuss the final aspect, namely system performance.

The points which have been shown on the curve in Figure 7.6 (page 72), refer to the performance of the particular system that was being tested, the Facet catalogue of metallurgical literature used in the W.R.U. test. The section shown in solid line is that part of the performance curve for which we have definite information, and this shows how one can obtain, for instance, 90% recall. We also know how to obtain 100% recall, for this can always be done in any system and for any question by looking at every document in the collection. Since it is known in the W.R.U. test collection that there was for each question an average of 3 documents with some degree of relevance, to take this extreme action of looking at every document would produce the low relevance ratio of $\frac{3 \times 100}{1100} = 0.27$. It would probably be possible to improve this relevance ratio slightly by some form of broad grouping without losing the 100% recall, but inevitably there would be some stage where the improving relevance will result in a breakaway from the 100% recall. This argument will not, of course, hold in an environment where the breadth of the question requirement is equal to the breadth of the collection index. If the requests are for all information on metallurgy, and the document collection consists of only documents on metallurgy, the 100% recall will be achieved with 100% relevance.

In considering recall and relevance it is therefore necessary to consider the environment in which the system is operated and here the most important factor is the type of question which will be put to it. Commonly one finds questions being defined as "specific" or "general", but it is difficult to give any agreed assessment to these terms; a question that might be considered specific in a general reference library would be a general question for a library specialising in the particular subject area of the question. Some suggestions have been proposed for defining specificity or generality by relating it to the number of concepts contained in the question, and this method has been considered. While it may be reasonable to do this in comparing different questions in relation to each other in a given situation, it appears to be of doubtful use when attempting to obtain more precise values. It is therefore proposed that this matter should be controlled by giving question specificity or generality a definite measure which will be obtained by relating the size of the total collection to the number of relevant documents which the collection contains. This would assume that the subject content of the collection was restricted to a single discipline, and the following table is suggested as giving this measure based on a collection of 100,000 documents:-

Number of Relevant Documents	Question Generality Figure
0 - 4	1
5 - 10	2
11 - 20	3
21 - 40	4
41 - 100	5
101 - 500	6
501 - 2000	7
2001 - 10000	8
10001 - 20000	9
More than 20000	10

TABLE 10.2

QUESTION GENERALITY FIGURES

Indications are that the general level of operation is covered by Generality Figures 5 to 6, although individual questions would cover a far wider range.

Since, to return to the previous argument, it is known that without using any system, one can always obtain 100% recall, it therefore appears logical to argue that the indexing is not carried out for the purpose of finding relevant documents so much as the purpose of not having to look at large numbers of irrelevant documents. In stating, therefore, the performance requirements of an information retrieval system, one can either ask that in a given environment, it must give a certain recall ratio with the best possible relevance figure, or say that it must have a given relevance figure with the best possible recall ratio. Add to that the requirement that the cost must not be above a certain figure and one has a complete operational specification.

We can now start working back to the indexing to find how this can be effected. First to the discussion broken off concerning the essential similarity between pre-co-ordinate and post-co-ordinate systems. If the fourth descriptor language in Table 10.1 is taken to represent a post-co-ordinate system such as Uniterm, it is definite that it contains no more information concerning the basic document than do the other three pre-co-ordinate systems. The apparent difference between the two types of systems is that the post-co-ordinate system has the ability to retrieve any combination of the concepts, whereas the pre-co-ordinate system can only do this by having the requisite entries in the catalogue. It has frequently been implied that this is an outstanding advantage which makes a post-co-ordinate system far more effective in retrieval, but the results of the investigation show that this advantage, though it existed, was not large . In the Facet catalogue of the W.R.U. test, when eight entries were made for each document, it had virtually disappeared. The difference between the two types of system is therefore shown to be not a fundamental difference but merely one of cost or convenience, and it has not been proven as yet on which side the advantage lies.

This brings us back to the indexing decisions, and here the obvious requirement is for more work to be done to help the indexers. For discussion on this point, the following definitions are proposed.

<u>EXHAUSTIVE INDEXING</u>

The indexing of every possible item in a document implies that several different, but quite independent, units of information are given in the document. The criterion is whether such a unit of information is a useful piece of information in its own right and is a truth even when taken out of context. It differs from the bits of subject concepts which go to make up a compound subject and which are represented by the elements in a notation or a compound subject heading or by the descriptors in a post-co-ordinate system.

<u>Definition</u>

The provision in the retrieval system of an entry for each individual unit of information which is capable of standing alone and which comprises a useful and valid piece of knowledge whether considered in the context of the document in which it is contained or in isolation. (Such entries need not necessarily be 'specific' entries).

<u>SPECIFIC INDEXING</u>

An entry may be made under a heading which can be very broad and which includes the subject being indexed, or very narrow and covering only part of the subject, or can reach a degree of 'specificity' such that the heading represents the total subject content of the topic being indexed and no more. (i.e. the parts of the heading together are necessary and sufficient). In other words the ultimate in 'specificity' is the situation wherein the heading is co-extensive with the subject it represents.

Definition

The provision of a heading in a pre-co-ordinate system, which by definition or usage, is co-extensive with the subject of the unit of information being indexed, whether the unit of information is part of a document or comprises the entire document. In post-co-ordinate indexing, specific indexing consists of the posting of the unit of information to all the terms which taken together form a description of the unit which is co-extensive with its subject content. 'Specific' used in this sense is absolute, but can also be used relatively to indicate different levels of specificity in indexing.

SYNTACTIC INDEXING

Most alphabetical subject headings which consist of several elements are syntactic in that they display adjectival and adverbal relationships, and show the objects of processes, the subjects of problems, etc., but this type of heading in the present state of the art usually shows a low level of specificity. Such headings as coloned U.D.C. numbers are not syntactic in that there can be ambiguity regarding the relationship of one element to another. The use of 'role indicators' is syntactic in principle but in the case of post-co-ordinate indexing 'syntactic headings' as such do not exist until they are formulated as a search programme.

Definition

The use of headings which display the relationship between the various elements, as distinct from those which merely show the existence of several attributes relevant to the subject indexed.

WEIGHTED INDEXING

Conventional indexing involves a 'Yes' or 'No' assessment; a concept either is or is not considered worthy of inclusion in the index. It is possible for the indexer to indicate the relative importance of different concepts in a document.

Definition

The provision with the indexing term of an indication of the relative importance of the term in the context of the document indexed.

Comparatively little is known of the cost and the effect on efficiency of exhaustive indexing, apart from the certainty that it will result in higher recall but lower relevance. Specific indexing on the other hand, will result in lower recall but higher relevance. This will always be true whatever descriptor languages are used, if, as was implied with the systems set out in Table 10, they are operated at the same level.

Considerable emphasis is being placed on techniques designed to show the association between terms, but none of these techniques appear to have any chance of by-passing this fundamental problem of recall and relevance. As Fairthorne puts it one can have "all but not only" or "only but not all". It is important to realise that it is the indexing and the descriptor language which determines the highest relevance ratio that a system can attain, whereas recall can always be improved by adjusting the search programme, even, if necessary, up to the absurd limit where the whole collection is retrieved. If a classification scheme such as U.D.C. is never used beyond the first four figures, it will be useless to attempt in retrieval to distinguish between, say, 'altitude performance of piston engined cargo aircraft' (629.138.4:621.431.75:533.6.015.5) and 'range performance of jet-propelled private aircraft' (629.138.56:621.45:533.6.015.74) for both would be shown as 629.1:621.4:533.6.

The same is true in a post-co-ordinate system if the descriptor language only includes 300 descriptors as against 4,000 or so uniterms. Such indexing will give good recall, but the best possible relevance will be lower than it would be with the more specific indexing which can be done with the full U.D.C. schedules or by using precise uniterms. Yet with the greater specificity and therefore better relevance, it is always possible to broaden a search so as to achieve higher recall, the penalty being that search procedures are more complex than when the indexing is less specific.

It now becomes necessary to amplify the argument based on Table 10.1. It remains true that given the same concept indexing, any two descriptor languages will have the same information content, and therefore the same potentiality for retrieval. This might be modified by stating that their performance will be similar if they are operated at the same level of indexing specificity. If this level varies, then for a single level of search programme, it might be that the performance of four systems could be shown as in Table 10.3.

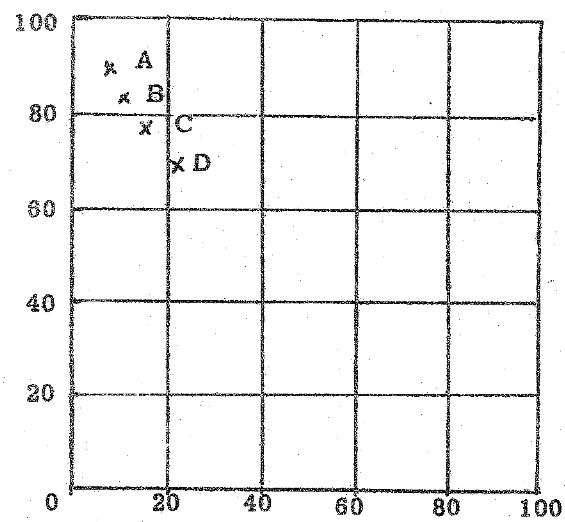

TABLE 10.3

HYPOTHETICAL PERFORMANCE OF FOUR DESCRIPTOR LANGUAGES OPERATING AT DIFFERENT LEVELS

It is suggested, however, that system D, which can be seen to be utilising more specific indexing, could, with broader levels of searching, achieve the same performance figure as system A. On the other hand, it would not be possible for system A to match the performance figure of D, since it lacks the power to improve the relevancy figure. All this leads to the conclusion that it is not the alternatives of classified or alphabetical arrangement, of post-co-ordinate or pre-co-ordinate indexing (much less the alternatives of manual or mechanical searching) which make any real difference in performance but the power of the descriptor language, allied to the standard of the indexing. The 'power' of a descriptor language is in its ability to eliminate irrelevant references, and in addition to a hospitality for specific indexing, there are at least two other devices which can be used, namely, "syntactic indexing" and "weighted indexing". As far as is known, no valid evidence exists as to what improvement these techniques can bring about, but logically it would appear that they must assist in eliminating irrelevant references. Any such improvement would probably have to be paid for by higher input costs.

To summarise the argument, it is maintained that the most important factor in the efficiency of an I. R. system is the concept indexing. More work is required to assist the indexer in this stage of the work, particularly in relation to the influence of exhaustive indexing on performance. There is the possibility that computers will be able to do concept indexing; if the infallible machine can be given a programme which will allow it to operate at 90% of perfect indexing, it will be near the level reached by the fallible human indexer. The translation of the concept indexing (whether done by humans or machines) into the descriptor language is a clerical process which can, in itself, not affect the efficiency of the system. The main difference of importance between types of descriptor languages is in their power, which includes their receptivity for specific indexing and other techniques such as syntactic indexing and weighted indexing. These improve the ability of the system to eliminate irrelevant references and obtain a good relevance ratio. The relevance ratio in combination with the recall ratio is the measure of performance of an I. R. system, and can be expressed in a series of curves indicating the performance according to environment, indexing level and preciseness of search.

In an earlier paper we quoted a remark made by Mr. M. J. Lighthill, F. R. S., Director of the Royal Aircraft Establishment, Farnborough. It was taken from a paper in which he was discussing the advances made in aeronautical engineering over the last fifty years. Mr. Lighthill wrote, "Countless ingenious experiments on models lay at the back of every advance and brilliant theories have been devised to make sense of the experiments". The present investigation has been one such experiment,(but we would not claim that it was particularly "ingenious") and we hope that others will find in this report the data to help devise theories that make sense of the experiment. More than anything this investigation has highlighted the major basic problem in information retrieval. As they appear to us, we have attempted to set them out in this chapter; the continuation of the project will attempt to find some of the solutions.

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APPENDIX 2A

1. Document Group 14001 - 14100
2. Selection of documents used for compilation of search questions
3. Questions resulting from selection
4. Extract of letter sent to compilers of questions

PART 1. DOCUMENT GROUP 14001 - 14100

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P14005 QUEIJO, M.J. Theoretical span load distributions and rolling moments for sideslipping wings of arbitrary plan form in incompressible flow. 1955. NACA TN. 3605.

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PART 3. QUESTIONS RESULTING FROM SELECTION

P14001	40-06	Boundary-layer shock wave interaction.
P14004	40-12	Elastic characteristics of 26 x 6.6 pneumatic tyres.
P14007	40-07	Effect of change of aerofoil design lift coefficient on the type of flow obtained in the transonic region.
P14009	40-11	Method of calculating sidewash on vertical fin due to wing rolling, for delta wing at M = 2.
P14017	40-01	Locate a table giving specific entropy of air at temperatures from 500 to 8000 ^{o}K.
P14020	40-08	Stresses at joins between a pressurised spherical shell and a cylinder.
P14025	40-02	Plastics in radomes.
P14038	40-15	Use of networks to modify the voltage/frequency and impedance/frequency characteristics of an alternator.
P14041	40-09	Data on strength of R.R.58 sheet at elevated temperatures.
P14053	40-13	Application of Tsien's hypersonic similarity theory for potential flow to two dimensional and axially-symmetric nozzle flow.
P14053	40-03	Application of hypersonic similarity theory to analysis of nozzle flow.
P14060	40-04	Comparison of convertiplanes with helicopters.
P14060	40-14	Weight and power estimates for convertiplane, helicopter, and airplane, each with 4,000 pounds pay loads.
P14063	40-05	Optimum shapes for two-dimensional wing sections at supersonic speeds.
P14083	40-10	Super-compressibility factor of natural gas at flow temperature 80 ^{o}F and flow pressure 1400 p.s.i.g.

PART 4. EXTRACT OF LETTER SENT TO COMPILERS OF QUESTIONS

"The Test Programme

"The testing of the systems will be done by putting to the various indexes questions which are based on documents in the collection. We need altogether a total of 1,500 questions, and we should be grateful for offers to compile twenty questions or multiples of twenty.

"To those who volunteer to help in this aspect we will send a selected list of references to papers included in the project. We will ask that questions based on the listed documents should be compiled, and that such questions should range from the specific to the general, i.e. some questions should be so specific that the document on which they are based is likely to be the only document which would give the answer, while other questions are of such a general nature that a satisfactory answer might be expected to be found in a number of documents. Examples of such questions might be 'hinge moments of a horizontal tail, 45 deg., sweptback planform, of aspect ratio 2 and taper ratio 0.5', or 'effect of surface roughness on drag of aircraft'. While these two examples deal with aerodynamics, we shall require questions based on all the subject fields included in this project."

APPENDIX 2B

PROGRAMME RULES

1. A single search consists of an exhaustive permutation (as far as the system permits) of any given combination of elements.

   (a) In U.D.C. each permutation of the selected elements shall constitute a sub-search.

   e.g. A 533.6.013.12   ABC = 1a
   B 533.693.31   BAC = 1b
   C 533.69.032   CAB = 1c

   (b) In Facet a sub-search will be each search where the given elements are in combination with other elements.

   e.g. Cd(Ij)Nr Oss = 1a
   Cd(Ij)Nbk Nr Oss = 1b
   Cd(Ij)Nbj Nr Oss = 1c

   (c) In Alphabetical a sub-search will be where a more specific heading is searched.

   e.g. WINGS, DELTA - Drag = 1a
   WINGS, DELTA, SUPERSONIC - Drag = 1b
   WINGS, DELTA, TRANSONIC - Drag = 1c

2. The alteration or deletion of any one or more parts of the original set of elements shall constitute a new search.

   e.g. 1st Search ABC
   2nd Search ABD
   3rd Search AB
   4th Search DE

3. The complete search programme may be continued to a stage where there is one less than the original number of concepts required.

   e.g. If the basic search is for ABC, it is permissible to search AB, BC or AC, but <u>not</u> A or B or C.

APPENDIX 3A

STATISTICAL ANALYSIS

- by -

J. T. Harris

For the purpose of statistical analysis it was found possible to combine tables 3.2 and 3.9, 3.3 and 3.10, and 3.4 and 3.11. Each combined table could then be subjected to a 3-factor analysis of variance procedure. Each of the tables 3.5, 3.6 and 3.7 were subjected to a 2-factor analysis of variance procedure. However the six tables analysed involved only eight main factors since one factor appeared in each of the six tables and another in each of the three combined tables.

Tables 3.1 and 3.6 were excluded from the statistical analysis since the factors involved would be covered by the above analyses.

Since the original data was in percentage form it was considered appropriate to subject them to an angular transformation before proceeding with the analysis. In addition a value of sixty was deducted from each value thus obtained so as to ease the subsequent numerical calculations without affecting the results. The figures so adjusted appear as the transformed values in the tables below.

The procedure of analysis of variance separates the total variance into that contributed by the separate factors. Using Snedecor's F test it is possible to determine whether the variation introduced by a given factor is significantly different from sampling fluctuation . Where an F value reaches the 5% level of significance it is denoted by one star, where it reaches the 1% level it is denoted by two stars, and where it reaches the 0.1% level it is denoted by three stars. The three situations are referred to as significant, highly significant, and very highly significant, respectively. Full details of the procedure can be obtained in an appropriate statistical handbook.

The definitions of the symbols and their subscripts appear in the tables where they are first employed. A brief summary is given with each analysis and an overall one is included at the end.

Tables 3.2 and 3.9

Percentage retrieval for indexers for searches by project and technical staff

Times (mins.)(T)		16	12	8	4	2
Method (M)	Staff (S)	T_1	T_2	T_3	T_4	T_5
U.D.C.	Project (S_1)	82	80	74	77	72
M_1	Technical (S_2)	84	86	78	78	76
ALPHA	S_1	89	85	77	85	73
M_2	S_2	81	78	74	76	63
FACET	S_1	76	79	71	71	71
M_3	S_2	62	73	66	55	70
UNITERM	S_1	89	85	83	88	75
M_4	S_2	85	83	73	87	85

Transformed Values

6.4	8.0	2.0	2.0	0.7
4.9	3.4	-0.7	1.3	-1.9
4.2	2.0	-0.7	0.7	-7.5
10.6	7.2	1.3	7.2	1.3
-8.1	-1.3	-5.7	-12.1	-3.2
0.7	2.7	-2.6	-2.6	-2.6
7.2	5.6	-1.3	8.9	7.2
10.6	7.2	5.6	9.7	0.0

Means of Times

	T_1	T_2	T_3	T_4	T_5
	4.56	4.35	-0.26	1.89	-0.75
Ex.Facet	7.32	5.57	1.03	4.97	-0.03

Means of Staff

	S_1	S_2
	0.75	3.16
Ex.Facet	3.03	4.51

Means of Methods

M_1	M_2	M_3	M_4
2.61	2.63	-3.48	6.07

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	473.57	3	157.86	
S	58.32	1	58.32	
T	198.19	4	49.55	**
Interactions				
M x S	110.46	3	36.82	*
M x T	149.40	12	12.45	
S x T	26.27	4	6.57	
Residual	73.70	12	6.14	
Total	1089.92	39	27.95	

Analysis of Variance (Ex. Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	79.35	2	39.68	
S	16.58	1	16.58	
T	235.16	4	58.79	***
Interactions				
M x S	84.61	2	42.31	**
M x T	45.86	8	5.73	
S x T	9.55	4	2.39	
Residual	61.19	8	7.65	
Total	532.30	29	18.36	

The full analysis of variance table indicates that the M x T and the S x T variances do not differ significantly from the residual. A new residual variance of 8.91 was thus possible by combining the three. Against this the M x S variance and the T variance were significant and highly significant respectively. The M and S variances are not significant when tested against the value for M x S.

Since Facet appears to behave in a distinctly different way from the other Methods the analysis was undertaken with its exclusion. Once again a new residual combining the original and the M x T and the S x T variances was possible and a value of 5.83 obtained for it. The conclusions however remain unchanged except for significance at a higher level.

Tables 3.3 and 3.10

Percentage retrieval for indexers for searches by project and technical staff

Indexers (I)		Hadlow	Warburton	Sharp
Method (M)	Staff (S)	I_1	I_2	I_3
M_1	S_1	74	81	77
	S_2	81	77	83
M_2	S_1	80	85	83
	S_2	76	70	78
M_3	S_1	71	78	71
	S_2	63	69	64
M_4	S_1	84	83	86
	S_2	78	85	82

Transformed Values

-0.7	4.2	1.3
4.2	1.3	5.6
3.4	7.2	5.6
0.7	-3.2	2.0
-2.6	2.0	-2.6
-7.5	-3.8	-6.9
6.4	5.6	8.0
2.0	7.2	4.9

Means of Indexers

	I_1	I_2	I_3
	0.74	2.56	2.24
Ex.Facet	2.67	3.72	4.57

Means of Staff

	S_1	S_2
	3.15	0.54
Ex. Facet	4.56	2.74

Means of Methods

M_1	M_2	M_3	M_4
2.65	2.62	-3.57	5.68

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	271.57	3	90.52	
S	40.82	1	40.82	
I	15.16	2	7.58	
Interactions				
M x S	55.58	3	18.53	*
M x I	19.99	6	3.33	
S x I	9.37	2	4.69	
Residual	37.72	6	6.29	
Total	450.22	23	19.57	

Analysis of Variance (Ex.Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	37.21	2	18.61	
S	14.76	1	14.76	
I	10.87	2	5.43	
Interactions				
M x S	44.14	2	22.07	*
M x I	2.86	4	0.71	
S x I	9.82	2	4.91	
Residual	36.70	4	9.18	
Total	156.36	17	9.20	

The full analysis of variance table indicates that a new residual combining the original and the M x I and the S x I variances is possible. Its value is 4.79. Against this the M x S variance is significant and the I variance not significant. The M and S variances are not significant in comparison with that of M x S.

An analysis excluding Facet reveals the same conclusions with in this case a new residual of 4.94.

Tables 3.4 and 3.11

Percentage retrieval according to subject for all searches by project and technical staff

Subject (J)		Aeronautical	General
Method (M)	Staff (S)	J_1	J_2
M_1	S_1	73	79
	S_2	77	82
M_2	S_1	79	84
	S_2	72	74
M_3	S_1	70	77
	S_2	62	72
M_4	S_1	82	82
	S_2	81	81
Transformed Values		-1.3	2.7
		1.3	4.9
		2.7	6.4
		-1.9	-0.7
		-3.2	1.3
		-8.1	-1.9
		4.9	4.9
		4.2	4.2

Means of Methods

M_1	M_2	M_3	M_4
1.9	1.62	-2.97	4.55

Means of Staff

	S_1	S_2
	2.30	0.25
Ex Facet	3.38	2.00

Means of Subjects

	J_1	J_2
	-0.17	2.72
Ex Facet	1.65	3.73

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	117.20	3	39.07	?
S	16.81	1	16.81	
J	33.64	1	33.64	
Interactions				
M x S	40.06	3	13.35	**
M x J	15.42	3	5.14	*
S x J	0.09	1	0.09	
Residual	2.23	3	00.74	
Total	225.47	15	15.03	

Analysis of Variance (Ex. Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	20.87	2	10.44	
S	5.74	1	5.74	
J	13.02	1	13.02	*
Interactions				
M x S	34.73	2	17.37	*
M x J	7.42	2	3.71	
S x J	0.70	1	0.70	
Residual	0.90	2	0.45	
Total	83.39	11	7.58	

The full analysis of variance indicates that the S x J variance can be combined with that of the residual to yield a new value of 0.58. Against this the M x J and the M x S variances are significant and highly significant respectively. When the S variance is compared with the M x S variance it is not significant and similarly when the J value is compared with that of the M x J value. There is no way of telling whether the M value is significant.

Once again an analysis excluding Facet was undertaken. A new residual as above was possible with a value of 0.53. Against this however the M x J variance was not significant so that a further new residual of 1.80 was possible. The M x S and J variances were significant in comparison with this value but the M and S variances were not in comparison with the M x S value.

Table 3.5

Percentage retrieval according to indexing sub-programme for searches by College staff

Documents (D)	1 - 6000	6001 - 12000	12001 - 18000
Method (M)	D_1	D_2	D_3
M_1	64	74	77
M_2	75	80	82
M_3		74	74
M_4	70	77	86
Transformed Values	- 6.9	-0.7	1.3
	0.0	3.4	4.9
	(- 7.1)	-0.7	-0.7
	- 3.2	1.3	8.0

Means of Methods

M_1	M_2	M_3	M_4
-2.10	2.77	-2.83	2.03

Means of Documents

D_1	D_2	D_3
-4.30	0.82	3.37

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	72.67	3	24.2	*
D	122.23	2	61.12	**
Residual	17.77	6	2.96	
Total	212.67	11	19.33	

The analysis reveals that the D main effect is highly significant and that of M significant. These results are sufficiently strong to require no modification arising from the use of an estimated value in cell D_1, M_3. Facet itself does not appear to behave in such a way as to demand any further analysis.

Table 3.6

Percentage retrieval for searches by project staff in the three rounds of testing

Round (R)	1	2	3
Method (M)	R_1	R_2	R_3
M_1	78	74	76
M_2	83	78	84
M_3	73	69	79
M_4	78	81	87
Transformed Values			
	2.0	-0.7	0.7
	4.9	2.0	6.4
	-1.3	-3.8	2.7
	2.0	4.2	8.9

Means of Methods

M_1	M_2	M_3	M_4
0.67	4.43	-0.80	5.03

Means of Rounds

	R_1	R_2	R_3
	1.90	0.42	4.67
Ex. Facet	2.97	1.83	5.33

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	72.89	3	24.30	*
R	37.25	2	18.63	
Residual	22.76	6	3.79	
Total	132.90	11	12.08	

Analysis of Variance (Ex.Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	33.61	2	16.81	
R	19.14	2	9.57	
Residual	19.37	4	4.84	
Total	72.12	8	9.01	

In the full analysis the main effect M is significant but the R effect falls just short of it. When Facet is excluded neither main effect reaches significance.

Table 3.7

Percentage retrieval by searching for project staff in first two rounds of testing

Persons (P)	Warburton	Hadlow	Cleverdon	
Method (M)	P_1	P_2	P_3	
M_1	77	75	76	
M_2	80	84	77	
M_3	74	71	70	
M_4	83	78	82	
Transformed Values				
	1.3	0	0.7	
	3.4	6.4	1.3	
	-0.7	-2.6	-3.2	
	5.6	2.0	4.9	
Means of Methods	M_1	M_2	M_3	M_4
	0.67	3.70	-2.10	4.17
Means of Persons	P_1	P_2	P_3	
	2.40	1.45	0.92	
Ex Facet	3.43	2.80	2.30	

Analysis of Variance (Full)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	78.17	3	26.06	**
P	4.47	2	2.24	
Residual	20.21	6	3.37	
Total	102.85	11	9.35	

Analysis of Variance (Ex Facet)

Source of Variance	Sum of Sqq.	D. of F.	Variance	Significance
Main Effects				
M	21.67	2	10.83	
P	1.94	2	0.97	
Residual	19.34	4	4.83	
Total	42.94	8	5.37	

In the full analysis the P variance can be combined with the residual to give a new residual of 3.08. Against this the main effect is highly significant. The exclusion of Facet gives rise to a situation where M is not significant.

Whilst different values for the residual terms are obtained in the different analyses close agreement is seen to exist between those of the full 2-factor analyses and between two of the full 3-factor analyses. The same applies, but with a higher value for the residual,in situations where Facet is excluded. The behaviour of the combined tables 3.4 and 3.11 appears in certain respects to be out of keeping with that of the others and so the conclusions of its analysis needs to be treated with a certain amount of reservation.

The values obtained generally for the residual are high and well above those that would arise from binomial variation alone. A large amount of extraneous variation. is present and it is against this almost entirely that the contributions of the various factors have to be judged.

There are amongst the eight factors considered some whose contribution is not significantly different from that of the residual. These are Persons representing different searches, Indexers, and Rounds of testing. Documents introduces very significant variation with seemingly a strong correlation between success and document numbering. There also appears to be a significantly better response with General subjects as with Aeronautical ones.

Time itself is a significant factor but the mode of its behaviour is seen to be peculiar. The values for 4 minutes are higher generally than those for 8 minutes especially when Facet is excluded. This suggests the need for further investigation.

The contributions of Method and Staff are significant by way of interaction and in order to study the behaviour of these more closely the averages of Method and Staff for the three combined studies are recorded below. The ordering has been altered to rank favourably for Project.

		Uniterm	Alpha.	U.D.C.	Facet
Time	Project	6.62	5.52	1.40	-0.88
	Technical	5.52	-0.26	3.82	-6.08
Indexers	Project	6.67	5.40	1.60	-1.07
	Technical	4.70	-0.17	3.70	-6.07
Subject	Project	4.90	4.55	0.70	-0.95
	Technical	4.20	-1.30	3.10	-5.00

It will be observed that the results for Technical are more varied than those for Project. For both Uniterm is the most and Facet the least favourable. However the lead of Project for Uniterm is not so great as that for Facet. Next to Uniterm for Project comes Alphabetical. The difference is small and the actual values seem slightly higher than those of Uniterm for Technical. In the third place for Project comes U.D.C. but it is nearer to Facet than it is to Alphabetical. The second place for Technical is held by U.D.C. and this is fairly close to Uniterm. The reversal of the ranking of Alphabetical and U.D.C. is very interesting - the difference between them for Project and for Technical appears significantly the same. Whilst Facet holds fourth position for Technical the difference between it and Alphabetical is relatively great.

APPENDIX 4A

100 QUESTIONS BASED ON SOURCE DOCUMENTS LISTED IN APPENDIX 4B

20-06 Magnitude of reductions in heat transfer on the nose region of a body when ablation of the surface takes place. (P12002)

20-07 What is the crack propagation rate for 7075-T6 aluminium alloy. (P12004)

20-08 Panel flutter analysis. (P12055)

20-09 Typical shear values for commercial huckbolts. (P12063)

20-10 Use of stabilizing signals in servo-mechanisms. (P12098)

21-06 Frequency and natural modes of the vibrations of box-beam and delta wings. (P12120)

21-07 Electrical analogy methods - lifting line calculator. (P12125)

21-08 Comparison of calculated and experimental performance of an axial compressor stage having constant stator inlet air angle of 50% reaction at mean stage radius. (P12136)

21-09 Corrosion-resistance controls on production of stainless steels. (P12179)

21-10 Enthalpy boundary layer profiles on a cone at large yaw. (P12187)

22-06 Wind tunnel interference on oscillating wings. (P12221)

22-07 Analysis of the tuned circuits of a demodulator for frequency modulation. (P12243)

22-08 A method of using hot wire technique to measure turbulence functions in turbulent supersonic flow. (P12257)

22-09 What metallographic procedure is followed for TiC cermets. (P12282)

22-10 What is the equation of magnetohydrostatics. (P12300)

23-06 Relation of surface-cooling to boundary layer transition. (P12309)

23-07 Performance of centrebody intakes. (P12311)

23-08 Rate of fuel vaporization in the combustion chamber of a heptane oxygen rocket engine. (P12313)

23-09 Velocity profile, heat transfer and skin friction data for turbulent boundary layers in hypersonic flow. (P12355)

23-10 Dimensional analysis of the performance of one-stream combustion chambers. (P12362)

24-06 The effective pitching moment of inertia of an aircraft with a flexible swept wing. (P12406)

24-07 The effects of lateral damping on the dispersion of fighter aeroplane gunfire. (P12414)

24-08 The effect of crossover passages in the blade tip on circulation of coolant through passages in turbine rotor blades. (P12439)

24-09 Calculation of damping in roll at supersonic speeds. (P12456)

24-10 Effect of altitude on helicopter performance. (P12475)

25-06 Effect of vibration on the structural properties of a wing. (P12504)

25-07 Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading. (P12514)

25-08 Electromagnetic analogy for downwash. (P12538)

25-09 What humidity is considered allowable in intermittent wind tunnels, and how is it obtained most efficiently. (P12576)

25-10 Approximate solution of 2-d supersonic rotational flow in the neighbourhood of an expansive corner. (P12587)

26-06 Mechanism by which hydrogen leaves the molecular phase and enters a metal. (P12611)

26-07 Reverse flow theorems at supersonic speeds. (P12615)

26-08 Comparison of heat transfer theories in forced, non-isothermal, convection over arbitrary surfaces. (P12662)

26-09 Explain the significance of flying boat forebody warp with regard to the characteristics of longitudinal stability, blister spray generation and impact loads encountered during landing. (P12675)

26-10 What values have been reported for actuation energies of the damping process in aluminium-copper alloys. (P12695)

27-06 Effect of flexible walled nozzles on supersonic flow. (P12706)

27-07 Effect of shear lag on transverse oscillations of thin-walled cylindrical beams. (P12712)

27-08 Experiments on throttle fuel controls for gas-turbine engines. (P12740)

27-09 Impedance testing of aircraft power control units. (P12767)

27-10 Stability data for propane air mixtures stabilized by an annular air jet. (P12776)

28-06 Reduction of the nonlinear partial differential equations for the laminar boundary layer over a cone at large angles of attack in supersonic flow, to a set of simultaneous algebraic equations. (P12810)

28-07 Theoretical calculation of the performance of half -delta wing-tip controls on the tips of delta wings. (P12838)

28-08 Theoretical method for predicting pressure distribution on an oscillating airfoil in two-dimensional flow at Mach number 4 or greater. (P12860)

28-09 Beam riding guidance of anti-aircraft missiles. (P12864)

28-10 What is the effect of rapid quenching on A356 aluminium casting alloy. (P12895)

29-06 Can cermets be used as structural materials above 1000°C. (P12939)

29-07 Alleviation of the airplane pitch-up problem by the use of leading edge slats. (P12944)

29-08 Effect of combined tension and bending on curvature of beams in the plastic range. (P12956)

29-09 Transformation theory of the partial differential equations of gas dynamics. (P12959)

29-10 Design practices to minimize stress corrosion of metals. (P12979)

30-06 What is the average decrease in gas consumption per horse power hour for reciprocating aircraft engines in the course of their history. (P13059)

30-07 Optimum thickness distribution for elliptical plan form. (P13066)

30-08 Unsteady laminar boundary layer flows. (P13069)

30-09 How does the fatigue life of aluminium alloy M.G.5 vary with the maximum induced stress in bending fatigue tests. (P13074)

30-10 Importance of inherent instability in the controllability of an aircraft. (P13080)

31-06 A photoelastic investigation of stress concentration. (P13102)

31-07 Wave drag of shrouded bodies. (P13113)

31-08 Effect of shock waves on laminar boundary layers. (P13142)

31-09 Theory of deformation of a thin conical sheet. (P13171)

31-10 Calculation of the net drag imposed by a ram-air cooling system (for aircraft). (P13177)

32-06 Separated laminar flows at hypersonic Mach numbers. (P13207)

32-07 Effect of leading edge flaps on NACA 0006 airfoil at low speeds. (P13212)

32-08 The required length of double-diaphragm shock tubes using helium. (P13259)

32-09 Factors to be considered in the design of cooling fins for an air cooled semiconductor rectifier. (P13267)

32-10 How to reduce size and weight of computer equipment whilst maintaining ease of serviceability and military service standard of reliability. (P13269)

33-06 Local temperature-recovery factor of a turbulent boundary layer on a supersonic 40^{o} cone. (P13304)

33-07 Effect of stress frequency on metal fatigue. (P13307)

33-08 Prevention of transition to turbulent boundary layer flow by distributed suction. (P13334)

33-09 How does the shock standoff distance vary with the strength of the magnetic field. (P13362)

33-10 Controlled thermonuclear reactions for space flight. (P13387)

34-06 Portable devices for reducing noise level of jet aircraft on the ground. (P13403)

34-07 Effectual porosity on the pressure distribution over a suction flap. (P13408)

34-08 Have Thescal hard solders been A.I.D. approved. (P13451)

34-09 Possible applications for shrouded propellers. (P13461)

34-10 Advantages of using solid rockets in preference to liquid rockets. (P13461)

35-06 The use of suction as a means of boundary layer control in the design of a diffuser for turbo-jet engines. (P13505)

35-07 Vibrations in 45^{o} delta wings - deflectional behaviour under static tests. (P13509)

35-08 Formula for calculating fatigue damage. (P13523)

35-09 Hovercraft model tests. (P13563)

35-10 Calculation of heat flows in a cylinder surrounded by a radiation shield. (P13576)

36-06 Wing-aileron flutter in three-degrees of freedom for three-dimensional flow. (P13604)

36-07 Effect of Mach number on transition of three-dimensional boundary layer. (P13608)

36-08 Pressure distribution over a small aspect ratio unswept wing in a yawed stream. (P13616)

36-09 Types of failures of pressure cabins. (P13645)

36-10 Measurement of surface pressure on thin bodies. (P13653)

37-06 Tensile and compressive stress-strain tests on specific ferrous alloys. (P13705)

37-07 Heat transfer in turbulent boundary layers of a flat plate at supersonic speeds. (P13718)

37-08 In strain-gauge techniques employing a Wheatstone Bridge can it be assumed that the bridge output is linear with applied strain. (P13750)

37-09 Approximate solutions for lowest natural frequency of isosceles triangular plates with equal edges simply supported and base clamped. (P13781)

37-10 Effect on the shock line of accelerating a slender supersonic aerofoil. (P13789)

38-06 Measurement of screech in rocket engines. (P13807)

38-07 Relationship between thermal stability of pentaborane and temperature. (P13841)

38-08 Effect of helium diffusion field at Mach 8 on laminar boundary layer. (P13856)

38-09 Comparison of distribution of radial and circumferential stresses for circular hole in thin infinite plate, given by Tresca and Mises' yield conditions. (P13888)

38-10 Material on Boeing's data processing system. (P13900)

39-06 The use of thrust reversal in reducing the air speed of a jet aircraft. (P13903)

39-07 Properties and combustion data of cordite SU/K and other solid propellants. (P13908)

39-08 Characteristics of flow past cones at incidence at supersonic speeds. (P13931)

39-09 Choice of power-plant installations for supersonic jet transports. (P13985)

39-10 Editing of flight test data. (P13993)

APPENDIX 4B

TITLES OF SOURCE DOCUMENTS FOR QUESTIONS LISTED IN APPENDIX 4A

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APPENDIX 4C

POSTINGS AND RESULTS FOR DOCUMENTS P12001 - P14000

(Average postings per document = UDC 3.9; Alpha. 2.7; Facet 5.9; Uniterm 9.38)

Document	U.D.C.		ALPHA.		FACET		UNITERM	
Number	Result	Total	Result	Total	Result	Elements	Result	Total
12002	s	2	f	1	s	4	s	11
12004	s	12	s	10	s	12	s	15
12055	s	2	f	4	f	11	s	11
12063	s	6	s	4	s	13	s	11
12098	s	2	f	2	f	3	s	7
12120	s	18	s	9	s	3	s	12
12125	f	4	s	3	s	8	s	12
12136	s	5	f	2	s	6	s	15
12179	f	4	s	4	f	4	s	12
12187	f	6	f	3	f	9	f	10
12221	s	8	s	4	s	10	s	11
12243	s	2	s	3	s	6	s	7
12257	s	3	s	3	s	4	s	14
12282	s	6	s	2	s	11	s	15
12300	s	1	s	1	s	1	s	6
12309	s	16	s	6	s	7	s	22
12311	f	3	s	3	s	3	f	19
12313	s	6	s	4	s	4	s	15
12355	s	5	s	3	s	11	s	17
12362	s	2	f	4	s	6	s	20
12406	f	4	s	4	s	11	s	11
12414	s	6	s	9	s	15	s	10
12439	s	2	s	2	s	7	s	13
12456	s	12	f	6	f	14	s	11
12475	s	2	s	2	s	5	s	7
12504	s	4	s	2	s	7	s	5
12514	s	8	s	5	s	11	s	11
12538	f	8	f	4	f	11	s	11
12576	f	1	s	2	s	2	s	8
12587	s	1	s	7	s	9	s	11
12611	s	6	f	2	s	5	f	7
12615	f	2	s	5	f	2	s	7
12662	s	4	f	1	f	4	f	8
12675	s	4	s	3	s	6	s	9
12695	f	4	s	2	s	5	s	11
12706	f	1	s	1	s	3	s	6
12712	s	2	f	3	f	5	s	12
12740	f	1	s	3	f	5	s	8
12767	s	1	s	1	s	3	s	7
12776	f	3	s	6	f	5	s	11
12810	s	4	s	3	s	7	s	14
12838	s	2	f	4	s	9	s	10
12860	s	4	s	2	s	10	s	11
12864	s	4	s	2	s	2	s	10
12895	s	6	s	5	s	8	s	11

Document Number	U.D.C. Result	U.D.C. Total	ALPHA. Result	ALPHA. Total	FACET Result	FACET Elements	UNITERM Result	UNITERM Total
12939	s	2	s	2	s	3	s	12
12944	f	8	f	3	f	9	s	16
12956	f	4	s	3	s	5	s	9
12959	f	2	f	3	f	6	f	7
12979	s	2	s	4	s	4	s	5
13059	f	2	f	2	f	8	f	7
13066	f	3	f	2	f	6	s	13
13069	s	2	s	2	f	5	f	7
13082	s	6	s	5	s	5	s	8
13080	s	3	s	6	s	5	f	8
13102	s	8	f	3	s	4	f	8
13113	s	4	s	2	f	3	s	15
13142	f	8	s	4	f	19	s	17
13171	f	2	f	2	s	4	f	6
13177	f	1	f	2	f	6	s	11
13207	s	6	s	2	f	8	s	11
13212	s	6	s	3	s	5	s	12
13259	s	4	s	2	s	3	s	9
13267	s	2	s	1	s	6	f	7
13269	s	2	s	1	s	2	f	6
13304	s	4	s	4	s	12	s	12
13307	s	2	s	2	f	5	s	5
13334	s	6	s	2	s	5	s	10
13362	s	6	s	4	f	5	s	10
13387	s	1	s	2	s	2	s	10
13403	s	3	s	1	s	7	f	8
13408	s	12	s	4	f	4	s	12
13451	s	4	s	3	s	4	s	6
13461	s	3	s	3	f	1	s	10
13470	f	3	s	2	s	1	s	5
13506	s	6	s	3	s	10	s	14
13509	s	4	s	1	s	9	s	7
13523	s	2	s	1	f	6	s	5
13563	f	2	s	2	s	2	s	12
13576	f	2	s	2	f	5	s	10
13604	f	12	s	4	s	14	s	10
13608	s	4	s	2	s	4	s	10
13616	s	2	s	2	s	3	s	6
13654	s	3	s	2	s	3	s	6
13653	s	2	f	2	f	3	s	8
13705	s	4	s	6	s	8	s	10
13718	s	12	s	3	s	9	s	11
13750	s	2	s	2	f	2	s	7
13781	s	2	s	2	s	4	s	6
13789	f	3	s	2	s	7	s	8
13807	f	2	f	2	f	3	s	8
13841	s	4	s	3	s	7	s	7
13856	s	2	f	2	f	6	s	6
13888	s	1	s	1	s	3	s	8
13900	s	2	s	2	f	2	s	5
13903	s	2	f	2	f	4	f	10
13908	f	2	f	2	f	5	s	9
13931	s	6	f	3	s	8	s	11
13985	s	1	s	2	s	4	s	13
13993	f	2	s	2	s	1	s	11

s = successful search
f = failure

APPENDIX 4D

CORRELATION OF TERMS USED IN 300 SEARCHES FOR INDEXING AND SEARCHING

Part 1. Universal Decimal Classification
Part 2. Alphabetical
Part 3. Facet
Part 4. Uniterm

PART 1. UNIVERSAL DECIMAL CLASSIFICATION

Term		Number of terms used in Indexing	Searching
001.1	Design	9	1
001.5	Experiments	1	-
001.6	Development	3	-
002.2	Production	1	-
002.3	Materials	3	-
003.12	Cost estimates	1	-
004.15	Performance	-	2
004.4	Protection	1	-
004.63	Failure	1	-
512.1	Formulae (Algebra)	1	1
516.1	Plane geometry	1	-
517.9	Differential equations	1	-
517.93	Non-linear differential equations	1	-
517.944	Partial differential equations	-	2
518	Calculation	2	-
518.12	Numerical calculation	1	-
518.5	Computers	3	2
523.51	Meteorites	-	1
53.089.6	Calibration	1	1
530.152.15	Hysteresis	1	-
530.17	Analogies	-	2
531.113	Acceleration	1	-
531.15	Rotation	1	1
531.22	Stress analysis	5	4
531.222	Tensile stresses	1	1
531.223	Compression stresses	1	-
531.224	Bending stresses	1	1
531.224.4	Axial compression stresses	2	3
531.225	Torsional stresses	2	-
531.226	Shearing stresses	1	1
531.394	Transformation. Dynamics	-	1
531.52	Falling bodies	1	-
532.11	Pressure	1	-
532.5:538	Magnetohydrodynamics	2	4
532.5.031	Inviscid flow	1	1
532.513	Pressure recovery	3	-

Term		Number of terms used in Indexing	Searching
532.517.2	Laminar flow	1	2
532.517.4	Turbulent flow	2	-
532.525	Jets. Hydrodynamics	-	1
532.525.2	Jets	1	-
532.526	Boundary layer	5	14
532.526.2	Laminar boundary layer	12	8
532.526.3	Transition. (B.L.)	4	4
532.526.4	Turbulent boundary layer	7	10
532.526.5	Separation (B.L.)	5	5
532.526.7	Skin friction (B.L.)	1	1
532.527	Vortices	5	8
532.529	Mixed flow	1	1
532.529.3	Jet mixing	2	1
532.529.6	Spray. (Gas liquid mixtures)	2	-
532.53	Channels	1	1
532.54	Pipes	-	1
532.542	Annular flow	3	3
532.542.2	Laminar flow. Pipes	1	-
532.582.24	Rectangular plates	2	1
532.72	Diffusion	-	1
533.1	Properties. Gases	-	1
533.12	Density. Gases	1	-
533.15	Diffusion	2	1
533.21	Compressibility. Gases	-	1
533.275	Humidity	-	1
533.5	Rarefaction	-	1
533.6-24	Two dimensional flow	-	2
533.6.011	Shear flow	1	1
533.6.011:533.696.4	Conical flow	1	1
533.6.011.12	Scale effect	1	1
533.6.011.35	Transonic flow	8	5
533.6.011.5	Supersonic flow	49	38
533.6.011.55	Hypersonic flow	11	8
533.011.6	Aerodynamic heating	17	15
533.6.011.72	Shock waves	11	9
533.6.011.8	Rarefied gases. (Flow)	1	1
533.6.013.1	Forces and moments	3	-
533.6.013.12	Drag	7	6
533.6.013.12(083.7)	Nomenclature. Drag	-	1
533.6.013.122	Area rule	1	1
533.6.013.125	Pressure drag	1	-
533.6.013.126.5	Profile drag	-	1
533.6.013.127	Surface friction	1	-
533.6.013.129	Wave drag	6	4
533.6.013.13	Lift	7	6
533.6.013.15	Pitching moments	4	6
533.6.013.16	Rolling moments	1	1
533.6.013.18	Hinge moments	1	-
533.6.013.4	Stability	3	3
533.6.013.412	Longitudinal stability	3	1

Term		Number of terms used in Indexing	Searching
533.6.013.413	Lateral stability	1	1
533.6.013.42	Aeroelasticity	2	4
533.6.013.422	Flutter	5	8
533.6.013.423	Balances	-	1
533.6.013.65	Manoeuvring	1	1
533.6.013.66	Stalling	1	3
533.6.015.1	Take-off	1	-
533.6.015	Performance	-	1
533.6.015.2	Landing.	1	1
533.6.015.32	Velocity	-	1
533.6.015.5	High altitude performance	1	3
533.6.015.74	Range	1	-
533.6.015.8	Standard atmosphere	1	-
533.6.05	Flight testing	-	2
533.6.053	Flight testing, full scale	1	2
533.6.057	Wing flow method	1	-
533.6.071	Wind tunnels	5	4
533.6.071.12	Vanes	1	1
533.6.071.18	Nozzles. Wind tunnels	-	2
533.6.071.2	Power plants (Wind tunnels)	2	-
533.6.071.3	Instrumentation. Wind tunnel apparatus	-	1
533.6.071.31	Visualisation methods	-	1
533.6.071.32	Stings	1	1
533.6.071.33	Models. (Wind tunnel apparatus)	1	2
533.6.071.42	Turbulent flow	-	3
533.6.071.43	Calibration	1	1
533.6.071.46	Gases. (Flow problems)	1	-
533.6.071.54	Humidity	-	1
533.6.071.55	Pressure recovery	-	1
533.6.073	Shock tubes		
533.6.073.2	Shock tube driver gases	-	1
533.6.076	Potential flow tanks	2	1
533.6.082.3	Pressure tubes	3	4
533.6.082.7	Hot wire anemometers	2	1
533.65	Aeroplanes. (Aerodynamics)	3	-
533.652	Landplanes	-	1
533.652.6	Vertical take-off landing aircraft	2	3
533.652.9	Canards	-	1
533.655.2	Float seaplanes	1	-
533.655.3	Flying boats	1	1
533.66	Helicopters	1	4
533.662.2	Propellers	2	3
533.662.24	Shrouded propellers	1	1
533.662.6	Rotors	3	-
533.662.63	Tip-driven rotors	-	1
533.662.7	Wind turbines	-	1
533.665	Missiles	4	2
533.69.031	Aspect ratio	4	3
533.69.032	Camber	3	1

Term		Number of terms used in Indexing	Searching
533.69.034	Thickness distribution	2	2
533.69.036	Surface roughness	2	1
533.69.037	Thickness ratio	2	-
533.69.048	Airflow variables	-	1
533.69.038.1	Aerodynamic loading	1	4
533.69.048.2	Pressure distribution	21	11
533.69.048.25	Centre of pressure	1	-
533.69.048.3	Wakes	2	3
533.69.048.4	Velocity distribution	5	1
533.69.048.5	Gust loads	1	2
533.69.048.6	Angle of attack	1	-
533.69.048.7	Aerodynamic centre	1	1
533.692	Aerofoil sections	6	3
533.692.4	Flat plate aerofoil sections	7	6
533.692.5	Wedge aerofoil sections	1	-
533.693	Wings	13	23
533.693.1	Sweptback wings	9	5
533.693.31	Delta wings	5	5
533.693.34	Arrowhead wings	-	1
533.693.35	Triangular wings	2	2
533.693.5	Elliptical wings	-	1
533.693.6	Rectangular wings	4	1
533.693.92	Cruciform wings	-	1
533.694.2	High lift devices	4	2
533.694.22	Slotted flaps	1	1
533.694.25	Leading edge flaps	-	1
533.694.26	Slats	1	-
533.694.27	Slots. High lift devices	-	1
533.694.5	Control response	5	4
533.694.51	Lateral control	-	1
533.694.511	Aileron reversal	2	1
533.694.512	Moving wing tip ailerons	2	-
533.694.53	Longitudinal control	1	-
533.694.531	Tailplanes, fixed.	1	1
533.694.533	Elevators	1	-
533.694.58	Spring tabs	1	-
533.694.6	Jet flaps	1	1
533.694.71	Boundary layer suction	3	3
533.694.72	Blowing	1	-
533.695	Interference	1	5
533.695.12	Wing body combinations	4	2
533.695.124	Tail-wing-body combinations	1	1
533.695.29	Canopy-fuselage combinations	1	-
533.695.5	Propeller slipstream	-	1
533.695.7	Jets	-	3
533.695.8	Cascades	1	2
533.695.9	Aircraft canopies	-	1
533.696	Bodies	5	6
533.696.2	Spheres	-	1
533.696.3	Cylinders	4	4

Term		Number of terms used in Indexing	Searching
533.696.4	Cone-cylinders	9	9
533.696.5	Blunt bodies	11	1
533.696.6	Wedges	2	-
533.697.2	Intakes	2	1
533.697.23	Nose intakes	-	1
533.697.24	Side intakes	1	2
533.697.3	Ducts	7	4
533.697.4	Nozzles	8	5
533.697.5	Outlets	1	-
534	Vibrations	-	9
534.014.2	Forced oscillations	-	2
534.11	Vibration of linear bodies	-	2
534.13	Vibration of three dimensional bodies	10	-
534.14	Methods of exciting vibrations	1	-
534.2	Propagation of vibrations	1	-
534.21	Noise	2	9
534.321	Frequency	1	4
534.372	Damping of mechanical vibrations	1	-
534.832	Noise, prevention at source	1	3
534.833	Absorption. (Noise)	1	-
534.839	Measurement. (Noise)	1	1
535.42	Diffraction	-	1
536.2	Heat transfer	5	6
536.2.02	Conductivity	3	1
536.2.08	Measurement of conductivity	1	-
536.21	Thermal insulation	1	-
536.24	Conduction. Heat exchange	-	1
536.25	Convection	1	2
536.253	Gases. (Convection)	1	-
536.33	Thermal emissivity	1	1
536.422	Ablation	-	1
536.422.1	Transformation from solid to gas	1	-
536.423.1	Liquid-gas vapourisation	2	-
536.45	High temperature	2	1
536.46	Combustion	1	4
536.461	Flames	2	1
536.495	Heat resistance	5	5
536.5	Temperature	10	4
536.532	Thermocouples	-	1
536.6	Colours	1	-
536.722	Enthalpy	-	1
537	Electricity	-	2
537.122	Electrons	-	1
537.533.73	Diffraction	-	1
539	Molecular physics	-	1
539.155.2	Isotopes	1	1
539.16	Radioactivity	1	-
539.214	Plasticity	-	1
539.217.1	Porosity	1	-

Term		Number of terms used in Indexing	Searching
539.3	Elastic solid bodies	1	1
539.319	Residual stresses	2	4
539.37	Deformation	-	2
539.374	Plastic deformation	1	2
539.375	Limit of deformation	-	1
539.377	Thermoelasticity. Deformations	1	-
539.382	Stress/strain	-	1
539.384	Bending	2	10
539.384.4	Buckling	4	8
539.389.3	Relaxation	1	-
539.4	Resistance to stress	2	2
539.4.014.13	Residual stresses	-	1
539.41	Rigidity	2	3
539.413	Bending strength	1	-
539.42	Tensile strength	2	1
539.431	Fatigue strength	7	2
539.434	Creep strength	-	2
539.538	Wear	1	1
539.557	Flexibility	-	1
539.89	High pressure, effects of	-	2
541.124.7	Dissociation (Physical chemistry)	1	2
541.4	Chemical combination	-	1
541.42	Decomposition	1	-
546.11	Hydrogen	1	1
546.171.1	Ammonia	1	-
546.21	Oxygen	1	1
546.27	Boron	-	1
546.291	Helium	-	2
546.3	Metals	-	1
546.33-36	Sodium hydroxide	1	-
546.391.75	Ammonium nitrates	1	-
547.213	Propane		
547.215	Pentanes	1	-
547.56	Phenols	-	1
547.91	Hydrocarbons	-	2
551.55	Winds	-	1
611	Human body dimensions	-	1
620.1.05	Testing machines	-	1
614.86	Passenger safety	1	-
620.162.4	Pressure tests	4	-
620.17	Strength tests	1	-
620.171.5	Photoelasticity	1	1
620.172	Tensile tests	3	1
620.172.21	Load measurement	1	-
620.172.251.224	Tensile strength when hot	1	-
620.173	Compression tests	4	1
620.173.251.224	High temperature compression tests	1	-
620.173.26	Buckling tests	1	1
620.176	Shearing tests	1	-
620.178.3	Fatigue testing machines	6	1
620.178.311.81	Notches	1	-

Term		Number of terms used in Indexing	Searching
620.191.33	Cracks. Surface defects	3	1
620.192.46	Cracks	-	1
620.192.52	Shrinkage	-	1
620.192.63:539.56	Brittleness	1	-
620.193.41	Corrosion by inorganic acids	1	1
620.193.54	Oxidation tests	-	1
620.196.5	Influence of impurities	-	1
621-181	Size	1	-
621-186.5	High pressure	1	-
621-229.3	Jigs	-	1
621-272	Springs	1	2
621-272.2	Helical springs	1	1
621-402	Curved shapes	1	1
621-403.7	Spiked	1	2
621-412	Slabs	1	-
621-413	Plates	2	1
621-414	Thin plates	13	25
621-415-47	Perforated plates	1	3
621-419	Sandwich plates	1	3
621-422	Bars	1	2
621-422.4	Wedge-shaped sections	1	1
621-423	Cruciform sections	1	-
621-423-7	Angle bars	-	1
621-426	Wires	1	-
621-427.3	Wire screens	1	-
621-431	Tapered shapes	1	-
621-434.5	Cones	-	2
621-45	Slots	1	-
621-451	Notches	1	-
621-46	Cavities	2	2
621-46-434.1	Conical shells	2	3
621-464	Tubular shapes	1	2
621-464	Hollow spheres	1	1
621-47	Perforated objects	1	1
621-472	Holes	1	1
621-477	Annular shapes	-	1
621-491.4	Capsules	1	1
621-495.5	Flexible (Material forms)	1	2
621-52	Automatic control	1	1
621-523	Electric servomechanisms	1	1
621-71	Cooling	2	4
621-711	Fins	2	1
621-712	Air cooling	-	2
621-713.1	Water cooling	1	-
621-72	Lubrication	-	1
621-733	Air cleaners	1	-
621-752.2	Vibration dampers	1	1
621-784.7	Shielding	1	1
621.039	Atomic reactors	3	2
621.3	Electrical engineering	-	1

Term		Number of terms used in Indexing	Searching
621.3.011.2	Conductance	-	1
621.3.04	Electric circuits	1	1
621.301	Electrical engineering. Definitions, notation	-	1
621.314.6	Rectifiers	-	1
621.314.635	Silicon rectifiers	-	1
621.314.7	Transistors	1	1
621.315.59	Semi-conductors	-	1
621.316.1	Networks	1	1
621.317.733	Bridges. Electrical measuring apparatus	-	1
621.352.7	Dry cells	1	-
621.38	Electronics	-	1
621.385.2	Diodes	1	-
621.396.619.11	Amplitude modulation	1	-
621.396.619.13	Frequency modulation	1	1
621.396.933	Tacan. (Navigation systems)	1	-
621.396.933.25	Guide beams	-	1
621.43.018.35	Fuel consumption	-	2
621.43.019.2	Combustion problems	-	1
621.43.032	Fuel systems	1	-
621.43.033.15	Throttles	1	-
621.43.038.8	Fuel injectors	2	-
621.43.056	Combustion chambers	-	1
621.43.064.5	Tail pipes	-	1
621.43.065	Noise suppressors	-	1
621.432	Piston engines	-	1
621.438	Gas turbines	2	5
621.438-5	Control. Gas turbines	-	2
621.438-75	Gas turbines	-	1
621.438.013.93	Jet efflux	-	1
621.438.018.5	Performance. Gas turbines	-	1
621.438.019.2	Combustion problems. Gas turbines	-	1
621.438.019.93	Afterburners	1	-
621.438.031.3	Compressor. (Gas turbines)	3	-
621.438.031.3.018.5	Performance. Compressors. Gas turbines	-	1
621.438.035.37	Diffusers. Intakes	-	1
621.438.038	Fuel injection	-	1
621.438.056.5	Combustion chambers. (Gas turbines)	2	1
621.438.057.3	Water injection systems	1	1
621.438.057.54	Starting. Gas turbines	-	2
621.438.086.4	Ducted fan engines	-	1
621.438.1.068	Noise suppressors	1	2
621.438.067.3-225.3	Variable propelling nozzles	1	1
621.438.067.6	Thrust reversers	1	1
621.438.084	Jet engines	4	6
621.438.085.5	Free turbine engines	1	1

Term		Number of terms used in Indexing	Searching
621.438.086.2	Turbine-propeller engines	1	2
621.438.086.4	Ducted fan engines	-	1
621.438.1-253.5	Turbine blades	2	1
621.439.2	Pulse jet engines	-	1
621.439.4	Ram jets	2	2
621.45	Rocket engines	7	3
621.45.013.3	Vapourisation. Rocket engines	-	1
621.45.018.5	Performance. Rocket engines	-	1
621.45.019.2	Combustion problems	2	-
621.45.032	Fuel systems	1	-
621.45.038	Distributors	1	-
621.45.056	Combustion chambers	1	3
621.45.057.54	Starting	1	-
621.56/.59	Refrigeration	1	-
621.65	Pumps	-	1
621.66	Rotary pumps	-	1
621.75	Toolmaking	-	1
621.751	Etching. Marking	1	-
621.757	Assembly	1	-
621.762.6	Sintering	1	-
621.784	Baths for hardening	1	-
621.785.8	Quenching	-	1
621.791.3	Soldering	-	1
621.792	Redux bonding	-	1
621.835	Cams	-	1
621.882	Bolts	1	1
621.882.082	Screw threads	1	-
621.9	Cutting tools	2	1
621.9.018.3	Electric discharge machining	1	2
622.556.6	Air-to-air firing	-	1
623.13.012.1	Skins	-	1
623.4.027	Missile guidance	1	1
623.4.084	Missile guidance systems	3	3
623.418.4	Guns, aircraft	1	-
623.451-519	Guided missiles	3	2
623.54	Trajectories. (Ballistics)	2	3
623.746.3	Fighters	1	1
624.042	Load calculation	1	1
624.046	Permissible loads	1	-
624.072.2	Beams	5	4
624.075.2	Struts	-	1
624.078	Joints	3	2
624.078.2	Bolted joints	1	-
624.078.8	Stiffeners	1	-
629.11.012.49	Air cushions	1	-
629.13	Aircraft	3	4
629.13-71	Heat exchange	1	-
629.13.012	Structural parts (aircraft)	9	6
629.13.012.126	Ducts. Engine compartment covering	-	1

Term		Number of terms used in Indexing	Searching
629.13.012.134	Windscreens	1	-
629.13.012.134.4	Hoods	-	1
629.13.012.525	Fuel tanks	1	-
629.13.012.59	Pressurised cabins	3	3
629.13.014.3	Wings	2	2
629.13.014.311.5	Delta wings	1	2
629.13.014.315.6	Integral constructions	-	1
629.13.014.5	Flying controls	-	1
629.13.014.5-8	Powered flying controls	1	1
629.13.014.59	Automatic pilots	-	1
629.13.014.71-253.65	Rotor blades	1	2
629.13.014.715	Tip-driven rotors	-	1
629.13.015	Landing gear	1	1
629.13.015.14	Shock absorbers	-	1
629.13.03	Propulsion	1	1
629.13.035.4	Rocket propulsion	1	-
629.13.035.5	Jet aircraft	1	4
629.13.035.53	Ram jet propulsion	1	1
629.13.038	Propellers	1	2
629.13.05	Aircraft instruments	-	2
629.13.053.33	Compass controlled directional gyroscopes	-	1
629.13.055.7	Fuel consumption meters	-	1
629.13.061.4	Oxygen systems	1	-
629.13.067	Air conditioning systems	1	1
629.13.071.55	Cargo weight	-	1
629.13.072.2	High speed aircraft	1	1
629.13.079	Short take-off and landing aircraft	-	1
629.135.27	Pilotless aircraft	-	1
629.135.45	Helicopters	2	6
629.135.52	Flying boats	1	-
629.136.3	Missiles	2	6
629.138.035.5	Jet propelled transport aircraft	1	1
629.138.4	Cargo aircraft	-	2
629.138.5	Passenger aircraft	1	1
629.138.744	Prototype aircraft	-	1
629.19	Astronautics	1	2
658.54	Work study	1	-
658.542.1/.3	Motion study	-	1
661.65	Boron	-	1
662.3	Solid propellants	1	1
662.35	Cordite	-	1
662.69	Natural gases	-	1
662.7	Chemically produced fuels	-	1
662.75	Liquid propellants	4	3
662.76	Gaseous fuels	-	1
662.8	Solid fuels	-	4
666.3:669	Cermets	2	2
669	Metallurgy	-	1
669-135	Extrusions	1	1

Term		Number of terms used in Indexing	Searching
669-14	Castings	1	-
669...893	Ceramic coatings on metals	-	1
669.018.45	High temperature alloys	1	2
669.12	Iron	-	1
669.14	Steel	1	3
669.14.018.45	Heat resistant steel	-	1
669.14.018.8	Corrosion resistant steel	-	1
669.15.24.26-194	Stainless steel	1	1
669.246	Nickel alloys	1	-
669.285	Molybdenum alloys	1	1
669.295	Titanium	-	1
669.295.5	Titanium alloys	-	1
669.295.5.779	Titanium-phosphorous alloys	1	-
669.296	Zirconium	-	1
669.55	Zinc alloys	-	1
669.715-135	Extruded aluminium alloys	-	1
669.715.3	Aluminium-copper alloys	-	1
669.784	Titanium-carbon alloys	1	1
669.71	Aluminium	1	-
669.715	Aluminium alloys	13	10
669.718.568	Aluminium cladding	1	-
669.721.5	Magnesium alloys	2	2
669.721.5.296-14	Cast magnesium-zirconium alloys	1	-
669.779	Phosphorous	1	-
677.52	Glass fibres	-	1
678.632	Phenolic resins	-	1
678.744.335	Plexiglas	-	1
678.842	Silicones	-	1
679.5	Plastics	1	1

PART 2. ALPHABETICAL (MAIN HEADINGS)

Term	No. of times used in Indexing	Searching
Ablation	-	2
Aerofoils	9	1
Aerofoils, Circular Arc	1	-
Aerofoils, Low drag	-	1
Aerofoils, Supersonic	4	1
Aerofoils, Transonic	-	1
Aeroplanes	9	3
Aeroplanes, Fighter	6	-
Aeroplanes, Jet	-	2
Aeroplanes, Pilotless	1	-
Aeroplanes, Sweptback Wing	2	4
Aeroplanes, Transport	2	2
Aeroplanes, Transport, Jet	4	1
Afterburners	1	-
Ailerons, Moving Wingtip	1	-
Air Cleaning	1	-
Air Cushions	1	-
Aircraft	4	-
Aircraft, Vertical Take off and landing	3	1
Aircraft components	-	1
Aircraft industry	-	1
Alloys, High temperature	6	1
Aluminium alloys	19	15
Aluminium alloys (Duralumin)	3	3
Ammonia	1	-
Ammonium nitrates	1	-
Analogy, Electric	1	6
Anemometers	-	1
Anemometers, Hot wire	3	2
Angle of attack	1	1
Area rule	1	1
Aspect ratio	5	1
Balances, Strain gauge	1	-
Bars	-	1
Bars, Aluminium alloys	1	-
Bars, Curved	-	1
Batteries	-	1

Term	No. of times used in Indexing	Searching
Beams	4	-
Beams, Box	8	1
Beams, Curved	-	1
Beams, Cylindrical	-	4
Beams, Rectangular, Cross section	2	1
Bends (Internal Aerodynamics)	7	-
Bibliography	1	-
Blades, Rotor	6	1
Blades, Turbine	4	2
Bodies	2	3
Bodies, Bluff	1	-
Bodies, Bluff, Hypersonic	2	1
Bodies, Blunt	-	1
Bodies, Blunt, Hypersonic	1	-
Bodies, Blunt, Supersonic	1	2
Bodies, Insulated	2	-
Bodies of revolution	2	1
Bodies of revolution, Hypersonic	1	-
Bodies, of revolution, Supersonic	-	2
Bodies, Slender, Supersonic	2	-
Bodies, Spiked	1	2
Bodies, Spiked, Hypersonic	2	1
Bolts	4	4
Bonding	-	1
Boundary layer	6	8
Boundary layer, Hypersonic	1	-
Boundary layer, Laminar	9	3
Boundary layer, Laminar, Supersonic	2	1
Boundary layer separation	2	1
Boundary layer, Supersonic	2	1
Boundary layer, Transition	2	2
Boundary layer, Transition, Supersonic	1	1

Term	No. of times used in Indexing	Searching
Boundary layer, Turbulent	3	5
Boundary layer, Turbulent, Hypersonic	3	3
Boundary layer, Turbulent, Supersonic	3	2
Boundary layer, Turbulent, Transonic	2	1
Cabins	4	-
Cabins, Pressurised	4	4
Camber	-	3
Cams	-	3
Canopies, Cockpit	2	1
Cascades	2	2
Cermets	3	4
Channels (Hydrodynamics)	2	-
Channels, Curved	-	1
Circuits, Wheatstone bridge	-	1
Coatings, Ceramic	-	1
Coatings, Enamel	-	2
Combinations, Wing-Aileron	2	-
Combinations, Wing-Fuselage	2	3
Combinations, Wing-Fuselage, Supersonic	3	-
Combinations, Wing-Fuselage, Transonic	1	-
Combustion	2	-
Combustion chambers	2	5
Combustion chambers, Gas turbine	-	2
Compressors, Axial	2	4
Cone-Cylinders	-	1
Cone-Cylinders, Elliptic, Supersonic	-	1
Cone-Cylinders, Supersonic	4	1
Cones	3	4
Cones, Hypersonic	2	-
Cones, Supersonic	6	4
Cones, Yawed	-	2
Controls	1	4
Control, Longitudinal	1	-
Controls, Power Operated	1	-
Cooling	1	-
Cooling, Ablation	1	-

Term	No. of times used in Indexing	Searching
Cordite	-	1
Corners	-	1
Correction	-	1
Corrosion, Stress	2	-
Corrosion tests	-	1
Costing	-	1
Cowlings	2	1
Cracking tests	-	2
Cracks	3	1
Crystals	1	-
Cylinders	3	2
Cylinders, Circular	2	2
Cylinders, Circular Cross section	2	3
Cylinders, Concentric	-	1
Cylinders, Hypersonic	1	-
Cylinders, Stiffened	1	-
Cylinders, Supersonic	1	1
Dampers	1	1
Data processing	-	1
Data reduction	3	2
Detectors, Radio	-	3
Diffraction	-	2
Diffusers	6	1
Diffusers, Supersonic	2	2
Diodes	1	-
Discriminators	1	-
Dissociation	1	-
Drag	-	1
Economics	-	1
Enamelling	-	1
Engines	-	1
Engines, Gas turbine	8	10
Engines, Ramjet	4	2
Engines, Rocket	9	6
Engines, Turbine propeller	-	1
Etching	-	1
Exhauster	-	1
Expansions (Internal Aerodynamics)	1	-
Extrusions, Magnesium	1	-
Fatigue tests	1	-
Feedback	1	-
Fibreglass	-	2
Filters (Machine Components)	1	-
Fineness ratio	-	1
Fins, Cooling	1	-
Flames	3	1
Flaps	1	-
Flaps, Jet	-	2

Term	No. of times used in Indexing	Searching
Flaps, Slotted	-	1
Flaps, Slotted, Double	-	1
Flaw detection	1	-
Flow, Compressible	-	1
Flow, Conical	1	1
Flow, Conical, Supersonic	-	1
Flow, Hypersonic	-	1
Flow, Laminar	1	-
Flow, Mixed, Supersonic	2	-
Flow, Parallel, Supersonic	1	-
Flow, Rotating	-	1
Flow, Rotating, Supersonic	1	1
Flow, Reverse	1	-
Flow, Reverse, Supersonic	1	2
Flow, Shear, Supersonic	1	-
Flow, Subsonic	2	-
Flow, Supersonic	2	5
Flow, Turbulent	3	2
Flow, Vortex	-	1
Flow in pipes	4	1
Flow in pipes, Supersonic	2	-
Flow problems	1	-
Fluids, Viscous	1	2
Flutter	4	-
Forces, Centrifugal	1	-
Flying	1	-
Formulae	2	2
Fretting	-	1
Fuel injectors	-	2
Fuel systems	2	2
Fuels	-	1
Fuels, Gaseous	2	-
Fuels, Liquid	3	-
Functions	2	-
Fuselage, Supersonic	2	-
Gases	3	-
Gases, Natural	-	1
Generators	2	-
Geometry	1	-
Gliders	1	-
Grooves	2	-
Guidance	2	-

Term	No. of times used in Indexing	Searching
Guidance systems	2	-
Guns, Aircraft	1	2
Gusts	-	1
Heating, Aerodynamic	2	2
Heat transfer	1	4
Helicopters	2	1
Helium	-	1
Heptane	1	1
Holes	1	2
Hulls	-	4
Human engineering	-	1
Hydrogen	-	2
Impurities	1	-
Inducers, Axial flow	-	1
Intakes	2	1
Intakes, Annular	-	1
Intakes, Centrebody	-	3
Intakes, Side	-	1
Intakes, Supersonic	3	1
Intakes, Transonic	1	-
Iron alloys	-	1
Jet deflections	-	1
Jet mixing	3	-
Jet noise	2	-
Jets	2	2
Jigs	1	-
Joints	-	2
Joints, Lap, Aluminium alloy	2	-
Joints, Riveted, Aluminium alloy	1	-
Joints, Riveted, Butt	1	-
Joints, Riveted, Lap	1	-
Leading edges	2	-
Lift coefficient	-	1
Loads, Gust	-	1
Machine tools	-	2
Magnesium	-	1
Magnesium alloys	5	2
Magnetohydrodynamics	2	4
Materials, Radioactive	-	1
Measurement	-	1
Metals	2	5
Meteors	-	1
Milling, Chemical	-	1
Missiles	3	3
Missiles, Ballistic	3	-
Missiles, Guided	11	1
Missiles (Bloodhound)	2	2
Mixtures, Fuel	-	1

Term	No. of times used in Indexing	No. of times used in Searching
Mixtures, Gas	-	2
Models	1	2
Models, Structural	-	1
Modulation frequency	1	4
Molybdenum	-	1
Moments, Pitching	-	2
Navigation	1	-
Networks, Electric	2	1
Nickel alloys	1	-
Noise, Aerodynamic	1	-
Nose shapes	-	1
Noses	-	3
Nozzles	3	2
Nozzles, Supersonic	3	-
Nozzles, Transonic	2	-
Optical instruments	-	1
Oscillation	1	1
Oxygen	1	2
Panels	-	3
Panels, Sandwich construction	-	1
Pentaborane	1	2
Perspex	-	1
Phosphorous	1	2
Pilots, Automatic	1	-
Pitot tubes	-	1
Plastics	1	2
Plates	1	4
Plates, Circular	4	3
Plates, Clamped	1	-
Plates, Curved	1	-
Plates, Flat	5	6
Plates, Flat, Supersonic	2	-
Plates, Parallel	-	1
Plates, Perforated	1	1
Plates, Rectangular	1	1
Plates, Rectangular, Stiffened	3	-
Plates, Stainless steel	2	-
Plates, Stiffened	-	1
Plates, Supersonic	2	-
Plates, Supported	6	1
Plates, Supported, Supersonic	2	-
Plates, Tapered	2	1
Potential flow tanks	1	-
Pressure losses	1	-
Pressure distribution	1	-
Probes	1	-
Propane	3	-
Propellants	-	2
Propellants, Liquid	3	-
Propellants, Solid	1	1
Propellers	1	2
Propellers, Shrouded	1	-
Propellers, Supersonic	1	1
Propulsion, Nuclear	1	-
Propulsion, Turbine-propeller	-	1
Pull-out	1	1
Radioactivity	1	1
Refrigeration	2	1
Reynolds number	1	1
Rockets	1	2
Rockets, Nuclear propellant	-	1
Roughness effect (Aerodynamics)	1	1
Rubber, Silicon	-	2
Screw threads	1	-
Servomechanisms	-	4
Servomechanisms, Electric	-	2
Sheets, Aluminium alloy	6	7
Shells	2	1
Shells, Conical	1	1
Shells, Spherical	3	-
Shock absorbers	-	1
Shock tubes	3	1
Shock tubes, Hypersonic	1	1
Shock waves	1	5
Shock waves, Detached, Hypersonic	2	-
Shock waves, Oblique, Supersonic	1	-
Shock waves, Hypersonic	2	-
Shock waves, Supersonic	2	3
Sintering	-	2
Skins, Supersonic	2	-
Skin friction	-	1
Slabs	2	-
Slats, Leading edge	1	-
Springs	2	1
Springs, Helical	1	1
Stabilisers	2	1
Stability	1	-

Term	No. of times used in Indexing	Searching
Stability, Longitudinal	1	-
Stalling	-	1
Static pressure tubes	1	-
Steel	2	2
Steel, Stainless	2	4
Steel enamelling	-	2
Steps	-	1
Strain gauges	1	1
Stresses	1	1
Structures	1	1
Structures, Aircraft	15	2
Supports	-	1
Surfaces	1	-
Surfaces, Curved	-	1
Surfaces, Insulated	2	-
Tabs, Servo	1	-
Tailplanes	3	-
Temperature measuring instruments	2	1
Thermoelectricity	1	-
Thermometers	-	1
Throttles	1	-
Thrust reversers	-	1
Titanium	2	1
Titanium alloys	-	1
Titanium carbide	1	-
Trajectories	1	1
Transformation	-	1
Transistors	1	2
Tubes	-	3
Tubes, Rectangular Section	1	-
Tubes, Cylindrical	2	2
Turbulence	-	1
Undercarriages	1	1
Vanes	8	-
Vaporisation	-	1
Visualisation	-	1
Vortex generators	2	-
Vortex sheets	1	1
Wakes	-	1
Wakes, Laminar	-	2
Wakes, Supersonic	1	1
Water	1	-
Water injection	1	-
Wedges	2	-
Wind tunnel equipment	1	1
Wind tunnels	2	-
Wind tunnels, Blowdown	-	2
Wind tunnels, Hypersonic	1	1
Wind tunnels, Intermittent	-	1
Wind tunnels, Intermittent, Supersonic	1	1
Wind tunnels, Supersonic	1	1
Wind tunnels, Transonic	-	1
Windows	2	-
Wing flow tests	1	-
Wings	21	10
Wings, Arrowhead	-	2
Wings, Delta	10	4
Wings, Delta, Supersonic	1	6
Wings, Low drag	1	4
Wings, Oscillating	2	4
Wings, Oscillating, Supersonic	1	-
Wings, Rectangular	5	-
Wings, Rectangular, Supersonic	1	-
Wings, Slotted	-	1
Wings, Sweptback	5	8
Wings, Sweptback, Supersonic	3	2
Wings, Sweptback, Transonic	1	1
Work study	1	1

ALPHABETICAL (SUBHEADINGS)

Term	No. of times used in Indexing	No. of times used in Searching
Accuracy	1	2
Aerodynamics	3	2
Aeroelasticity	2	-
Aids	1	-
Altitude effect	-	2
Analysis	15	2
Application	26	12
Aspect ratio	-	1
Bending	2	7
Bending strength	1	-
Bonding	-	1
Buckling	9	8
Calculation	62	11
Calibration	2	2
Camber	4	-
Casting	4	-
Causes	2	-
Centre	2	-
Choking	1	-
Combustion	8	4
Compressibility	-	1
Compression	6	1
Compression tests	3	1
Conductivity, Thermal	1	1
Construction	3	1
Control	13	1
Convection	4	-
Conversion	2	2
Cooling	5	5
Cooling, Air	1	-
Cooling, Liquid	1	2
Corrosion	9	4
Corrosion resistance	2	-
Cost control	2	-
Cracking	9	1
Creep	-	1
Damping	16	6
Deceleration	1	-
Decomposition	1	-
Deflection	1	5
Deformation	1	1
Design	18	8
Development	3	1
Diffusion	3	-
Dimensions	1	-
Displacement	-	2
Dissociation	-	1
Distribution	-	1
Drag	14	13
Drag, Skin friction	2	-
Drag, Wave	8	3
Ductility	1	-
Economics	2	1
Effectiveness	1	1
Efficiency	4	-
Elastic limit	2	-
Elasticity	2	-
Embrittlement	1	-
Erosion	-	1
Etching	4	2
Expansion	1	-
Failure	4	2
Fatigue	14	4
Fatigue strength	6	-
Fatigue testing	2	-
Fatigue tests	6	-
Flight tests	7	4
Flow	22	5
Flow distribution	12	7
Flutter	19	11
Forces and moments	6	-
Forming	-	1
Guidance	4	-
Gunfire tests	2	-
Heat transfer	23	18
Heating	1	-
Heating, Aerodynamic	5	3
Hinge	1	-
Humidity	1	-
Impact	-	2
Impedance	2	-
Impurities	1	1
Installation	2	-
Interference	2	12
Lift	8	3
Lift-drag ratio	3	-
Loading	4	3
Loads	1	3
Loads, Aerodynamic	6	1
Loads, Compressive	1	-
Loads, Gust	-	1
Machining	1	3
Materials	5	1
Measurement	10	4
Modifications	2	2
Moments	4	-
Moments, Pitching	-	4
Moulding	-	1

Term	No. of times used in Indexing	Searching
Movements	6	1
Noise	11	8
Operating analysis	1	-
Operation	3	1
Oxidation	-	1
Performance	5	13
Photoelastic tests	2	-
Pitching	5	-
Plasticity	-	1
Porosity	3	1
Position	1	-
Pressure	2	1
Pressure, Base	1	2
Pressure distribution	19	7
Pressure gradient	4	1
Pressure losses	3	-
Pressure recovery	2	-
Pressure tests	4	-
Pressurisation	1	-
Prevention	1	-
Production	3	-
Propagation	2	1
Properties	9	4
Propulsion	5	1
Pressure drop	1	-
Range	-	1
Recombination	-	1
Reduction	2	-
Resistance	5	-
Resonance	-	1
Rolling	3	-
Separation	4	2
Shape	1	1
Shearing	3	3
Shielding	1	-
Sintering	2	-
Size	-	1
Soldering	2	-
Solution	3	-
Stability	10	6
Stability, Lateral	2	5
Stability, Longitudinal	2	-
Stalling	1	1
Starting	1	2
Stiffness	1	-
Strength	14	9
Stress analysis	4	-
Stress distribution	3	1
Stresses	3	12
Stresses, Buckling	1	-
Stresses, Thermal	5	-
Suppression	5	1
Temperature	4	7
Temperature distribution	3	2
Temperature effect	3	2
Tension	5	3
Tension strength	2	1
Tension tests	3	1
Testing	9	1
Tests	59	5
Thermal	1	2
Thickness	2	2
Thickness distribution	3	-
Thrust	1	1
Torsion	3	-
Trajectories	2	2
Transition	1	-
Turbulence	-	1
Vaporisation	1	2
Velocity	4	-
Velocity gradient	1	-
Velocity distribution	2	1
Vibration	19	9
Visualisation	3	-
Wakes	1	-
Water injection	1	-
Weight	2	1
Wind tunnel tests	42	1
Wing flow tests	2	-
Yawing	1	2

PART 3. FACET

Term		No. of terms used in Indexing	No. of terms used in Searching
A	Aviation	1	-
Aba	Transport	1	-
Abb	Passenger carrying	2	-
Abd	Cargo	-	1
Aj	Military aviation	1	-
An	Fighter operations	3	1
Av	Astronautics	-	1
B	Aircraft	3	1
Bc	Aeroplanes	6	4
Bcf	Flying boats	4	1
Bhb	Piston engine aeroplanes	-	1
Bhg	Turbojet aeroplanes	2	2
Bhk	Nuclear propelled aeroplanes	-	1
Bkb	Tailless aeroplanes	-	1
Bmf	V.T.O. aeroplanes	-	2
Bn	Pilotless aeroplanes	-	1
Br	Helicopters	4	4
Brf2	Twin rotor helicopters	1	-
Bt	Missiles	4	3
Btb	Ballistic missiles	3	-
Btc	Guided missiles	4	-
Btf	Surface to air missiles	-	1
Bzp	Satellites	-	1
C	Aircraft structures	8	-
Ca	Combinations	2	2
Cc	Aerofoils	6	3
Cd	Wings	34	25
Cn	Tail units	-	1
Cnd	Tailplanes	2	-
Cp	Control surfaces	2	-
Cpb	Ailerons	2	-
Cq	Elevators	1	-
Cr	Flaps	4	-
Crf	Slotted flaps	1	1
Cs	Jet flaps	-	1
Ct	Slots	1	1
Cuj	Servotabs	1	1
Db	Rotors	3	2
Dc	Propellers	2	3
Dj	Blades	2	1
Ea	Fuselages	4	1
Ed	Cockpits	-	1
Edb	Cabins		
Edd	Pressurised cabins	2	2
Efd	Canopies	1	1
Egb	Windows	1	-
Ek	Cowlings	1	1
Em	Skins	1	-
Emb	Undercarriages	1	-
Eqd	Retractable mechanisms	1	-
Eqf	Shock absorbers	-	1
Er	Wheels	-	1
Evd	Assisted flying controls	-	1
Ew	Servomechanisms	-	1
Ewm	Autopilots	1	1
Ezn	Wind tunnels	2	1
Ezpd	Intermittent wind tunnels	-	1
Ezpf	Shock tubes	2	2
Ezpz	Blowdown wind tunnels	-	1
Ezss	Stings	1	1
Ezv	Recording equipment	-	1
Fa	Structures	1	2
Ffb	Sheets	3	5
Ffe	Plates	14	7
Ffh	Panels	3	2
Ffm	Shells	3	1
Fge	Stiffeners	1	-
Fhb	Beams	-	1
Fje	Rods	1	3
Fkb	Sandwich structures	2	2
Fkm	Monocoque structures	-	1
Fm	Bodies	6	5
Fnf	Wedges	2	-
Fp	Bodies of revolution	1	2
Fq	Cylinders	6	6
Fqd	Discs	1	1
Fr	Cones	3	2
Fu	Blunt bodies	2	2
Fv	Bluff bodies	3	1
Fw	Surfaces	4	-

Term		No. of terms used in Indexing	No. of terms used in Searching
Fx	Corners	1	1
Fy	Holes	1	1
Ga	Engines	1	-
Gb	Piston engines	-	1
Gc2	2 stroke engines	-	1
Gf	Gas turbine engines	4	3
Gg	Jet engines	5	6
Gh	Turboprop engines	1	-
Gi	Direct combustion engines	1	-
Gib	Ram jet engines	4	1
Gj	Rocket engines	7	4
Gjb	Liquid propellant rocket engines	-	1
Gjd	Solid propellant rocket engines	2	1
Gk	Nuclear reactors	1	-
Gkb	Fission reactors	1	-
Gkd	Fusion reactors	1	-
Gn	Fuel system	1	-
Gp	Fuel injectors	-	2
Gq	Air intakes	4	1
Gs	Exhaust systems	1	-
Gsg	Jet deflectors	-	1
Gsi	Afterburners	1	-
Gsk	Silencers	1	-
Gt	Cooling systems	-	1
Gug	Air conditioning systems	1	-
Gut	Refrigerating systems	1	1
Gvh	Electrical systems	-	1
Gvn	Guidance systems	4	-
Gvy	Guns	3	1
Gwd	Axial flow compressors	1	-
Gx	Turbines	2	-
Gy2	2 stage turbines	1	-
Gzf	Heat exchangers	2	-
Gzp	Oxygen equipment	1	-
Hbb	Walls	-	1
Hbf	Grids	2	1
Hbh	Cascades	1	2
Hdb	Rotors (machine components)	-	1
Hdv	Blades	2	1
Hdp	Cams	-	1
Hke	Housings	-	1
Hks	Cylinder(machine components)	-	1
Hku	Combustion chambers	2	2
Hn	Springs	-	1
Hnb	Helical springs	1	-
Hr	Ducts	1	-
Hrd	Pipes	6	3
Hrf	Channels	4	2
Hrj	Nozzles	3	-
Hrm	Diffusers	3	2
Hs	Clamps, Jigs	1	1
Hu	Joining	2	2
Hvd	Rivets	1	1
Hwe	Bolts	1	-
Hwi	Screws	1	-
Hz	Tools	1	1
Ibe	Front	1	1
Ibi	Side	2	1
Ic	Inside	-	2
Icb	Centre	1	-
Icf	Cross section	3	-
Id	Tips	1	1
Idb	Roots	1	1
Ie	Edges	-	1
Ieb	Leading edges	1	2
Igq	Cylindrical	1	1
Igr	Conical	3	3
Igs	Spherical	1	1
Ihe	Sharp	1	-
Iibb	Sweptback	7	4
Iid	Triangular	3	2
Ij	Delta	3	2
Ije	Wedge-shaped	1	-
Ikb	Rectangular	6	-
Imd	Arrow	-	1
Ipc	Circular	2	3
Ipe	Concave	1	1
Ipi	Convex	1	-
Ipn	Oval	2	-
Ips	Annular	1	-
Iqb	Semicircular	1	-
Irv	V shaped	1	-
Is	Flat	4	3
Itc	Notched	1	-
Itk	Perforated	2	1
Iu	One-dimensional	1	-
Iud	Curved	1	2
Iuf	Bent	1	-
Iv	Thin	3	3

Term		No. of terms used in Indexing	Searching
Ivd	Tapered	2	2
Iwd	High	1	2
Iwh	Long	-	1
Ixd	Horizontal	1	1
Ixp	Parallel	-	2
Iyh	Hollow	1	-
Iym	Concentric	1	-
Iys	Symmetrical	2	-
Ja	Performance	-	1
Jc	Range	-	1
Je	Propulsion	1	-
Jeb	Thrust	1	-
Jg	Propulsive efficiency	1	1
Jy	Altitude	1	2
K	Flying operations	3	-
Kd	Take-off	1	-
Keb	Hovering	-	1
Kg	Landing	1	1
Kga	Planing	1	-
Kh	Stalling	1	3
Km	Aerobatics	1	-
Kp	Rolling	-	1
Kub	Pull-out	2	1
Lj	Astronavigation	1	-
Lp	Radio navigation systems	1	-
Lun	Inertial navigation	2	1
Mkb	Strain gauges	2	1
Mkf	Pressure-measuring instruments	1	-
Mm	Temperature measuring instruments	-	1
Mmd	Thermocouples	1	-
Mmj	Pitot tubes	1	1
Mmm	Hot wire anemometers	1	-
Mup	Pilots	-	1
Mzp	Drop impingement	1	-
Naq	Gases (aerodynamics)	2	1
Nas	Rarefied gases	2	1
Nb	Aerodynamic entities	-	1
Nbf	Flow	1	1
Nbh	Subsonic flow	1	-
Nbj	Transonic flow	6	3
Nbk	Supersonic flow	22	20
Nbm	Hypersonic flow	11	5

Term		No. of terms used in Indexing	Searching
Ncd	Laminar flow	8	2
Ncf	Turbulent flow	2	4
Nci	Unsteady flow	1	-
Ndb	Rotational flow	2	1
Ndj	Diabatic flow	-	1
Ndp	Non-isentropic flow	-	1
Nef	Reversible flow	1	1
Nek	Free molecule flow	3	1
Nep	Shear flow	2	-
Nev	Mixed flow	2	-
Nf2	2 dimensional flow	-	1
Nfd	Non-viscous flow	1	-
Nff	Viscous flow	1	2
Nfj	Compressible flow	1	1
Nfk	Boundary layer	10	11
Nfn	Transition(B.L)	1	1
Nfp	Separation(B.L)	2	4
Ngc	Streamlines	1	-
Nge	Sources	1	-
Ngk	Vortices	2	2
Ngp	Vortex sheets	1	1
Ngx	Jets	8	1
Nhd	Shock waves	3	5
Nhf	Normal shock waves	5	-
Nhh	Oblique shock waves	2	-
Nhj	Attached shock waves	-	1
Ni	Velocity (aerodynamics)	1	-
Nie	Velocity gradient	1	-
Njm	Reynolds number	2	1
Nmd	Spray	1	1
Nnc	Density (fluids)	1	-
Nng	Compressibility	-	1
Np	Aerodynamic characteristics	2	2
Npa	Aerodynamic forces	2	-
Npb	Aerodynamic loads	2	3
Nq	Lift	7	3
Nr	Drag	9	6
Nrf	Skin friction drag	-	1
Nrh	Wave drag	6	2
Nrm	Interference drag	1	-
Ntq	Gust loads	1	1
Nu	Moments	1	-
Nub	Pitching moments	4	3
Nud	Rolling moments	1	-

Term		No. of terms used in Indexing	Searching
Nuf	Yawing moments	1	-
Nv	Pressure	6	4
Nvf	Pressure distribution	10	3
Nvh	Centre of pressure	3	-
Nvk	Pressure gradient	2	1
Nvm	Pressure recovery	1	-
Oa	Control (aero-dynamics)	3	1
Ob	Stability	5	3
Od	Manoeuvrability	-	1
Oe	Interference	2	3
Og	Choking	1	-
Oi	Aerodynamic heating	5	3
Ojb	Downwash	2	1
Ojh	Wake	1	3
Ojp	Turbulence	1	1
Okb	Suction	3	3
Okd	Blowing	1	-
Omb	Vibrations (aero-elasticity)	-	1
On	Flutter	15	8
Onb	Flexure torsion flutter	-	1
Oqb	Angle of attack	6	1
Oqm	Planform	-	1
Oqt	Aspect ratio	8	4
Oqw	Thickness ratio	1	-
Osq	Aerofoil sections	2	1
Oss	Camber	3	2
Pcc	Gaseous fuels	1	1
Pce	Liquid fuels	6	1
Pcg	Solid fuels	1	-
Pck	Propellants	2	-
Pcn	Explosives	-	1
Pe	Metals	1	-
Pea	Alloys	1	1
Peal	Aluminium	13	9
Pefe	Iron	1	2
Pemg	Magnesium	5	1
Pemo	Molybdenum	2	1
Peni	Nickel	2	-
Peti	Titanium	3	2
Pf	Steel	2	3
Pfcrni	Stainless steel	-	1
Pgg	Glass	-	1

Terms		No. of terms used in Indexing	Searching
Pgp	Artificial fibres	-	1
Pgv	Cermets	5	2
Ph	Plastics	-	1
Phb	Thermoplastic plastics	-	1
Pht	Rubber	-	1
Pmr	Radioactive materials	1	1
Pnch	Chlorine	1	-
Ppb	Water	2	1
Pph	Air	1	-
Pqh	Hydrogen	1	1
Pqhe	Helium	-	1
Pqnaoh	Sodium hydroxide	1	-
Pqo	Oxygen	1	1
Pqp	Phosphorous	1	1
Prb	Solids	1	-
Prf	Gases	1	1
Prj	Mixtures	1	-
Q	Manufacturing processes	1	2
Qb	Casting	-	1
Qcc	Melting	-	1
Qdg	Extrusion	1	-
Qg	Machining	1	-
Qhh	Sintering	3	-
Qjc	Quench hardening	2	1
Qk	Joining	1	1
Qkf	Redux bonding	-	1
Qny	Soldering	2	1
Qpp	Chemical etching	2	2
Qqn	Cladding	2	1
Rab	Dimensions	3	-
Raf	Thickness	3	1
Ram	Mass weight	1	1
Rc	Kinematics	1	1
Rcd	Rotation	-	1
Rda	Angular velocity	2	-
Rer	Mechanical efficiency	1	-
Rev	Sliding friction	1	1
Rfb	Trajectory	4	1
Rgz	Deformation	1	-
Rh	Elasticity	2	1
Rip	Plasticity	3	1
Rji	Shrinkage	-	1
Rk	Effects of deformation	1	1
Rkf	Cracking	2	1
Rkh	Buckling	7	5
Rkm	Fatigue	18	6

Term		No. of terms used in Indexing	Searching
Rkn	Endurance limits	-	2
Rkq	Failure	2	1
Rm	Stresses	16	7
Rmk	Residual stresses	-	1
Rmp	Safety factor	4	-
Rmt	Thermal stresses	9	1
Rp	Strength	13	3
Rpm	Life	3	1
Rq	Leading	3	1
Rqe	Tension	7	2
Rqg	Compression	5	1
Rqi	Shear	2	2
Rqj	Torsion	1	-
Rqm	Bending	6	2
Rqu	Creep	-	1
Rrh	Stiffness	1	-
Rv	Roughness	1	1
Rve	Slot	1	-
Rvg	Crack	2	2
Rvq	Projections	1	-
Rvn	Stepped	1	1
Rx	Porosity	1	1
Rxd	Diffusion	2	1
Sa	Vibrations	20	5
Sb	Modes	1	-
Sed	Noise	2	3
Seh	Engine noise	7	3
Sej	Propeller noise	2	2
Sfd	Frequency	2	1
Sfg	Wavelength	-	1
Sfm	Propagation (vibrations)	-	1
Sfr	Attenuation	2	1
Sfs	Hysteresis	1	1
Sfu	Damping	6	2
Sg	Electromagnetic waves	-	1
Shn	Radioactive radiation	-	1
Skb	Photoelasticity	1	1
Sjn	Magnetohydro-dynamics	1	3
Slb	Fluorescence	-	1
Snm	Evaporation	1	2
Ssb	Temperature	9	1
Ssd	High temperature	4	2
St	Heat transfer	17	10
Stc	Cooling	8	5
Std	Sweat cooling	-	1

Term		No. of terms used in Indexing	Searching
Ste	Gas cooling	1	-
Stg	Convection	2	1
Stj	Forced convection	1	-
Stn	Radiation	-	2
Stq	Conduction	-	1
Stv	Thermal conductivity	3	1
Stx	Thermal insulation	1	-
Tab	Nuclear structure	-	1
Td	Crystal problems	2	-
Tfd	Impurities	1	1
Tm	Chemical reaction	5	-
Tmd	Dissociation	1	1
Tnc	Flames	3	1
Tr	Corrosion	1	1
Trc	Chemical corrosion	-	1
Trj	Stress corrosion	2	-
Ug	Equilibration (medicine)	1	1
Ujs	Shielding	-	2
Usg	Gusts	-	1
Usk	Atmospheric turbulence	-	1
V	General technical operations	3	-
Vbb	Production engineering	1	-
Vbd	Design	12	3
Vbj	Assembly	1	-
Vbp	Development	2	-
Vdj	Work study	1	1
Vfc	Control	7	2
Vfd	Starting	1	-
Vff	Stopping	1	-
Vgg	Cleaning	1	-
Vgj	Lubrication	-	1
Vh	Damage	-	1
Vhb	Failure	1	-
Vhd	Prevention	2	3
Vhm	Modification	-	1
Vi	Tests	46	4
Vif	Flight tests	5	2
Viv	Visualisation	2	1
Vix	Analogy	4	3
Vn	Wind tunnel tests	24	2
Vt	Calibration	2	-
Vtb	Accuracy	1	-
Vte	Errors	1	-
Vx	Recording methods	-	1

Term		No. of terms used in Indexing	Searching
Wad	D. C. Generators	1	-
Wah	A. C. Alternators	1	-
Wd	Circuits	1	-
Wdn	Electric Discriminators	2	1
Wfe	Rectifiers	-	1
Whb	Batteries	3	1
Whi	Cores	-	1
Wk2	Diodes	1	1
Wnc	Transistors	1	-
Wng	Junction transistors	-	1
Wrl	Impedance	-	1
Wqd	Magnetic field	-	1
Wsd	Frequency	1	1
Wsu	Amplitude	1	-
Wtn	Diffraction	-	1
Wtt	Modulation	2	1
Xbc	Costing	1	1
Xs	Theory	2	-
Xu	Application	4	-
Xy	Analysis	10	-
Xz	Measurement	5	1
Ya	Calculation	52	1
Yaf	Formula	1	-
Yas	Solution	4	-
Yfg	Partial differential equations	-	1
Ygd	Eigenvalue equations	1	-
Yhf	Non-linear equations	1	-
Yj	Functions	1	-
Ym	Geometry	2	-
Yre	Curve fitting	-	1
Yx	Computers	1	2
Yxd	Digital computers	1	1
Yz	Computer operation	1	-
Yzs	Simulation	1	-
Zb	Stability	3	-
Zbc	Resistance	1	-
Zdb	Rise	4	-

Term		No. of terms used in Indexing	Searching
Zdd	Fall	2	-
Zf	Distribution	8	-
Zfg	Gradients	1	-
Zg	Ratio	1	-
Zh	Coefficient	-	1
Zk	Response	-	1
Zqf	Minimum	1	-
Zqh	Very low	1	-
Zqj	Low	1	1
Zqn	High	1	2
Zqp	Very high	-	1
Zqt	Maximum	1	-
Zs	Model	1	1
Zub	Free	1	-
Zuk	Simply supported	4	1
Zuz	Pressurised	-	1
Zvf	Hydraulic	-	2
Zvh	Electric	3	1
Zz	Television	3	1

PART 4. UNITERM

Term	No. of times used in Indexing	Searching
Abatement	-	1
Absorbers	-	1
Absorption	2	-
Acceleration	-	2
Accuracy	-	1
Acetate	1	-
Adiabatic	1	-
Advance	1	-
Aerobatics	1	-
Aerodynamics	15	7
Aeroelasticity	2	-
Aerofoils	9	-
Aeroplanes	-	6
Aerorez	1	-
Afterburners	2	-
Ailerons	1	2
Air	9	7
Aircraft	32	26
Aisi	1	-
Alclad	-	2
Algebra	-	2
Alkali	-	1
Alloys	18	17
Aluminium	12	7
Ammonia	2	-
Amplitudes	1	-
Analogy	2	-
Analyser	-	1
Analysis	16	-
Angles	8	2
Annular-us	2	3
Anti-aircraft	-	2
Applications	4	-
Area	-	1
Argon	1	-
Arrowhead	-	1
Aspects	7	4
Assistance	4	1
Astronautics	2	2
Atmosphere	-	2
Attached	-	1
Attack	4	3
Augmenters	1	-
Automatic	1	2
Autopilots	1	-
Auxiliary	-	1
Axial	4	2
Axis	1	-

Term	No. of times used in Indexing	Searching
AZ	1	-
B	-	4
Bars	3	5
Bases	2	5
Batteries	2	1
Beams	5	7
Bending	9	11
Bibliographies	1	-
Biconvex	1	-
Blades	5	3
Bloodhound	1	1
Blowdown	-	1
Blowing	1	-
Bluff	2	1
Blunt	4	2
Bodies	22	14
Boeing	-	2
Bolts	-	1
Bonding	-	1
Boosters	-	1
Borides	1	1
Boundaries	16	29
Bow	1	1
Boxes	1	1
Breaks	1	-
Bridge	-	2
Bristol	1	1
Brown Boveri	1	-
Buckling	5	7
Bump	-	1
Burners	1	-
Bursting	1	-
By-pass	1	-
Cabins	3	4
Calculations	36	14
Calibration	3	2
Camber	4	1
Cams	2	1
Canopies	1	1
Cantilevers	1	-
Capacities	1	-
Carbides	1	-
Cargo	-	1
Cascades	3	1
Casings	-	1
Casting	1	2
Caustic	-	1
Cell	3	-

Term	No. of times used in Indexing	Searching
Centres	3	-
Centrifugal	1	-
Ceramic	-	1
Cermets	1	2
Chambers	3	2
Changes	3	4
Channels	2	2
Characteristics	3	6
Charts	-	1
Chemical	1	2
Chords-wise	2	-
Circuits	3	1
Circular, Circles	6	5
Civil	1	1
Cleaning	1	-
Coatings	-	1
Coefficients	1	-
Columbium	1	-
Combinations-ed	8	1
Combustion	5	4
Comet	-	1
Comparison	3	2
Components	16	1
Compressibility	1	1
Compression-ed	8	6
Compressors	3	-
Computers	4	2
Concentric	1	2
Conditioning	1	-
Conduction	3	3
Cones	11	13
Constant	2	-
Contraction	-	1
Costrictions	1	-
Construction	1	1
Consumption	2	-
Controls	13	13
Convection	3	3
Convex	1	-
Cooling	2	9
Copper	1	1
Cordite	-	1
Cores	-	1
Corners	-	2
Correction	-	1
Corrosion	4	4
Costs	5	1
Cowlings	1	1
Crack	-	1
Creep	2	1
Crews	1	-
Crosses	6	3
Cruising	-	1
Curves	3	6
Cushions	1	-
Cut-outs	1	-
Cyclones	1	-
Cylinder	14	8
Damage	-	1
Dampers	1	1
Damping	5	5
Data	2	2
DC	1	1
Decay	-	1
Decomposition	-	1
Deflection	5	6
Deformations	3	6
De Havilland	-	1
Delta	-	6
Design	22	16
Detached	2	1
Detection	1	-
Developments	3	-
Deviations	1	-
Diabatic	-	1
Diagram	-	1
Diamonds	1	-
Diaphragms	1	-
Differences	2	-
Diffraction	-	1
Diffusers	6	5
Digits	2	-
Dimensions	5	5
Diodes	1	-
Direct	1	-
Discs	1	1
Dispersion	2	-
Displacement	1	1
Dissociation	1	2
Distances	-	2
Distortion	1	1
Distributions	27	19
Double	1	3
Douglas	1	1
Downwash	1	2
Drag	18	14
Droplets	2	1
Dryness	1	-
DTD	2	-
Ductility	1	-

Term	No. of times used in Indexing	Searching	Term	No. of times used in Indexing	Searching
Ducts	5	2	Fluctuations	1	-
Dynamics	2	3	Fluids	1	2
Dynamos	1	-	Flutter	6	8
Economy	-	1	Flux	1	-
Edges	4	7	Flying boats	2	2
Editing	1	1	Foams	1	-
Effects	2	3	Forced	2	2
Efficiency	1	1	Forces	2	-
Eigenvalue	1	-	Formed	1	-
Ejectors	1	-	Formulae	2	3
Elasticity	5	-	Foundations	1	1
Electricity	1	4	Free	3	1
Electromagnetic	2	-	Freight	2	1
Electron	-	1	Freon	1	-
Electronics	1	3	Frequencies	5	6
Elements (Metals)	1	-	Fretting	2	1
Elevators	1	-	Friction	2	1
Ellipses	2	3	Fuels	9	7
Energies	1	1	Functions	1	1
Engines	27	21	Fuselages	8	3
Enthalpy	1	-	Fusion	1	-
Entries	3	-	Gaps	1	-
Equations	9	7	Gases	18	13
Equipment	3	5	Gauges	2	2
Etching	2	2	Geometry	1	-
Exchangers	1	-	Germanium	1	-
Exhausts	2	3	Glider	2	-
Expansion	1	2	Gradients	5	1
Extraction	1	-	Grains	2	-
Extrusion	2	-	Graphs	1	1
Failures	5	4	Grating	1	-
Falling	1	-	Grooves	1	-
Fatigue	13	13	Guidance	2	3
Ferranti	1	-	Guided	1	3
Field	-	2	Guns	-	2
Fillets	1	-	Gusts	3	1
Filters	1	-	Gyroscopes	-	1
Fineness	-	1	Handling	-	1
Finite	1	1	Hardening	1	-
Fins	1	2	Hardness	1	-
Firing	1	-	Heads	1	-
Fission	1	-	Health	1	-
Fixed	1	2	Heat	31	23
Flames	3	2	Heights	2	3
Flaps	5	8	Helical	2	1
Flat	16	5	Helicopters	1	7
Flaws	1	1	Helium	2	3
Flexible	1	-	Heptane	2	-
Flight	7	10	Herbert-Smith	1	-
Flows	60	49	High	8	7

Term	No. of times used in Indexing	Searching	Term	No. of times used in Indexing	Searching
Hodograph	1	-	Laminar	14	10
Holes	5	2	Landing	3	3
Hollows	1	-	Lateral	-	4
Horizontal	1	1	Laval	1	-
Hot	1	-	Layers	19	30
Hovercraft	1	2	Leading	4	6
Human	-	1	Lengths	2	5
Humidity	4	2	Life	3	2
Hydrocarbons	1	-	Lift	13	7
Hydrodynamics	1	-	Light	1	-
Hydrogen	-	2	Linear	5	-
Hydroxide	1	-	Lines	-	2
Hypersonics	13	10	Lining	-	1
Hysteresis	1	1	Liquids	6	7
Impact	3	2	Loads	1	10
Impedance	-	2	Long	-	1
Impingement	1	-	Longitudinal	2	1
Impurities	1	1	Losses	2	-
Incidence	-	1	Low	2	2
Increases	1	-	Lubricants	1	1
Inducers	-	1	Mach	3	2
Induction	1	-	Machines	2	-
Industry	-	1	Magnesium	4	2
Inelasticity	-	1	Magnetic	-	2
Inertia	2	1	Magnetohydrodynamics	1	-
Infinite	-	1	Manganese	1	-
Injection	4	3	Manoeuvres	1	1
Inlets	-	1	Manufacture	4	1
Inspection	1	-	Masses	1	-
Instability	1	2	Materials	1	3
Instruments	1	1	Matrices	3	1
Insulation	2	-	Measurement	10	11
Intakes	-	1	Mechanics	1	-
Interactions	1	1	Mechanisms	1	1
Interference	2	4	Mesh	-	1
Intergranular	1	-	Metals	3	8
Intermittent	-	2	Microscopes	1	-
Internal	1	1	Milling	-	2
Inviscosity	1	-	Mineral	-	1
Ions	-	1	Miniature	1	-
Iron	1	2	Minimum	4	-
Isosceles	-	1	Missiles	5	9
Isotopes	1	-	Mixes	4	4
Jets	12	13	Models	2	2
Jettison	1	-	Modes	1	-
Jigs	1	1	Modification	1	2
Joints	3	2	Molecules	1	3
Junction	3	-	Molten	1	-
Kinetic	2	-	Molybdenum	3	1
L	-	3	Moments	7	3

Term	No. of times used in Indexing	No. of times used in Searching	Term	No. of times used in Indexing	No. of times used in Searching
Moulding	-	1	Pitch	1	1
Movements	1	1	Pitching	4	3
Mufflers	-	1	Pitch-up	-	1
NACA	3	2	Pitots	1	-
Natural	1	1	Planes	3	2
Navigation	2	1	Planform	1	2
Networks	-	1	Plants	1	2
Neutral	-	1	Plasticity	2	2
Nickel	1	-	Plastics	1	2
Nitrates	1	-	Plates	29	19
Nitrides	1	-	Pneumatics	1	1
Noise	8	8	Points	1	-
Nonlinear	2	-	Pollution	1	-
Nonuniform	2	2	Porosity	1	3
Normal	2	-	Position	2	-
Noses	1	1	Potentials	1	1
Nozzles	5	2	Potentiometers	1	-
Nuclear	2	4	Powder	1	-
Numbers	5	-	Power	1	3
Oblique	3	-	Precipitation	1	-
Oils	1	3	Precision	1	-
Operations	2	-	Pressures	43	24
Optimum	2	-	Prevention	2	4
Orbits	1	-	Probes	2	-
Orowan	1	-	Processing	-	1
Orthotropic	1	-	Profiles	1	-
Oscillations	17	13	Projection	-	2
Oxidants	1	-	Propagations	1	1
Oxidation	-	1	Propane	2	2
Oxygen	3	1	Propellants	-	3
Panels	-	2	Propellers	6	6
Parabolic	3	-	Properties	5	3
Parallel	2	3	Propulsion	8	3
Passages	-	2	Prototype	-	1
Passengers	3	-	Pullout	2	-
Payload	1	-	Quenching	-	2
Pentaborane	1	1	RR	1	-
Perforated	-	1	Radial	1	-
Performance	5	7	Radiations	2	1
Perspex	1	1	Radio	1	-
Petrol	-	2	Radioactivity	1	1
Phases	1	-	Radioisotopes	1	-
Phenol	-	1	R.A.F.	1	-
Phosphorous	1	-	Ramjets	4	1
Photoelasticity	-	1	Rams	1	-
Pictures	1	-	Range	1	1
Pilotless	1	1	Rarefied	1	1
Pilots	1	1	Rates	1	-
Pipes	3	2	Ratios	12	6
Pistons	1	2	Reaction	1	-

Term	No. of times used in Indexing	Searching	Term	No. of times used in Indexing	Searching
Reciprocating	2	-	Sheets	5	9
Recombination	1	-	Shells	4	4
Recorders	1	2	Shields	1	1
Recoveries	5	2	Shocks	9	17
Rectangular	1	-	Shrinkage	1	2
Rectifier	-	2	Shrouds	2	4
Reduction	6	11	Sides	1	1
Redundancy	1	-	Silencers	1	3
Redux	-	1	Silicides	1	-
Refining	1	1	Silicon	2	1
Refractions	2	-	Simple	3	-
Refrigeration	2	1	Simulators	1	-
Regulators	1	-	Simultaneous	2	-
Research	-	1	Size	-	2
Resistance	5	-	Skins	6	1
Residual	-	1	Slabs	1	-
Resonance	-	2	Slats	1	2
Responses	1	2	Slender	4	3
Retractible	1	1	Sliderules	1	-
Reverse	2	4	Slots	2	2
Revolutions	7	2	Sodium	1	-
Reynolds	1	1	Solids	5	3
Ribs	1	1	Solutions	8	2
Rigidity	1	-	Space	2	2
Rise	3	-	Spans	1	-
Riveted	2	-	Spars	2	-
Rockets	12	9	Specific	2	-
Rolls	2	2	Spectroscopy	1	-
Roots	1	1	Spectrum	1	-
Rotation	4	4	Speeds	11	1
Rotors	1	3	Spheres	1	-
Roughness	2	1	Spikes	2	-
Rubbers	-	1	Spinning	1	1
Rules	1	1	Spray	3	1
Rupture	1	-	Springs	2	1
Safety	2	-	SR-N1	1	-
Sandwich	2	2	Stabiliser	1	-
Saunders-Roe	1	-	Stability	17	10
Schlieren	1	-	Stagger	1	-
Screen	2	1	Stagnation	2	-
Seals	1	1	Stainless	1	-
Sections	-	5	Stalls	2	4
Semicircular	1	1	Starting	1	2
Semiconductors	1	-	Static	3	3
Separation	4	5	Statistics	1	1
Servo	1	1	Steel	3	1
Servomechanism	1	-	Steps	1	-
Shapes	2	-	Stiffeners	2	1
Sharp	-	1	Stiffness	1	1
Shear	4	3	Strains	1	6

Term	No. of times used in Indexing	Searching
Stream	1	-
Strength	13	9
Streicher	1	-
Stresses	25	21
Stringer	2	1
Strips	1	-
Structures	12	16
Struts	-	2
Study	3	1
Sublimation	2	-
Subsonic	1	3
Suction	3	9
Supersonic	43	43
Suppressors	3	-
Surfaces	10	5
Sweep	7	4
Symmetry	3	1
Systems	9	5
Tables	1	-
Tabs	1	-
Tailplanes	2	-
Tails	1	2
Take-off	3	2
Taper	1	1
Taylor	1	-
Temperature	22	16
Tension	6	7
Tests	48	17
Theory	8	4
Thermenol	1	1
Thermocouple	1	-
Thermoelasticity	1	-
Thickness	10	3
Thin	-	7
Threads	1	-
Throttle	1	2
Thrust	6	5
Tin	1	-
Tips	3	-
Titanium	1	1
Tolerances	-	1
Tools	1	-
Tooth	1	-
Torsion	5	1
Trailing	3	1
Trajectories	4	2
Transfer	17	7
Transformations	-	2
Transients	5	1
Transistors	1	1
Transitions	5	5
Transonics	6	5
Transports	6	3
Travelling	-	1
Triangles	10	3
Tubes	9	9
Tunnels	12	6
Turbines	10	13
Turbojets	4	6
Turboprops	1	-
Turbulence	14	11
Ultimate	1	-
Undercarriages	1	1
Units	-	2
Unsteady	1	2
U.S.	1	-
V	1	1
Valves	1	-
Vanes	1	-
Vaporisation	2	-
Vehicles	2	2
Vertical	2	1
Viscosity	4	2
Visualisation	1	-
Visibility	1	-
Vortices	4	1
Wakes	1	1
Vortex	-	2
Walls	1	1
Warping	1	-
Water	-	1
Waves	18	15
Wedges	2	-
Weight	5	4
Wheatstone	1	2
Wheels	1	-
Wide	1	1
Windows	1	-
Winds	13	6
Wings	40	37
Wires	2	-
Working	3	1
X-rays	1	-
Z	-	1
ZRE	-	1

APPENDIX 4E

RESULTS FOR DOCUMENTS P12001 to P14000 SHOWING NUMBER OF SEARCHES REQUIRED

Question Number	UDC	SEARCH ALPHA.	RESULT FACET	UNITERM
20 - 06	1	x	4	2
- 07	1	1	2	1
- 08	2	x	x	2
- 09	2	3	3	2
- 10	2	x	x	1
21 - 06	2	1	3	3
- 07	x	1	1	1
- 08	1	x	2	1
- 09	x	1	x	1
- 10	x	x	x	x
22 - 06	2	5	1	1
- 07	1	2	1	1
- 08	2	1	2	1
- 09	1	1	1	1
- 10	1	1	1	1
23 - 06	1	1	1	1
- 07	x	3	1	x
- 08	4	4	2	1
- 09	1	2	2	1
- 10	2	x	1	3
24 - 06	x	1	1	1
- 07	2	1	1	3
- 08	3	1	2	3
- 09	2	x	x	1
- 10	4	4	2	1
25 - 06	1	1	1	1
- 07	1	6	2	3
- 08	x	x	x	1
- 09	x	1	2	1
- 10	5	1	2	2
26 - 06	2	x	1	x
- 07	x	1	x	1
- 08	1	x	x	x
- 09	2	3	1	2
- 10	x	2	2	5
27 - 06	x	4	1	2
- 07	4	x	x	1
- 08	x	1	x	2
- 09	2	2	2	3
- 10	x	2	x	3
28 - 06	1	2	1	3
- 07	1	x	1	2
- 08	2	1	1	2
- 09	2	3	1	2
- 10	2	2	1	1

Question Number	UDC	SEARCH ALPHA.	RESULT FACET	UNITERM
29 - 06	1	1	2	1
- 07	2	x	x	3
- 08	x	1	3	1
- 09	x	x	x	x
- 10	1	1	1	1
30 - 06	x	x	x	x
- 07	x	x	x	4
- 08	2	3	x	x
- 09	1	1	1	1
- 10	2	2	1	x
31 - 06	3	x	1	x
- 07	2	15	x	2
- 08	x	1	x	1
- 09	x	x	1	x
- 10	x	x	x	1
32 - 06	5	6	x	1
- 07	1	1	2	1
- 08	3	1	1	1
- 09	5	2	6	x
- 10	1	2	3	x
33 - 06	5	2	1	1
- 07	4	1	x	2
- 08	1	2	2	3
- 09	2	2	x	2
- 10	3	3	3	1
34 - 06	4	2	1	x
- 07	1	8	x	1
- 08	1	2	1	1
- 09	1	1	x	1
- 10	x	3	1	2
35 - 06	2	1	2	1
- 07	2	1	2	2
- 08	2	3	x	1
- 09	x	1	2	1
- 10	x	7	x	3
36 - 06	x	2	2	1
- 07	3	2	1	2
- 08	1	1	2	1
- 09	2	1	1	1
- 10	2	x	x	1
37 - 06	1	1	1	5
- 07	4	1	2	1
- 08	2	2	x	1
- 09	3	1	1	1
- 10	x	4	1	2
38 - 06	x	x	x	2
- 07	5	2	2	2
- 08	5	x	x	1
- 09	4	4	2	1
- 10	1	2	x	2
39 - 06	2	x	x	x
- 07	x	x	x	3
- 08	1	x	1	1
- 09	2	2	1	3
- 10	x	1	2	2

APPENDIX 5A

ANALYSIS OF FAILURES

1. QUESTION

(a) Too detailed:-

(1) 30-06. The question "What is the average decrease in gas consumption per horse power hour for reciprocating engines in the course of their history", was taken from an article entitled "The economics of large aircraft". The article was seven pages in length, yet the part upon which the question was based consisted of a single sentence:
"It must be remembered that the gas consumption of reciprocating engines used to be 1/10th of a gallon per horse power hour which amounted to 0.6 lb per horse power hour, and yet today, this has been reduced to almost half this figure."
The document remained untraced in all systems.

(2) 70-09. The question on recommended dimensions of masks for chemical milling of aircraft structures was taken from an article entitled "Modern methods of aircraft production". As the title suggests, the article reviewed many methods of manufacture and one short paragraph dealt with one particular method. Such a specific question, which, incidentally, could not be answered with any degree of satisfaction, would not be expected to trace a general review article.
The document remained untraced in all systems.

(3) 38-11. With a question "Supersonic drag of a parabolic nose cone", the document remained untraced in all systems, because the question was too specific for the material contained in the article. The questioner apparently took his question from the list of illustrations. There would be many more documents which would help the enquirer rather than this one, which contained so little on the specific subject. Only unrealistic indexing would have revealed the document.

(4) 58-15. With a question on the theoretical calculation of flutter of a cone at hypersonic speeds, the question was too specific in that it refers only to two paragraphs on the next to the last page of a ten-page article. The article referred to flutter of various aerodynamic shapes, which would have involved much detailed indexing if the indexer had included each shape mentioned. However, although cones were referred to, they were not mentioned in the summary. There would not have been sufficient material to help the enquirer when there are so many more documents specifically on the subject.
The document remained untraced only in U.D.C., partly because of lack of permutation, but was traced in the other three systems because of the approach via flutter and hypersonic flow.

(5) 70-11. The question "Use of an oil film technique to determine flow patterns at low Mach numbers", was based upon a single sentence in the main body of the report, which was also repeated in the summary. The document was about a particular high speed tunnel test of the effects of combined nose droop and outer-wing chord extensions on a $7\frac{1}{2}\%$ thick swept wing. The fact than an oil-film technique was used, was only briefly mentioned, and there was insufficient detail to help an enquirer posing this question. The document remained untraced in all systems.

(6) 70-14. A question "What factors limit the thickness of a panel which may be chemically machined and what are the advantages of this process over mechanical machining processes", was based on a single paragraph of a fifteen-page document. It is very doubtful whether the information contained in the paragraph would have been any help to the enquirer, as only two advantages of chemical machining over mechanical machining were given,those of cost and accuracy.

The document remained untraced in all systems.

(b) Too general:-

(7) 24-09. "Calculation of damping in roll at supersonic speeds". This question was based on a document entitled "The second-order lifting pressure and damping in roll of sweptback rolling airfoils at supersonic speeds".

The document was not traced in the Alphabetical system because the question proved too general for the scheme. As it was usual during the indexing programme to index as specifically as possible, the document was indexed under 'aerodynamic shape', with aerodynamic characteristic as subheadings. The question referred only to the aerodynamic characteristic - therefore the document remained untraced. Unless all subheadings are also used as main headings, thereby almost doubling the size of the catalogue, this situation will always arise. However, in real life situations, sufficient documents would have been found which treated the subject generally, to satisfy the enquirer.

(8) 41-06. "Boundary layer displacement effects". This question was based on a document entitled "Boundary layer displacement effects in air at Mach numbers of 6.8 and 9.6. The document was sixty-one pages in length, and went into detail about tests on pressure gradient and skin friction drag of flat plates and low drag wings. The indexer was allowed sixteen minutes, and hence made many entries, but she did not index the title. If the time allowance had been two minutes, possibly the title alone would have been indexed and the document traced.

However, in such an aerodynamic collection, the question would have brought forth many documents which would have satisfied the enquirer. The question is too general for the content of the paper, even though it was taken from the title.

The two concepts 'Boundary layer' and 'Displacement' cannot be expressed in U.D.C., except under 532.526 'Boundary layer'. This section consists of hundreds of cards. In Alphabetical, the heading BOUNDARY LAYER - Displacement is quite adequate. The Facet system is the same as U.D.C., in that only 'Boundary layer' can be expressed at Nfk. In Uniterm, of course, both concepts can be used.

Although the concepts could be adequately placed in Alphabetical and Uniterm, the question is still far too general to trace the required document in all systems, without bringing out hundreds of other documents.

(9) 45-08. The question on "The effect of roughness on skin friction" is too general for an aerodynamic collection. There are many articles written on the subject, any of which would satisfy the questioner, unless he were able to be more specific. The document title was "Turbulent boundary layers in adverse pressure gradients". If the concept 'turbulent boundary layer' had been added to the question, the document would have been traced without difficulty.

The document remained untraced in all four systems.

(10) 56-07. The question "Value of model testing for predicting instability of structural elements" was too general because the type of structural elements was not defined. The title of the document upon which the question was based is "Study of size effect on sheet-stringer panels".

The document remained untraced in U.D.C., Facet and Uniterm, but was found in the Alphabetical system because of the zealous approach of the searcher. Her train of thought led from MODELS, STRUCTURAL, to PANELS - Stability, then to PANELS, ALUMINIUM ALLOY, and finally SHEETS, ALUMINIUM ALLOY. Presumably, the searcher thought that, as aluminium alloy panels and sheets were very frequently discussed in articles, these headings were the most likely.

(11) 57-10. The question "High strength alloys" was based on the document entitled "High strength aluminium casting alloy 40E:DTD 5008: latest developments and foundry experience". It is obvious from the title that this article discusses a specific aluminium alloy - hence such a very general question is quite inadequate. The question would have been answered by many articles, or better still a chapter from a general book on metallurgy, or one of the ASM series.

The document was traced only in the Facet system because the searcher was also the indexer - and knowing that she had indexed several articles on high strength aluminium alloys, she checked under Peal-a in the classified sections. Many other documents were also retrieved.

(12) 65-06. "Structural stresses at which plastic flow occurs". This question was based on a document entitled "Practical solution of plastic deformation problems in the elastic-plastic range". The document was a NACA Technical Note of thirty-three pages of text, concerning plastic deformation of four types of structure, (a) a flat plate, (b) a thin shell, (c) a solid cylinder, (d) a rotating disc. Naturally, the indexer decided that these types of structure should be indexed, rather than giving one general heading covering 'structures'.

The only real concept received by the searchers was 'plastic flow'. 'Structural elements' was too vague to be useful. In U.D.C., the document was traced at the second attempt under 539.374 (Plastic deformation). In Alphabetical it was traced at the third attempt under DEFORMATION, PLASTIC, and in Uniterm it was found under 'Stresses' and 'Plasticity'. The searcher in Facet failed to trace the document, partly because of the form of the chain index, which gave fifty-six places to check under Rip (Plasticity) and also because the question gave only one useful concept. In other words, it was too general for the specificity of the document.

(13) 23-12. A question on the combustion of rocket engines proved too general for Facet. The document was specifically on propellant vaporisation as a criterion for rocket engine design, and gave calculations using various log-probability distribution of heptane drops. Actually the question was too general for all systems, but, in U.D.C., by widening the search to 621.45 (Rocket engines), in Alphabetical by looking under ENGINES, ROCKET - Performance, and in Uniterm, by finding ROCKET: ENGINES: COMBUSTION: PERFORMANCE, the document was traced.

In Facet, the searcher tried 33 entries containing 'rocket engines' and 'combustion'. She then abandoned the search, because to check under 'rocket engines' throughout the whole chain index, would have been too arduous and general a search.

Permutation of the Facet entries would have equated this system with the others.

(14) 64-11. The question "Investigation of flutter problems at high speed", proved too general for Facet. The searcher refused to check in the chain index under these two single concepts. With permutation, and adequate indexing, such a question should not involve a long and tedious search.

(15) 71-06. The question "Jet deflection by auxiliary air injection", proved a general one for an aerodynamic collection. There are many papers and articles indexed that include material on the subject. The deflection of jets could refer to theoretical studies, or one of the many applications, such as jet flaps for the increase of lift on aerofoils.

The document upon which the question was based is entitled "Internal characteristics and performance of an aerodynamically controlled variable discharge convergent nozzle". However, in spite of the generality of the question, and the specificity of the document, it was traced in Alphabetical, at the fourth attempt under JETS - Application, and at the second attempt in Uniterm under the same concept.

U.D.C. and Facet searching failed to trace the document, because of the number of places to check under 'Jets' in U.D.C. and also in Facet under 'Applications of jets'. With further explanation of the question, the document could have been traced in each case.

(c) Not easily understood:-

(16) 69-10. "The ratio of virtual shear stress to laminar shear stress τ^* is a measure of instability which occurs because of what".

This question was based on a document entitled "The heating of slabs with arbitrary heat inputs". The question is very complex, and the only entry into the catalogue is via the concept 'shear stresses'. It is a question, which, if presented to a librarian in a working library, would require explanation. One would want to know if there were any particular metal or component in which the shear stresses occurred.

When actually reading the one-page article, one finds that it is mostly concerned with a method of solving the heat conduction equation. 'Shear stresses' are not mentioned anywhere in the article, were not indexed by the indexer, and hence not traced in the searching.

The question failed on all four systems.

(17) 30-12. A question "What is meant by a moulded harness" failed in all four systems, because the searcher could get no clue from the question where to start the search. If the questioner had been available, the searcher would have been able to get more information from him. As it was, the only attempts were under 'safety harnesses'.

(18) 38-14. A question "Means by which the pilot of a military aircraft may achieve the maximum possible time in combat from his aircraft", proved a failure in all systems. The document was about range prediction, and discussed the parameters of fuel quantity, altitude, ambient air temperature, and their effect on range prediction.

The failures were due in part to lack of understanding by the searchers, but were also due to a rather ambiguous question.

(d) Misleading:-

(19) 46-10. The question "Thermal decomposition of solid AN by a high flux heating technique", was considered by the searchers to be misleading. From the article entitled "The gasification of solid ammonia nitrate", it is obvious that AN refers to ammonia nitrate. However, AN is not a recognised symbol for ammonia nitrate. The searcher in Alphabetical and Facet guessed the meaning of the abbreviation, and so traced the document, but the searchers in U.D.C. and Uniterm had no idea of the meaning. It is confusing to use such an abbreviation, which can easily be mistaken for a typing error of the chemical symbol A_n - Actinon. The fault was not that of the questioner, as the author used the same abbreviation in his text.

(20) 63-08. The question "Three dimensional boundary layers on slender wings", proved misleading to the searcher, but in U.D.C. and Uniterm the document was traced. In U.D.C., the searcher tried 532.526.2 (Laminar boundary layer): 533.693 + (wings of all types). The document was traced under 533.693.31 (Delta wings).

In Uniterm, three Uniterms were successful 'Wings', 'Boundary' and 'Layer'. This was considered a success.

The document title adequately explains the subject - "An approximate method of calculating the laminar boundary layer on a delta wing". Admittedly the delta wing referred to in the article is thin, but the term 'slender' in this context usually is associated with thin low -drag wings, and has been so interpreted by the searchers.

(21) 77-06. The question "Performance of engines with liquid injection" proved misleading. Three of the searchers understood that fuel injection was implied and limited their search programme to include this aspect. The fourth searcher immediately checked the correct place 621.438.057.3 (Water injection system. Gas turbine engines).

If the question had read "water injection" instead of "liquid injection", the document would have been found in all cases.

(22) 24-12. The question "Heat transfer and pressure drop of flow in pipes", can be considered misleading in that it refers to a very minor section of the paper. It cannot be considered too detailed because of the non-specificity of the question.

The article was entitled "Comparison of wall effects on supercavitating flows past symmetrical bodies in solid wall channels and jets", and was almost entirely concerned with cavitation flow in pipes. The concept of heat transfer was implied, but not mentioned in the paper, whilst there was brief mention of the effect of pressure.

(23) 65-13. The question "Reynolds stresses in two-dimensional parallel boundary layers" was misleading in that the concept 'boundary layer' was not mentioned in the article. However, as the document was about parallel flow between parallel planes, the concept of boundary layer was implied.

The document remained untraced in all four systems.

(24) 67-13. The question "Effect of incidence on pressure distribution on upper surface of 6% thick RAE 101 section with long bubble", remained untraced in all four systems because the searchers were misled by the aspect "RAE 101 section", which led them to limit their search to 'Aerofoil sections' and 'Aerofoils'.

Actually, there was no mention in the article of any type of aerofoil section by name, other than NACA 63009 and NACA 0006 series, under which presumably, RAE 101 is included.

(e) Incorrect:-

(25) 38-06. The question on the measurement of screech in rocket engines was actually incorrect. The document entitled "Study of screeching combustion in a six inch simulated afterburner", dealt with a comprehensive investigation on turbojet afterburners.

In the first paragraph of the paper, the author gave a summary of the work already done on the study of screech, mentioning screech in rocket engines. That is the only time that rocket engines is found in the whole of the paper. The questioner apparently read the introduction and understood, incorrectly, that the whole of the paper dealt with this aspect.

The document remained untraced in U.D.C., Alphabetical and Facet, because the searchers insisted upon 'rocket engines' being a necessary concept. The searcher in Uniterm was satisfied with 'noise' and 'engines' as the only two Uniterms to be successful.

(26) 75-06. The question "What are the aerodynamic characteristics of an 'arrow-wing' at high Mach numbers", was also incorrect. The paper, entitled "Idealized wings and wing-bodies at a Mach number of 3", as the title suggests, referred to supersonic flow, and not hypersonic flow, as suggested in the question. Hypersonic flow is usually considered to cover Mach numbers from five upwards.

The searchers in U.D.C., Facet and Uniterm insisted upon 'hypersonic flow' in their search programmes, and so failed to trace the document.

The searcher in the Alphabetical catalogue, after trying WINGS, ARROWHEAD, HYPERSONIC: WINGS, ARROWHEAD: WINGS, HYPERSONIC, found the document at her fourth search under WINGS, SUPERSONIC. This was a rather overzealous approach and so cannot be counted a true success.

(27) 78-10. The question on supersonic rotational flow with attached shock waves is quite incorrect. It was based on a document entitled "An investigation of the pressure distribution on the conical bodies in hypersonic flow". The article is two pages in length, and contains no reference to shock waves and also refers to hypersonic and not supersonic flow. There is no mention of rotational flow. The flow referred to is around cones. On checking with an aerodynamicist, he stated that rotational flow may, in some cases, be conical.

The document remained untraced in all four systems.

(28) 38-13. A question "Satisfactory welding conditions for experimental production joints in steel titanium", has a misprint. The question refers to sheet titanium. If the question had been correctly phrased, there would have been little difficulty in searching. The document was not traced in U.D.C. or Uniterm.

2. INDEXING FAILURES

(a) Insufficient indexing: -

(i) Personal errors
(α) Omission of an important concept:

(29) 38-13. The indexer ignored the aspect of the effect of helium on the diffusion fields of laminar boundary layers. He indexed 'flat plates' and 'laminar boundary layer' but did not mention helium.

The document was traced in U.D.C. by checking under the whole section 'laminar boundary layer' at 532.526.2. In Uniterm 'diffusion' had been added, and so sufficient Uniterms were found to be a success.

(30) 38-08. In an article on the measurement of pressure distribution on thin bodies, the indexer made only general entries under 'Measurement of pressure distribution' and 'Static pressure tubes'. He did not realise, or at least, failed to index the concept 'thin bodies' on which the importance of the paper hinged. The particular method of measurement described was devised for 'thin bodies' because their pressure distribution is difficult to measure by the more conventional means.

In U.D.C., the document was traced under 'Pressure tubes' at 533.6.082.3 and in Uniterm under 'Measurement: Pressure: Distribution'.

(31) 36-10. The indexer ignored 'Surfaces' in an article on "Forced convection over arbitrary surfaces". It is agreed that the adjective 'arbitrary' infers that any shape, or type of surface can be intended, but, as there is little other than 'Convection', or 'Heat transfer' to index, the concept of 'surface' should have been included. (This is substantiated by the search programme). The document was traced in U.D.C. because of inversion of entries - found under 536.25 Convection.

(32) 26-08. In an article on plate theory and analysis of stresses on plates, the indexer ignored the first concept. In Alphabetical there is a heading 'PLATE THEORY' which could have been used, and, in Facet, Ffe (Plates) + Xs (Theory) could have placed the concept. In U.D.C. the document was traced because there was no place for 'plate theory'. Thus the searcher knew that he had to check under Plates 621-415 + 530-539 Physics. As there was the recognised heading 'PLATE THEORY' - Alphabetical, the searcher limited his search to this. In Uniterm, sufficient other Uniterms were traced for a success to be considered.

(33) 68-08. The indexer omitted to index 'walls' in an article on the prediction of the separation of a turbulent boundary layer near a wall. This omission caused very general headings to be made under boundary layer separation and turbulent boundary layers. Thus in the Facet catalogue, there were too many entries in the chain index under the two concepts for the searcher to check through. The document was traced in U.D.C. and Alphabetical only after the searcher had checked through the whole section 'boundary layer separation'.

(34) 53-10. In an article on the use of a potential analyser to give the pressure distribution on thin wings, the indexer did not include 'potential analyser'. This term could have been included in the Uniterm system without trouble, and in the Facet system the term 'analogy' would be the most reasonable under which to include the term. If these entries had been made, the document would have been traced.

(35) 50-06. In an article describing testing plant used at the R.A.E. for simulating the effect flight conditions have on airborne equipment, an important part of the text concerned the effect of high altitude. This was ignored by the indexer. If it had been included in all systems, the document would have been traced.

(36) 20-13. The question "Drag divergence Mach number for NACA 23015 aerofoil section" failed in all four systems because the indexer did not index the concept 'NACA 23015 aerofoil section'. He had a time allowance of sixteen minutes, which should have been sufficient to enable him to include this concept.

The article was entitled "Effects of compressibility on the performance of two full-scale helicopter rotors" and included a description of the blades, stating that they were of the particular NACA section. This concept should have been noted by the indexer, and included.

(37) 26-12. The question on measurement of transverse velocities in annular flow between concentric cylinders, caused the document to remain untraced in U.D.C. The document was entitled "Experimental search for the effect of compressibility in unsteady Couette flow".

If the indexer had included the concept of 'annular flow' in all systems, although it would not have affected the results of the search in the other three systems, it would have enabled the document to be traced in U.D.C.

The document was found in Alphabetical because of the ability to index under CYLINDERS, CONCENTRIC - Flow. The same applies to Facet and Uniterm, in that the indexer was able to include this concept. In U.D.C., however, there is no place other than the general heading 'cylinders' at either the aerodynamic number or the material shapes number. Thus the searcher had to fall back on the concept 'annular flow' which had not been indexed.

(38) 31-13. A question "The hydrodynamics of fluid-fluid interaction at the interface of parallel stream" did not trace the required document in Alphabetical or U.D.C. The inclusion of 'interference' with the entries made, would have reduced the search considerably in Facet and Uniterm, and would have enabled the document to be traced in Alphabetical and U.D.C.

In U.D.C., 533.695 Interference, should have been added to 532.526.2 Laminar boundary layer, and in Alphabetical, the addition of the subheading 'Interference' should have been added to BOUNDARY LAYER, LAMINAR.

(39) 64-11. A document on aeroelastic problems in connection with high speed flight failed in U.D.C. and Alphabetical because the indexer omitted the concept of 'hypersonic flow' throughout the system. Had this been included, the search would have been successful in these two systems.

It would not have helped in Facet, unless permutation had been used, as the searcher would still have refused a search from the form of the question.

(β) <u>Too general indexing:-</u>

(40) 64-11 Although there was no mention in the summary to centrebody intakes, the term 'intakes' alone being used, the article was concerned specifically with centrebody intakes. This was ignored by the indexer, who made an entry, in all systems, under the general heading 'intakes'. As in Facet, there was no adjectival phrase 'centrebody' (although Icb 'Centre' could have been used), the searcher found the document under 'Intakes'. In Uniterm and U.D.C. if the more

specific entry had been made, the document would have been traced without trouble.

In Alphabetical, the document was traced because the searcher went back to the general heading 'INTAKES'.

(41) In an article on the methods of manufacturing of aircraft structures, the indexer was not sufficiently specific with his treatment of 'aircraft structures'. Instead of placing them at 629.13.012, he made a general entry under 629.13 (Aircraft). Thus his entries read 'Machining: Aircraft', and 'Workshop practice: aircraft' (also in each case, inverted). If the indexer had used the more specific entry in U.D.C., the document would have been traced.

(42) 70-09. A similar case to example (40) is the omission of 'circular', in an article on the buckling of stiffened circular cylinders. If the term 'circular' had been added in Alphabetical and Facet, the document would have been found.

However, in U.D.C., as there is no specific place for 'circular cylinders' the searcher knew that he would have to go to the section on 'cylinders'. In this section the document was found. In the Uniterm system, sufficient other Uniterms were brought out to consider the search a success.

(43) 20-15. In an article entitled "Aircraft design and mission compatibility", the indexer, with a time allowance of 16 minutes, made only general entries. For the major part of the article, the indexing was sufficient, but a particular example of a turboprop transport aircraft was mentioned, and upon this example, the question was based.

If the indexer had included the concept of turboprop transport aircraft in all systems, the document would have been traced in Alphabetical and Facet. Actually in U.D.C. it was found because the indexer had included an entry under 629.138.5 Transport aircraft. In Uniterm, the terms 'Aeroplanes' 'Weight' and 'Operation' were considered sufficient for a doubtful success. The addition of 'Transport' and 'Turboprop' would have ensured a firm success.

(44) 31-12. With a document on the boundary layer behind shock waves moving in a stationary fluid, it remained untraced in Alphabetical, because the indexer did not use the subheading 'Interference', which is the only one suitable in this instance. (The inability to combine these two concepts of shock waves and boundary layers, is discussed in another section). The searcher decided that a search through the whole section of 'shock waves' was too general, and so after checking under 'Boundary layer, laminar - Interference' and 'Boundary layer, turbulent - interference' the search was abandoned.

Actually, the same applies to the indexer's use of BOUNDARY LAYER, TURBULENT, and BOUNDARY LAYER, LAMINAR, without subheadings. If the same subheading 'Interference' had been used, the document would have been traced at the first search.

(45) 70-13. An article on the design and application of a monopropellant turbo-rocket, mentioned the type of propellants to be used. The indexer made only single, general entries under 'Turborocket engines', and completely ignored the concept of 'propellants'. As he had a time allowance of eight minutes, he should have had sufficient time to make more detailed entries.

As the question read "What single propellants have been used for air-turbo rockets", the searchers were not happy about the search under Gj Rocket engines, nor the Uniterms 'ROCKET' 'ENGINES' and 'TURBINES', but they considered the results successful.

With the same generality of search in U.D.C. and Alphabetical, the documents were not found, because of the use of new headings (see later discussion).

The addition of 'propellants' to all systems, would have enabled the document to be traced in Alphabetical and U.D.C., and would have considerably shortened the search in Facet.

(46) 70-14. An article entitled "Modern methods of aircraft production", principally referred to machining and press-forming methods used in aircraft structures. However, the indexer, with a time allowance of eight minutes, made general entries under 'manufacture of aeroplanes' - quite insufficient for the scope of the article.

If entries had been made under Panels 621-415 (U.D.C.), PANELS - Machining (Alphabetical), Ffh Qg Machining: Panels (Facet), plus the addition of PANELS to Uniterm, the document would have been traced in all four systems.

(γ) <u>Failure to recognise practical application:-</u>

(47) 70-14. In an article on fuel systems and the control and use of fuel as a coolant for supersonic engines, the indexer failed to recognise the importance of fuel as a coolant. If this aspect had been included in all systems, the document would have been traced.

(48) 44-10. An article on the design and performance of throttle-type fuel controls specifically refers to their application in gas turbine engines. This practical application was not indexed, and, as the words 'gas turbine engines' were included in the question naturally the searchers considered this concept important. The document was traced in Alphabetical under 'Fuel systems', and in Uniterm because sufficient other Uniterms were traced to consider the search a success, but in U.D.C. and Facet, the addition of 'gas turbine engines', would have enabled the document to be traced.

(δ) <u>Lack of technical knowledge:-</u>

(49) 29-08. In a highly theoretical paper on the flow of gases through nozzles, many equations and several hodographs were used. Presumably because of the indexer's lack of mathematical knowledge, he did not recognise the equations used as partial differential equations, and laid emphasis on the hodographs alone. The inclusion of the omitted concept would have enabled the document to be traced.

(50) 65-13. In this article, no specific reference was made to boundary layers, although the concept was implied, and the article was specifically concerned with parallel flow between parallel planes.

The searcher was aware of the connection of the subjects, but did not think through the article to the concept 'boundary layer'. An indexer with more knowledge of the subject would perhaps have automatically associated the two ideas, to make the correct and additional entries.

The document remained untraced in all four systems, as the question was phrased "Reynolds stresses in two dimensional parallel boundary layers".

(c) Effect of one concept on another:-

(51) 65-13. In an article on the frequency of vibration of conical shells, the effect of the vibrations on deformation of the shells was discussed. This aspect was not indexed. If it had been included, the document would have been traced in Alphabetical, U.D.C. and Uniterm.

In Facet, the document was traced because the searcher checked the chain index under 'Conical' (Igr) and looked at all entries in which this adjective occurred.

(b) Overdetailed indexing:-

(52) 31-09. From a very detailed N.A.C.A. Technical Note, the indexer made eighteen Alphabetical entries and has indexed much of the detail contained in the body of the document, which concerned the boundary layer pressure gradient, heat transfer, etc., on low drag wings and flat plates. If, however, the indexer had indexed only the title of the document "Boundary layer displacement effects in and at Mach number of 6, 8 and 9.6", which would have been the full extent of his indexing had the time allowance been two minutes instead of sixteen, the document would have been traced.

(53) 39-12. With a document on the measurement of the aerodynamic forces on oscillating aerofoils, the indexer indexed the example referred to in the text, of 'rectangular wing', plus 'oscillation', etc. As this was an example to demonstrate the measurement of oscillation, etc., a more general entry should have been made.

The question "Methods of measuring force and moment derivatives on oscillating aerofoils", gave unsuccessful searches in U.D.C. and Alphabetical because of the specificity of entry.

However, with additional permutation in U.D.C., the document would have been traced. In Alphabetical, a further more general search would have traced the document under OSCILLATION - Measurement.

Entries under AEROFOILS, OSCILLATING - Forces and moments, (with equivalent entry in each system) would have traced the document at the first search in all systems, instead of after a very lengthy search in Facet.

(54) 48-13. With an article on the thermal stresses caused by transient heating on the stiffness of various wing structures, the indexer made careful entries under the types of wing structure, e.g. AEROFOIL SECTIONS, DOUBLE-WEDGE; AEROFOIL SECTIONS, CIRCULAR ARC, and presumably chose these headings under Aerofoil sections because she was unable to express the qualifying adjectives under 'Wings' (see section under incorrect indexing).

A simple entry under WINGS - stiffness, with the equivalent entry in each system, would have traced the document without difficulty.

The document was traced in the Uniterm system because of the indexer's practice of including the terms in the title, as well as the terms indexed in other systems.

(55) 64-11. A question on the investigation of flutter problems at high speed remained untraced in U.D.C. and Alphabetical because of specificity of indexing in these systems.

The article was one entitled "Aeroelastic problems in connection with high speed flight", and consisted of a review of developments in the field of aeroelasticity in the last ten years. It is the type of article that is best treated by general entries, as there is insufficient detail contained therein on any one particular development to be of interest to an enquirer with a specific development in mind.

An entry in U.D.C. under 629.13.012 (Aircraft structures): 533.6.011.55 (Hypersonic flow), would have been adequate, plus the number 533.6.013.42 (Flutter). In Alphabetical FLUTTER, HYPERSONIC, would have been adequate, with an additional entry STRUCTURES, AIRCRAFT - Flutter.

(c) Incorrect indexing:-

(i) Personal errors:-

(56). 64-11. During the indexing programme the indexers agreed that all two-dimensional aerofoils and wings should be placed at 533.692 (except designated ones at 533.692.1) and all three-dimensional aerofoils and wings at 533.693. Despite this agreement, one indexer gave the headings 'AEROFOILS' in Alphabetical, Cc 'Aerofoils' in Facet, but gave the U.D.C. number 533.692 Aerofoil sections, or two dimensional aerofoils, in U.D.C. Becuase of this, the searcher, who checked the 533.693 number, together with various combinations, failed to find the document. U.D.C. was the only failure in the four search programmes.

(57) 37-10. In indexing an article on starting flow characteristics of rocket engines, the indexer, presumably because he did not check up the notation in the schedules, placed 'Rocket engines' at Gf (Gas turbine engines) instead of Gj. He obviously intended the document to be placed under 'rocket engines', as this was included in his interpretation of the entry for the catalogue.

(58) 32-06. The indexer when indexing in the Facet system an article on laminar flow, made the mistake of putting Ncf instead of Ncd. Had the error not been made, the document would have been traced with the searcher's second search programme.

(59) 29-12. With a document on boundary layer transition in supersonic flow around a 10" cone, the indexer made entries throughout the system, under 'transitional flow', instead of 'boundary layer transition'. As the question was "Boundary layer transition in supersonic flow", a very general one, the document was not traced in U.D.C., Alphabetical or Facet.

In Uniterm, the search was considered a success as 'transition' and 'transitional' are the same Uniterms.

(60) 35-14. With a document on an investigation of a turbojet engine with a variable exhaust nozzle, the indexer made entries in U.D.C. under 621.438.018.5 (Performance: Gas turbine engines) instead of 621.438.084.018.5 (Performance: turbojet engines).

Also in Facet, he made the same error by using Gf Gas turbine engines instead of Gg Turbojet engines.

In Uniterm, the indexer also did not use TURBOJET, although there is such a Uniterm.

Presumably these errors occurred because in Alphabetical, TURBOJET ENGINES are included under the heading GAS TURBINE ENGINES.

(61) 39-12. With a document on low speed wind tunnel calibration of a Mk 9A Pitot static head, the indexer in U.D.C., Alphabetical and Facet made entries under 'pitot tubes', although there was a specific place in each system for 'pitot static heads'. As the question was "Pitot static head calibration", the searchers naturally insisted upon checking under 'pitot static heads' in each system. In Uniterm, the indexer did include 'static'.

(62) 48-13. With a document on the thermal stresses caused by transient heating on the stiffness of wing structures, the indexer made entries in U.D.C., Alphabetical and Facet, under 'Aerofoil sections', presumably because in Alphabetical, he was able to express 'double-wedge' and 'circular arc'. Better entries would have been under 'WINGS' and 'STRUCTURES, AIRCRAFT'.

In Uniterm, these concepts were included.

(d) Insufficient number of entries:-

(63) 48-13. From an article on the interaction of oblique shock waves with laminar boundary layers on flat plates, the indexer chose seven U.D.C. places, which adequately covered the subject of the document. From these, he made eight permutations only, bringing five of his seven numbers to the head of the permutations. 'Shock waves' was used only twice, once in combination with 'flat plates' reading thus:-

Flat plates: shock waves: supersonic flow, and once thus:-

Shock waves: flat plates: supersonic flow.

'Shock waves' were never used in combination with 'laminar boundary layers'. If an entry had been made, to read - Shock waves: laminar boundary layer: supersonic flow, the document would have been traced at the first attempt.

(64) 31-08. From an article on the servo-tab system of control, the indexer decided upon two U.D.C. numbers: 621-52 Servo-mechanisms, and 533.694.58 Tabs. From these, he asked for only one entry reading - Tabs: servomechanisms.

He should also have inverted the two numbers, when the document would have been traced.

(65) 68-07. An article on thermoelastic stresses in a thick walled tube had four U.D.C. numbers allocated to it:

A.	621-462	- Tubes
B.	539.377	- Deformation
C.	536.495	- Thermal stresses
D.	536.5	- Temperature

Three entries only were made, each under 621-462 'Tubes' as first entry. If the indexer had included an entry reading CA 'Thermal stresses - tubes', the document would have been traced. The questioner asked for thermal stresses in a body exhibiting temperature dependent elastic properties, and so the searcher, after two search programmes, checked the whole of the section under 'thermal stresses'.

(66) 67-09. In an article on the heat transfer of a wedge in a supersonic wind tunnel, the indexer chose five U.D.C. numbers which adequately covered the subject of the document. From these five numbers, six entries were made, four of them beginning with 'Wedges'. The question referred to supersonic flor over a step which prompted the searcher to make the first search programme 'Boundary layer separation: supersonic flow'. If the indexer, who included these two concepts in his indexing had made an entry reading - 'Boundary layer separation: supersonic flow: wedges', the document would have been traced.

(67) 56-08. The indexer who indexed an article on the corrosion resistance of stainless steel plates, chose the correct U.D.C. numbers to cover these three concepts, but, again did not make sufficient permutations. He chose four combinations of the numbers, but did not make an entry reading - Stainless steel: corrosion by inorganic acids. He did however, make an entry - Corrosion by inorganic acids: stainless steel.

As the questioner asked for material on the corrosion-resistance controls on the production of stainless steels, the only sure way of finding the information was to approach it via 'stainless steels' + 620.193 onwards (which would include all subdivisions of corrosion).

The indexer should have realised that this type of approach could be made.

(68) 21-09. With an article on the use of a potential analyser to give the pressure distribution on thin wings, the indexer chose the U.D.C. numbers most appropriate (a little difficulty in placing 'potential analyser'), but did not make sufficient entries.

The question referred to 'loadings', which is the more general section under which 'pressure distribution' is placed. Therefore, the searchers' best approach was via 'wings: aerodynamic loadings' (which would include pressure distribution).

If the indexer had made an entry to read - 'Wings: pressure distribution', as well as the entry 'pressure distribution: wings', the document would have been traced.

(69) 50-06. In an article on the effect of thickness, camber and thickness distribution on aerofoil characteristics at Mach numbers up to 1.0, the indexer chose six U.D.C. numbers but only asked for seven entries. The indexer also, in three entries. put four U.D.C. numbers together - causing a very long notation, which is quite unnecessary.

If the indexer had made the following entry - 'Aerofoil sections: transonic flow: forces and moments', the document would have been traced.

(70) 23-13. With a document on the application of similarity rules for transonic flow past slender bodies of revolution at zero incidence, the indexer made entries under:

A. 533.696.4 Cones
B. 533.6.011.35 Transonic flow
C. 533.696.5 Bodies of revolution

The permutations suggested were AB and CB. Although it is not usual practice to make entries under speed of flow, in this particular document, where the similarity rules for transonic flow were discussed, such an entry BA, and BC, should have been made.

As the question asked for material on transonic similarity (laws and methods), with no other concepts, the only place possibie for the searcher to try was 533.6.011.35.

(71) 33-15. With a document on magnetohydrodynamic hypersonic flow past a blunt body, the indexer did not make sufficient permuations, to enable retrieval via 'blunt bodies' and 'hypersonic flow' only. (The master card is missing, but as the indexer made entry under BODIES, BLUNT, HYPERSONIC - Flow, in Alphabetical, one presumes that the same concepts were included in U.D.C. Therefore the reason for failure must be due to lack of permutation).

(72) 37-14 A document on the lubrication of journal bearings had the following places chosen in U.D.C. :

A. 621.822.5 - Journal bearings
B. 533.69.048.2 - Pressure distribution
C. 621.822.5-72 - Lubrication. Journal bearings.

The permutations made by the indexer were AB and BA. The concept C was ignored entirely. As the question asked for material on axial variation of pressure in the lubricating film of bearings, the searcher concentrated on 'lubrication' and 'bearings'. (The searcher could have used ' pressure distribution and bearings' as a search programme, but this is considered late).

(73) 38-13. In a document on the welding of titanium sheet, the indexer made the following entries:

A. 621-415 - Sheet
B. 669.295 - Titanium
C. 621.791.765 - Fusion welding

with the permutations ABC : BAC : CAB : CBA.

The question (which actually misprinted 'steel' for 'sheet') asked for "Satisfactory welding conditions for experimental production joints in steel titanium". Ignoring the typing errors the document should still have been traceable from 'titanium' and 'welding', i.e. 669.295: 621.791 +. With a further permutation BCA, the search would have been successful.

(74) 39-11. A document on wind tunnel observations of boundary layer transition on two sweptback wings at a Mach number of 1.61, was untraced, again through lack of permutation. The indexer chose the following places:

A. 533.693.1 - Sweptback wings
B. 532.526.3 - Boundary layer transition
C. 533.6.011.5 - Supersonic flow

with the permutations ABC and BAC.

The question "Method of detecting boundary layer transition in supersonic flow", gave only two concepts for searching. Therefore, if the indexer had made a permutation under BCA the document would have been traced.

(75) 54-12. With a document on the bursting speed of a rotating plastic disc, the indexer made entries under:

A. 621-415 - Plates
B. 539.214 - Plasticity
C. 531.15 - Stresses
D. 539.319 -Stresses due to technical operation.

The permutation read BAD : DAC : ABC : CAB. A further permutation AD, would have been consistent, and would have caused a success by one of the searcher's search programmes.

(76) 55-14. A document on four methods of measuring the properties of a supersonic boundary layer on flat plates, had the following entries:

A. 532.526.4 - Turbulent boundary layer
B. 533.6.011.5 - Supersonic flow
C. 533.692.4 - Flat plate aerofoil sections.

with permutations ACB : CBA.

The question "Method of measurement of supersonic boundary layer flow", gave only two (or almost two) of the concepts indexed. One of the searcher's programmes, under 'Turbulent boundary layer: supersonic flow', would have revealed the document if permutation ABC had been made.

(77) 56-12. A question "Base pressure behind circular cones at about M=3", was based on a document on the behaviour of flow behind a blunt base in supersonic flow, and the resulting interaction between shock waves and boundary layers. The indexer made the following entries:

A. 533.6.015.5 - High altitude
B. 533.69.048.2 - Pressure distribution
C. 533.6.071 - Wind tunnel tests
D. 533.696.5 - Bodies of revolution

with permutations BAC : DAC.

As there was only one concept in common between the question and the indexing, the searcher had difficulty but if a permutation BD had been made, it would have been possible for her to have looked under 533.69.048.2:533.696+.

(78) 58-15. A question "Theoretical calculation of flutter of a cone at hypersonic speeds" failed because the cone was only one of the many aerodynamic shapes mentioned in the article. If the indexer, who made the following entries:

A. 533.6.011.55 - Hypersonic flow
B. 533.6.013.422 - Flutter
C. 533.692 - Aerofoil sections

(with permutations CBA : BCA), had included a permutation BAC, the document should have been traced via the concept 'flutter: hypersonic flow: aerofoil shape (533.692+)'.

(79) 60-12. Although 12 permutations around 8 U.D.C. numbers were made for this document, it remained untraced. The document was on wind tunnel tests of damping in pitch of two-wing-body combinations, one with a triangular wing and the other with a straight, tapered wing. The question was "Does damping in pitch of wing disappear at transonic speeds".

If the indexer had made an additional permutation under 533.6.013.15 (Pitching moments): 533.693.35 (Rectangular wings), the document would have been traced at the searcher's third search programme.

(80) 72-14. A document on the strength in compression and tension of an aluminium alloy extruded angle to specification BS.L.65, had the following entries made:

A. 669.715-135 (B.S.L65) Aluminium alloy extrusion B.S.L65
B. 620.172 - Tensile testing
C. 620.173 - Compression testing
D. 621-423 - Angle sections

with permutations AB : AC : ADB : ADC : DAB : DAC.

The question was "Tangent modulus for B.S.L65 material in compression". Due to a mistake in indexing the type of alloy, (discussed elsewhere), the document was not found by that approach.

If however, there had been permuation under CA, the document would have been traced by the searcher's approach in 'Compression tests: aluminium alloys'.

(81) 29-07. With an article on the effect of leading edge slats on the aerodynamic characteristics of a 45 swept-back wing fuselage combination, at Mach numbers 0.4 to 1.03, there is plenty to index. In the Facet catalogue, unless a detailed question is asked in the same terms as the indexer indexed the document, such a question involves a long search. It was thought, later on in the indexing programme that shorter and more numerous entries would be more helpful than single, detailed entries.

In this particular failure, the indexer made an entry of nine elements, which, agreed, adequately indexed the document. If, however, he had made two entries instead of one, the document would have been traced, by the searcher's first programme.

(82) With an article on the air conditioning and pressurisation of aircraft cabins, the indexer, in Facet, did not include an entry under Edd 'Pressurised cabins'. He did include ' air conditioning of cabins' at Edb Gug. Had the extra entry been made the document would have been traced without difficulty.

(e) Careless indexing:-

(i) Personal errors:-

(83) 20-06. With an article on ablation and heat transfer on the nose region of a body, the only entries made in U.D.C., Alphabetical and Facet covered 'ablation' and 'cooling'. However, in Uniterm, the indexer included 'blunt' and 'bodies', so he obviously realised that this aspect was important. This should have been added to the three other systems, and would have constituted a success in Alphabetical system.

In U.D.C. the document was traced under 536.422.1 'Ablation', but to find it, the searcher checked the whole system.

In Facet, it was traced via the chain index under 'sublimation' (there being no place for ablation) at the fourth search programme.

In Uniterm, it was traced under 'Heat transfer', 'Cooling' and 'Bodies'.

(84) 21-08. With a report on the design and testing of an axial compressor, the indexer, except in Uniterm, ignored the concept 'design', and made entries under 'axial compressors', 'pressure distribution', temperature', and'tests'.

The document was found in U.D.C. by the searcher checking 'Performance of axial compressors' at 621.438.031.3.018.5. In Facet, it was traced by the searcher checking the whole classified section under Gwd and then the chain index. In Uniterm, the terms 'Compressors', 'Axial', 'Performance' and 'Stages' were retrieved. In Alphabetical, however, COMPRESSORS, AXIAL - Performance and COMPRESSORS, AXIAL - Design, drew a blank. Therefore, if the indexer had included 'design' in U.D.C., Alphabetical and Facet, or included 'performance' in Alphabetical and Facet, the document would have been found at either the first or second search in Alphabetical.

(85) 21-09. In an article on the corrosion resistance of stainless steels, the last aspect was included in U.D.C., Alphabetical and Uniterm. However, in Facet, the indexer limited his entry to Pf 'Steels'. The question demanded information specifically on stainless steels, so, naturally, the searcher decided that he would search only Pfcrmi 'Stainless steels' in the chain index.

If the indexer had been consistent, and included the term 'Stainless steels' in the Facet system, the document would have been traced at the first attempt without difficulty.

(86) 24-06. In the U.D.C. entries for an article on aerodynamic loads of a sweptback wing aircraft, the indexer included the aspect 'Sweptback wing' in all systems but U.D.C. (the only failure). If this had been included, the document would have been traced at the first attempt.

(87) 24-09. In an article on lifting pressure and damping in roll of sweptback aerofoils at supersonic speeds, the aspect 'damping', was included in all systems but Facet. If the indexer had been consistent the document would have been traced under the searcher's third search programme.

(88) 25-08. From an article describing an electrical device for measuring the downwash distributions, the questioner phrased his question "Electromagnetic analogy for downwash". In only Uniterm did the indexer include 'analogy', and this was the only system successful. If 'analogy' had been included in the other three systems, or more specifically 'Electromagnetic analogy', the document would have been traced in all the other systems.

(89) 26-06. In a document which clearly refers to the mechanisms by which hydrogen enters steel, the indexer omitted to include 'hydrogen' in the Alphabetical system, causing a failure. As the question referred to 'metals', instead of more specifically 'steel', the searcher could only approach the question via 'hydrogen' and to have checked through all types of metal would have been unrealistic.

(90) 26-07. An article on reverse flow theories had sufficient information on the effect of supersonic flow for the indexer to include it in Alphabetical, U.D.C., Uniterm, but it was omitted from Facet. As the question read "Reverse flow theories at supersonic speeds", the searcher insisted on 'supersonic'. If this had been added by the indexer, the document would have been traced under the first search programme in the searching of Facet.

(91) 27-07. With an article on the calculation of vibration on different types of cylindrical beams, cantilever and of rectangular cross-section, the indexer indexed all these concepts only in Uniterm. As there is no subdivision of 624.072.2 Beams, under shapes, in U.D.C., the document was traced, from a question demanding material on transverse oscillation of cylindrical beams. However, in Alphabetical and Facet, where there is provision for cylindrical beam, the searchers insisted on this aspect, therefore the document remained untraced.

Had the indexer included 'cylindrical' in all the systems, the result would have been a success.

(92) 27-10. With a detailed paper on flame stability in ducts, an important section dealt with the stability of propane air mixtures. This was noted by the indexer, who included 'propane' and 'gaseous fuels' in Uniterm and Alphabetical systems. 'Gaseous fuels' was included in Facet, but not 'propane', and neither were included in the U.D.C. system - although there was allowance in the schedules in each case. If the indexer had been consistent in all four systems, the document would have been traced.

(93) 30-08. In a paper on the unsteady laminar boundary layer on a flat plate, the indexer, presumably through carelessness, omitted to include 'laminar' as a Uniterm. He could also have added 'unsteady', although this is the only system under which the adjective could have been included. If this had been done, the document search would have been successful.

(94) 31-06. The indexer who indexed an article on a photoelastic investigation of stress concentrations due to small fillets and grooves in tension, included the concept 'photoelasticity' in U.D.C., Alphabetical and Facet systems, and ignored it in Uniterm. If this had been included, the document would have been traced. Also, an entry under the general heading 'PHOTOELASTICITY' in Alphabetical would have enabled the search to be a success.

(95) 31-10. With an article on ram-air cooling systems for aircraft generators, the indexer omitted to include 'cooling systems' in U.D.C., Alphabetical or Facet, and in none of these systems was the document traced. The indexer included 'Cooling' in these three systems, but this was not sufficient. Had entries been made in U.D.C., 621-712, instead of adding -712 to the number for generators, therefore, reading 621.313.12:621-712 - Generators - Cooling and inverted, 621-712:621.313.12, Cooling - generators, the document would have been traced. In Alphabetical, an entry COOLING SYSTEMS would have been sufficient, and in Facet, the addition of Gt to the original entry would have made a successful search.

(96) 33-07. With an article on the effect of stress frequency and temperature on the fatigue of metals, the indexer, except in Uniterm and Alphabetical, ignored the concept 'metals'. The document was traced in U.D.C., by checking under the whole section of fatigue at 539-431, which was a rather too zealous search. In Alphabetical, the document was traced under 'METALS - fatigue'. Facet, however, failed to retrieve the document, because of the omission of Pe - Metals. If this had been included, the document would have been traced. The addition of 669 in U.D.C. would have decided a successful search at the first attempt.

(97) 39-07. The indexer omitted to include 'solid propellants' in U.D.C., Alphabetical and Facet, when indexing an article which included material on solid propellants, as well as material on the design of rockets. He realised the importance of this aspect, as he included it in Uniterm. Had he not omitted it in the other three systems, the document would have been traced.

(98) 41-07. An article on a method of optimising aircraft auto-stabilizer systems was badly indexed. The indexer made an entry under STABILISERS, and AEROPLANES, PILOTLESS, in the Alphabetical system, but did not include these concepts in the same form in U.D.C. or Facet. Instead, he entered 'stability of control surfaces'. Had he been consistent, the document would have been traced. In Uniterm, he included 'Pilotless' and 'Stability', but these were the only concepts of the question to be traced. Therefore, the search was not considered successful.

(99) 46-07. With an article on supersonic flow about slender bodies of elliptic cross-section, the indexer included 'elliptic' in U.D.C., Facet and Uniterm, but ignored it in Alphabetical. If an entry had been made under ELLIPSOIDS, the document should have been traced with adequate searching. This aspect was included in Facet, which also failed to retrieve the document, but because of inadequate searching.

(100) 51-06. An article on a method for the deflection analysis of thin low-aspect ratio wings was not retrieved in the Alphabetical system because the indexer, although including the essential concepts, did not enter 'aspect ratio' as a subheading under WINGS, although this was allowed.

In the Facet system, the indexer did not include 'Low' (Zqj), although there is provision for the adjective in the schedules. It was included in Uniterm.

(101) 54-07. The failures in this question are rather complex. The indexer omitted, in all systems, to include 'Redux bonding', although the article was on stress fatigue tests on a redux-bonded and riveted double strap joints in 10 SWG aluminium alloy sheet. Had this aspect been included, the document would have been traced in the U.D.C. catalogue at the second instead of the fourth attempt. In the Alphabetical catalogue, a new heading, JOINTS, BONDED, ALUMINIUM ALLOY, would have been necessary. In Facet, the addition of Qkf Redux bonding, would have enabled the document to be traced.

Other reasons, discussed elsewhere, also contributed to the failures.

(102) 60-07. In the Uniterm system, the addition of 'network' (a recognised Uniterm), would have constituted the search a success. The article was concerned with electric networks and circuits. The failure in Facet was due to the search programme.

(103) 68-10. In an article on the effect of turbulent spots on boundary layer transition, it was not traced in the Facet catalogue because the searcher did not include 'Turbulence' at Ojp, although this aspect was included in the other three systems, in all of which the document was traced.

(104) 71-08. In a paper on air conditioning of aircraft, a major section of the paper was concerned with air conditioning systems for the cabins. The indexer forgot to include 'Cabins' in his indexing under the Uniterm system. If this concept had been included, the document would have been traced.

(105) 72-07. In an article on the design of a hypersonic wind tunnel, using ammonia-oxygen as a working fluid, the indexer omitted to include 'hypersonic flow' in his Facet indexing. If this concept had been included the document would have been traced at the third attempt.

(106) 75-08. The indexer did not index the concept 'shrinkage' in any system other than Uniterm. In U.D.C., the document was traced at the fifth attempt under 'Plastics - high temperature' at 678.5: 536.45. If 'shrinkage' at 620.192.52 had been included in the indexing, the search would have been successful at the fourth attempt.

The inclusion of 'shrinkage' in Alphabetical would have made no difference to the failure because of the bad search programmes. In Facet, the document would have been traced at the third attempt.

(107) 20-14. With a document on the adhesive bonding of magnesium alloys, the indexer in U.D.C. made an entry under 669.721, Magnesium, instead of 669.721.5 Magnesium alloys, although 'magnesium alloys' had been included in all other systems.

If the correct entry had been made, the document would have been traced.

(108) 25-12. The concept 'density' at 533.12 was omitted from the U.D.C. entries for a document on the effects of density fluctuations on the turbulent skin friction of an insulated flat plate, although the concept was included in all other systems. The concept was one necessary to the search programmes, and so the document remained untraced in U.D.C.

(109) 28-15. A document on the manufacture of stainless steel honeycomb structures had no entries in U.D.C., Alphabetical and Facet under 'stainless steel', although this concept was included in Uniterm. Because of this omission the document was not found in any of the three systems. The question was "Use of stainless steel in aircraft".

(110) 29-13. In an article on the effect of delta vanes on lift of wings in supersonic flow, the indexer did not include 'lift' at 533.6.013.13, although this concept had been included in all other systems. As the question asked for material on the lift of supersonic wings, the document remained untraced.

(111) 29-14. A document on the design details of a precision potentiometer and ratiometer instrument suitable for use in setting up analogue computers, was indexed in U.D.C., Alphabetical and Facet only under 'Potentiometers'. The concept of 'analogue computers' was included only in Uniterm.

As the question asked for methods of obtaining accuracy on analogue computers, the document was not found except in Uniterm.

(112) 30-11. In an article on transport aircraft suitable for use to carry fighter planes, etc., the indexer included the concept 'transport aircraft' in all systems but U.D.C. If an entry had been made at 629.138.5 (Transport aircraft) the document would have been traced at the third attempts.

(113) 32-13. With a document on the study of turbulence, the indexer included entries in Uniterm under 'Turbulence', but not in U.D.C., Alphabetical or Facet. If these entries had been made, the document would have been traced without difficulty.

(114) 41-14. A document on curved shock waves in three-dimensional gas flows had a question "Expression for vorticity vectors behind the shock waves in three dimensional gas flow".

The concept 'vorticity' was excluded but formed a part of the first search programme. Therefore, if the entry had been made under 532.527, the document would have been traced.

(115) 43-11. With an article on a mathematical theory of boundary layer transition and fully developed turbulent flow, the indexer included the concept of 'boundary layer transition' only in Alphabetical. Had it been included in the U.D.C., Facet and Uniterm, the document would have been traced.

As the question was "Transition from laminar to turbulent motion", the searcher had no other concept from which to search, other than by checking through the whole sections under 'laminar' and also 'turbulent flow'.

(116) 49-11. With a document on aerodynamic characteristics including pressure distribution, on wing-body combinations in subsonic flow, the indexer did not include 'pressure distribution' in either U.D.C. or Facet. If this had been done, the document would have been traced under 533.69.048.2 : 533.695.12 with U.D.C., or Ca Cd Ea Nvf with Facet.

(117) 51-11. A question on "Cooling a supersonic airstream by liquid injection", failed because only in Uniterm did the indexer include the concepts of 'cooling' 'liquid injection'. In the three other systems, he included only 'pressure recovery' 'diffusers' and 'supersonic flow'.

An entry under COOLING, LIQUID, would have been successful in Alphabetical. For Facet the entry should have read Hrm Nbk Stc(Pre).

(118) 54-11. A document on the range performance of aircraft, failed in U.D.C., because the indexer omitted the concept 'Range' in both U.D.C. and Alphabetical. The document was traced in Alphabetical by checking under the heading PERFORMANCE - Calculation.

If an entry had been made under 533.6.015.74, the document would have been traced.

(119) 60-12. In a document on the damping in pitch of wings in transonic flow, the indexer omitted to include the concept of 'damping' in U.D.C. Had this been included, and attached to 533.6.013.15, the document would have been traced.

(120) 66-13. A document on the behaviour of a supersonic jet, representing the flow of exhaust gases from a rocket motor, is studied. The indexer made entries throughout the system on jet mixing, but in only Alphabetical and, of necessity, Uniterm (because one can take out only the Uniterms required), was the aspect of vibration of supersonic jets (as apart from jet mixing) included.

The question was "What is the ultimate width of the jet of a supersonic rocket", and so, the approach was via jets + supersonic flow.

An entry in U.D.C. under 533.697.4 Jets (Internal Aerodynamics) would have enabled the document to be traced.

(121) 67-12. An article on the calculation of pressure loss in baffles used for flame stabilisation in combustion chambers, failed in U.D.C., because the indexer did not make an entry under 'baffles' at 621-712.2. Had this been done, the document would have been traced.

Also, a failure in Facet because of the same concept omission.

(122) 67-13. A difficult question on the pressure distribution on the upper surface of a 6% thick RAE 101 section with long bubble, could have traced the document, if the indexer had included the concept in U.D.C., of 'bubble' at 532.62 (see alsolater section), and in the Alphabetical and Facet.

The failure was also due to searching in that the searcher also ignored the concept of bubble in all systems.

(123) 20-15. A document on the design of turboprop transport aircraft was indexed under 629.138.5.001.1 Design. Transport aircraft, but the concept 'Transport aircraft' was omitted from Alphabetical, Facet and Uniterm.

In Alphabetical, if an entry had been made under AEROPLANES, TRANSPORT, the document would have been traced.

(124) 31-14. A document on an electrolytic tank as an analogue computing machine for factorizing high degree polynomials, failed in Alphabetical, because the indexer did not include EQUATIONS, POLYNOMIAL in Alphabetical. A different searching technique would have traced the document, but this is discussed later.

(125) 32-12. A document on the aerodynamic characteristics of a family of slender wing-tail-body combinations remained untraced in Alphabetical and Uniterm because the indexer omitted to include 'tailplanes', in these systems. As the question asked for material on the drag of tail units behind swept wings around M = 1, the searchers naturally insisted upon 'tail units' as a concept for searching.

An entry in Alphabetical reading COMBINATIONS - WING - FUSELAGE - TAILPLANE - Forces and moments, would have enabled the document to be retrieved. Uniterm merely required the additional entry for 'Tailplane'.

(126) 70-14. A document on the machining and press-forming of panels used in aircraft structures had the concept 'machining' and 'panels' indexed only in U.D.C. and Uniterm. If these concepts had been included in the other two systems, the documents would have been traced. Therefore an entry reading PANELS - Machining, would have been adequate.

In Facet, an entry Ffh Qg Maching: Panels, would have resulted in a successful first search.

(127) 23-13. A document on similarity rules in transonic flow, remained untraced in Facet, because the searcher would not check through the whole of Mbj Transonic flow, also because the indexer could have included 'Similarity parameters' at Nj.

Therefore an entry Mbj Nj Similarity parameters: Transonic flow, would have enabled the document to be traced, with better searching.

(128) 31-11. A similar case to (127). If the indexer had included an entry under 'similarity parameters' at Nj plus Nbm Hypersonic flow, the document would have been traced from the question "Hypersonic similarity law for slender bodies". The concept of 'Similarity rules' was included in all other systems.

(129) 41-11. With a document on the drag of aerofoil sections and thin wings, the indexer ignored this concept entirely in Facet, and concentrated on another aspect of boundary layer in hypersonic flow on flat plates. If an entry under Cd(Iv)Nr Drag: thin: wings, had been made, the document would have been traced.

(130) 62-13. A document on the deflection and twist of a sweptback wing bomber in rough air, was not traced in Facet, partly because the indexer omitted from this system, the concept of 'gust loads'. Had this been included at Cd(Iibb)Nq Gust loads: sweptback: wings, the document would have been traced via the question "Spar deflection of a swept wing measured in flight through gusts".

(131) 24-12. With a document on cavitation flow in pipes, the indexer included the concept 'pressure' in all systems but Uniterm. As the question was on pressure drop of flow in pipes, the searcher did not consider that sufficient Uniterms were retrieved without 'pressure'.

(132) 38-13. With a document on the welding of titanium sheet, the indexer, through carelessness, did not include either of the concepts, although there were adequate entries in U.D.C. and Alphabetical.

(133) 41-12. A document on the mechanical design of a gas turbine was not traced in Uniterm because the indexer omitted 'design', although it was included in U.D.C., Alphabetical and Facet.

(134) 43-14. A document on the tensile and fatigue properties of the Nimonic alloys at high temperatures, failed because the indexer, through carelessness, omitted to include NICKEL ALLOYS and HEAT in Uniterm. As the question asked for information on nickel-chromium based alloys, the searcher

insisted upon this concept.

(135) 45-11. If the indexer in Uniterm had included the concept 'downwash', in a document on the aerodynamics of wings and wing-body combinations, the searcher would have considered the search successful.

Although this concept was also omitted from Facet, the document was traced by the searcher checking in the classified catalogue under Cd Nbk Supersonic flow: Wings.

(136) 46-11. Careless indexing of Uniterm, by the omission of 'Vertical take-off' and 'Aircraft', caused this document not to be found. These concepts had been included in the other systems and as the document was entirely concerned with VTOL Aircraft, the additions should have been made.

(137) 48-12. A document on trajectories of various bodies of revolution remained untraced in Uniterm because the indexer omitted 'trajectories' from his list of Uniterms. As the question was "Stable trajectories for re-entry of high altitude rockets", the searcher felt that this concept was essential.

(138) 50-13. An article entitled "Minimum for problems in vertical and horizontal rocket flight" was indexed in the other three systems under 'Rocket propulsion', or 'thrust of rocket engines'. These concepts were not included in Facet. With more careful indexing, the document would have been traced.

(139) 50-14. A document on shaft gas turbines for helicopters had 'efficiency' or 'performance' included in Alphabetical and Facet. As 'helicopters' was the only Uniterm to be successful from the question "Data on fuel consumption of helicopters in relation to payload", the document was not found.

(f) <u>Lack of entry in indexes to schedules</u>:-

(140) 53-06. In an article on the range of applicability of the transonic area rule, the indexer included 'area rule' as an Alphabetical heading, as Uniterms, and at 533.6.013.122 in U.D.C. As there was no entry in the index to the Facet schedules, under 'area rule', the indexer presumed that there was no place for it, and so entered the article under 'drag' at Nr plus rectangular wings and wing-fuselage combinations, as the nearest possible place.

However, the searcher tried the chain index to Facet, and discovered an entry 'Area rule Oe', and therefore limited his searcher to the cards included there. If there had been an entry in the Alphabetical index to the schedules, or feedback of the index to the semi-completed catalogue, this error would not have arisen.

(141) 47-15. Because of a missing entry in the Alphabetical index to U.D.C., under 'Liquid metals', at 669-154, and another under 'Solidification' at 536.42, the searcher for a question on "Solidification of metals in a cylindrical mold", was unable to go further with the search. If the Alphabetical index had been correct, the search would have been very simple.

(142) 68-11. A document on carbon deposits in combustion chambers of gas turbine engines was indexed accurately at 621.438.019.942, but, as there was no entry to this number in the Alphabetical index to U.D.C., the searcher was unable to find the required place in the U.D.C. catalogue.

(143) 70-13. A new subdivision of 621.45 (Rocket engines) was used in indexing a document on turborocket engines, so one presumes that the number 621.456 was intended as the place for turborocket engines. However, no entry was made in the Alphabetical index to the U.D.C. schedules, and so the document was not traced.

(144) 75-12. A question on the corrosion resistance of aluminium-copper alloys was not traced in U.D.C., and one of the reasons was that there was no entry in the Alphabetical index to the U.D.C. schedules under 'aluminium-copper alloys' at 669.715.3, although that number had been used.

With the correct entry the document would have been traced. Again, in Alphabetical, a new heading was devised under ENGINES, TURBOROCKET. Later, this was included under ENGINES, ROCKET, GAS-TURBINE, but as there was no 'see' reference, the searcher was not directed to the correct place in the catalogue.

(g) Lack of cross references:-

(145) A question which failed in all four systems was "What is meant by a 'moulded harness'". As the searchers had no idea where to start the search except by attempts under 'safety harnesses' the document remained untraced.

Actually, the subject of the document was a new development in the protection of electric wiring for aircraft.

The only possibility of success in any system, other than knowledge of the term, would be to have 'see' references in the index to each system from 'moulded harness, see ......'.

3. SEARCHING FAILURES

(a) Lack of understanding:-

(146) 40-06. With a question on boundary layer shock wave interaction, the searchers in U.D.C., Alphabetical and Uniterm decided that boundary layer separation would be the result of the interaction, and accordingly included this aspect in their search programme. In each case, the document was traced. The searcher in Facet, however, did not think sufficiently, and checked only the words of the question.

(147) 53-08. With a question on the measurement of heat transfer between concentric cylinders the searchers in U.D.C. and Facet failed to trace the document because they did not connect the question with the problem of flow in channels, under which the document is indexed.

The searcher in Alphabetical thought of this aspect, whilst in Uniterm, 'parallel plates' was brought out, and so constituted a success. (See also (152)).

(148) 54-07. With a question on the fatigue strength of Redux bonded 10 SWG aluminium alloy sheets, the first consideration was that the question was rather misleading, as the document was actually about fatigue tests on joints. However, on second thought the inclusion of 'bonded' in the question should infer that some form of join was caused to the aluminium alloy sheeting. Hence 'joints' would be a logical place to search. In the Alphabetical catalogue, the searcher did not try this aspect, nor did the searcher in Facet. Had this aspect been chosen in the first search programme for each system, the document would have been traced immediately.

(149) 60-07. With a question on the transient response of ladder networks, the searcher in Facet tried only 'transient' and 'response' in the chain index. He did not think of checking under circuits, as there is no place for networks in Facet. In Uniterm, the searcher did not think of circuits, either.

(150) 67-09. With a question on thermal stresses in a body exhibiting temperature dependent elastic properties, the searcher in Alphabetical tried all combinations of the words used in the question, but did not try 'Thermoelasticity', which should have been the next logical step. Had this been done, the document would have been traced.

In U.D.C., there is no place for thermoelasticity, and so 'thermal stresses' at 536.495 plus 'Elasticity' at 539.377 was used. However, as neither of these concepts were brought to the head of the entry, the document remained untraced.

(151) 77-06. The question on the performance of engines with liquid injection was misunderstood by three of the searchers. They took the 'liquid injection' to refer to fuel injection, when, in actual fact, it referred to water injection.

A fourth searcher, in U.D.C., found the document from his first search programme, under 621.438.057.3 (Water injection systems. Gas turbine engines).

(152) 77-10. The question on the mean temperature in a cylindrical tube due to heat transfer by laminar flow, the searcher in Alphabetical, as with question 53-08, failed to relate this problem to flow in channels, under which the document was indexed.

(153) 79-06. With a question on the effect of Reynolds number on measurements of pitching moments at transonic speeds, the searches in U.D.C., Alphabetical and Uniterm were failures because the searchers did not take the next logical step from 'pitching moments', to 'longitudinal stability'. In Facet, the searcher did think of this aspect, and so traced the document.

(154) 30-12. The searchers when presented with a question "What is meant by a 'moulded harness'" had no idea of where to start the search. Perhaps a searcher with electrical engineering knowledge may have been able to associate the question with a new development in electrical wiring.

(155) 31-15. A question on impact loads on hydro-skis on aircraft failed partly because the searchers limited their search programmes to headings and numbers containing 'hydroskis'. (For another reason, i.e. had choice of heading in Alphabetical, see 4d).

If the searchers had considered the connection between impact loads and landing, the document could have been traced in U.D.C., Facet and Uniterm. In Alphabetical 'landing' would be hidden on a subheading, and so would have been useless as a searching concept.

(156) 36-14. The searchers in all systems did not think of checking under 'deflection', from the question "Bending of anisotropic plates", when the concept 'bending' did not trace the document. Instead, the searchers tried 'buckling' and 'stresses'.

Had this concept been included in searches in all systems, the document would have been traced.

(157) 38-14. A question "Means by which the pilot of a military aircraft may achieve the maximum possible time in combat from his aircraft", had an unimaginative search programmes. Although the question was rather ambiguous (1d), the searchers should have thought through the question to the concept 'range'. Had this been done, the document would have been found in all systems.

(158) 65-13. A question on Reynolds stresses in two-dimensional parallel boundary layer failed in Alphabetical, because the indexer accepted the term 'parallel boundary layer' and did not think of looking under 'parallel flow'. The concept 'parallel' if used in all four searchers, would have enabled the document to be traced (except in U.D.C., where there is no place for 'parallel flow').

(b) Failure to use all the concepts given in the question:-

(159) 26-08. With the question on the comparison of heat transfer theories in forced non-isothermal convection over arbitrary surfaces, the searcher failed to use any concepts - in fact, he did not attempt a search programme because of the generality of the question, and the number of entries in the chain index he would have needed to check to find the document.

As it happens, if he had checked under 'forced convection' in the chain index, he would have found eighteen entries, amongst them the document he was searching for.

(160) 41-09. As in question 26-08, the searcher refused to search for this document, because he said that there were too many entries under 'heat transfer' to attempt a search. In this he was wrong. The question asked for material on heat transfer coefficients and temperature recovery factors at Mach numbers of 1.62. If he had assessed this question carefully, he could have obtained three concepts: Measurements (which he would not have checked), Heat transfer: Supersonic flow. On checking the chain index directly under these two concepts, fifteen cards were traced, with the required entry second. Admittedly, for a full search, the searcher would have needed to check all cards under ' heat transfer' that contained 'supersonic flow', on the card, but the first checking in the chain index would have been a reasonable attempt.

(161) 46-07. With a question on pressure distribution on elliptic cones at supersonic velocities, the searcher in the Facet system did not use the concept 'elliptic'. If he had done so, the document would have been traced. In the search programmes for the Alphabetical and Uniterm systems, the concept was used. In U.D.C., the search tried 'Elliptic wings' at 533.696.5, and there is no place for elliptic sections in general.

(162) 56-07. The searcher checking the U.D.C. catalogue for a question on the value of model testing for predicting instability of structural elements, tried only 530.17 Analogies. He did not try any part of the aspects 'structural elements'. As the indexer indexed the document under 621-415 Sheets, it is doubtful whether the searcher would have checked through the types of structures to find this.

(163) 57-07. With a question on the performance of perforated supersonic diffusers, the searcher in the U.D.C. catalogue did not, in any of his search programmes, check the concept 'perforated'. If he had done so, with the number for diffusers 533.697.3 (already chosen in his first search programme) the

document would have been traced. In the other three search programmes, this concept was included, and helped to trace the document.

(164) 64-07. When searching for the required document in the U.D.C. catalogue, from the question "Would deflecting the jet exhaust from a turbine engine permit increases in lift with double slotted flap wing of order of magnitude of thrust", the searcher did not use the concept 'slotted flaps'. If she had done, the document would have been traced at 533.694.22 (Slotted flaps).

(165) 66-08. From the question on the aerodynamic centre of two-dimensional aerofoils at transonic speeds, the searcher in Alphabetical did not check the concept 'CENTRE, AERODYNAMIC'. If he had done so, the document would have been traced.

(166) 68-08. The searcher checking the Alphabetical catalogue to trace a document from the question "Applications of Mellin transforms to plate theory" tried only 'Plate theory'. A logical step would have been to check under 'Plates', where the document would have been found.

(167) 73-09. With a question on the reduction of kinetic heating from the structural standpoint to fundamental principles the searcher in Facet refused to search because he said there were too many entries under 'aerodynamic heating' in the chain index. Had he taken the concept 'structures' and from that tried C 'Aircraft structures' and Fa 'Structures', plus Oi 'Aerodynamic heating', the search would have been narrowed considerably, and would have become possible. In fact, if the searcher had tried the classified catalogue at C Oi, the document would have been traced.

(168) 75-08. With a question on the rate of shrinkage of plastics at high temperature, the searcher in the Alphabetical system ignored the concept of 'high temperature'. If he had indexed it in his search programme as 'temperature effect', the document would have been traced. The searchers in U.D.C. and Uniterm, who found the document, had included this concept in their programmes.

(c) Chain index:- (refers to Facet only)

(169) 20-08. In a question on panel flutter analysis, the searcher, after checking Ffh (Panels), On (Flutter) in the classified catalogue, decided that there were too many places to check in the chain index, and so gave up the search.

If the searcher had continued, and checked the many cards, the document would have been traced under either (1) Ffh(Is)(Zvk)On Ya or (2) Ffh(Is)(Zvk) Nbk On Ya.

(170) 29-07. With a question on the alleviation of pitch-up by the use of leading edge slats, the searcher checked Ct Ieb Nub (Pitching moments: Leading edge: Slats) in the classified catalogue, and then checked in the chain index under Nub Pitching moments + Ieb + Ct and found no entries. He then tried in the chain index for Nub plus Ieb Leading edges or Cd wings - and found fifty-seven cards to be checked. The document was actually under Ca Cd(Iibb)Ct Ea Ieb Nbj Ob Vn - Wind tunnel tests: stability: transonic flow: leading edges: fuselages: slats: sweptback: wings: combination. Therefore, it would only have been found if the searcher, instead of switching from Ct to Cd, had dropped an element from the first search and concentrated on all cards containing Ct and Ieb.

(171) 30-08. A question on unsteady laminar boundary layer flows proved too general for the chain index. The searcher checked in the classified section under Ncd Nci Nfk (Boundary layer: unsteady flow: laminar flow), and then checked in the chain index under Ncd where he found seventy-five cards. The search was then dropped.

The document was indexed at Ffe(Is)Ncd Nfk Ya. (Calculation: boundary layer: laminar flow: flat plates) - so, if the searcher had dropped the middle element, the document would have been traced eventually.

(172) 31-08. With a question on the effect of shock waves on laminar boundary layers, again as in the question above, this is a very general question (for such an aerodynamic collection) to be answered via the chain index.

The first programme consisted of the concepts Ncd, Nfk, Nhd - (Shock waves: boundary layer: laminar flow). After checking in the classified catalogue under these elements, the searcher tried the chain index under 'shock waves', plus the other two elements, and found eight places, with no trace of the required document.

As the following search programmes would have meant looking in the chain index under the sub-division of Nhd (Shock waves):-

Nhf - Normal shock waves
Nhh - Oblique shock waves
Nhj - Attached shock waves
Nhk - Detached shock waves

- each in turn with the other d elements required (Ncd and Nfk), the searcher did not proceed any further with the search.

The document would have been found under either:-

(1) Ffe(Is)Nbk Ncd Nfk Nhh Nvf Oe - Wind tunnel tests: interactions: pressure distribution: oblique shock waves: boundary layer: laminar flow: supersonic flow: flat plates.

(2) Ffe(Is)Nbk Ncd Nfk Nhh Ni(2F)Oe Vn - Wind tunnel tests: distribution: velocity: oblique shock waves: boundary layer: laminar flow: supersonic flow: flat plates.

(173) 41-09. With a question on heat transfer coefficients and temperature recovery factors at Mach number of 1.62, the searcher refused to conduct a search because of the number of cards under heat transfer. In fact, the failure was due to the searcher giving some of the concepts given in the question.

If the searcher had checked under all cards under heat transfer, the document would have been traced at:-

Hrj(Ips)Nbk St Xz - Measurement: heat transfer: supersonic flow: annular nozzles.

(174) 50-06. With the question "Use of potential analyser to give loadings on thin wings", the searcher failed to trace the document because he tried Npb (Aerodynamic loads) in the chain index together with Cd Wings, but when this was not successful, he felt that to check under each type of loading separately would be too long. (There are twenty-eight subdivisions which would have meant

215 entries into the chain index).

The document would have been found under either:-

(1) Cd(Ikb)Nvf Oqb Oqt 6 - Aspect ratio 6: angle of attack: pressure distribution: rectangular: wings.

(2) Cd(Ij)Nvf Oqb Oqt 4 - Aspect ratio 4: angle of attack: pressure distribution: delta wings.

(3) Cd(Iibb 45)Nvf Oqb Oqt 3. - Aspect ratio:3: angle of attack: pressure distribution: sweptback 45: wings.

The searcher would have reached Nvf (Pressure distribution) at the twenty-second search, if he had worked down the schedules.

This question shows particularly clearly how specific one has to be when compiling search programmes for the chain index; unless one is willing to look under the entire general section, in this case Cd (Wings). Yet, if this happened, the searcher would not be sure that everything under 'wings' had been checked - he would also have to check 'Wings', in the chain index and try all entries under that heading.

In Alphabetical, the document was traced by checking the whole section under WINGS, LOW DRAG, and in U.D.C., by using the inversion of 533.693: 533.69.048 +.

(175) 56-07. With a question on the value of model testing for predicting instability of structural elements, the searcher did not attempt a search, or formulate a search programme, as she said that the question was far too general for Facet. The aspect 'structural elements' could be under any section of Fa (Structures). Under this heading are thirty-eight types of structural parts, elements, or type of structure.

If she had persevered, and formulated a search programme, the document would have been traced at Ffh Peal-a Rqg Vi - Tests: compression: aluminium alloys: panels.

(176) 57-08. With a question on the flexive-torsion flutter characteristics of aerofoils, the searcher tried Onb Flexive-torsion flutter + Cc Aerofoils with no success. She then tried On Flutter + Cc Aerofoils, but decided that there were far too many cards under 'Flutter' which included aerofoils, or wings to conduct a realistic search.

The document would have been traced at Cd(Ikb)On Sfu - Damping: flutter: rectangular: wings.

(177) 65-06. With a question asking for information on structural stresses at which plastic flow occurs, the searcher was only able to obtain two concepts, one 'plasticity' and the other 'stresses'. He checked under 'Stresses' in the chain index, andfound thirteen entries where both 'Stresses' and 'Plasticity' occurred. The document was not found here, so Rip Plasticity was checked. At this number fifty-six cards were found, and so the search was abandonded. If it had been continued, the document would have been found under either:-

(1) Rgz Rip Ya - Calculation: Plasticity: deformations.

(2) Ffe(Is)Rip Rmt Ya - Calculation: thermal stresses: plasticity: flat: plates.

(3) Ffn Rip Rmt Ya - Calculation: thermal stresses: plasticity: shells.

(4) Fqd Rip Rmt Ya - Calculation: thermal stresses: plasticity: discs.

(5) Fq Rip Rmt Ya - Calculation: thermal stresses: plasticity: cylinders.

In this case, the subdivision of 'Stresses' at Rm into seven, caused a failure. 'Thermal stresses' would have been seventh on the list if the searcher had worked down the schedules.

(178) 68-10. With a question on the fundamental mechanism of the growth of turbulence in the boundary layer, the searcher failed to find the required document in Facet, because of the number of cards he met when checking the chain index under boundary layer and turbulence. Fifty-three possible places were traced.

As it happened the document was not indexed under turbulence, therefore the search would have been further prolonged. It was actually indexed under: Nbk Nfk Nfn Rv - Roughness: transition: boundary layer: supersonic flow.

(179) 71-06. The searcher looking for a document from the question "Jet deflection by auxiliary air injection", after trying Gsg (Jet deflection) and Cs (Jet flaps) in the chain index, checked under Ngx (Jets). Here, he found far too many cards to constitute a realistic search.

If he had continued, the document would have been traced at Gf Gs Hrj(Zd)Ngx - Jets: variation: nozzles: exhaust systems: gas turbine engines.

(180) 76-06. Another example of the difficulty of searching for a general question in the chain index occurs with 'Manufacture of wind tunnel models'. As there is no indication in the question as to what type of model is referred to (there being no general section for 'models', only the adjectival form), the number of places to check proved too much for the searcher.

The document would have been traced under Bc(Zs)Qg - Machining: model: aeroplanes.

(d) <u>Failure to search systematically</u>:-

(181) 25-09. With a question on the allowable humidity in intermittent wind tunnels, the searcher, amongst other combinations, tried 533.6.071.54 - the number for humidity of wind tunnels, with no success. The next logical step would be to check 533.6.071. As the indexers did not use the sub-divisions of this number by type of wind tunnel, all types were classed at 533.6.071. If the searcher had checked here, the document would have been traced at 533.6.071: 533.6.011.5.

(182) 33-09. From a question on the variance of the shock standoff distance with the strength of a magnetic field, the searcher in Facet tried Nhd Shock waves with Sjn Magnetohydrodynamics, as his first search programme. If he had searched systematically, he would then have tried the sub-section of shock waves, e.g. normal, oblique, attached and detached, plus magnetohydrodynamics. The document would have been traced at Fp Fu Nbm Nhk Sjn - Magnetohydrodynamics: detached shock waves: hypersonic flow: blunt bodies: bodies of revolution.

(183) 27-08. With a question on throttle fuel controls for gas turbine engines, the searcher in Facet compiled a search programme of Gf - Gas turbine engines, Gn - Fuel systems and Vfc - Controls. When this proved unsuccessful, he dropped Gn, Fuel systems. In my opinion, he should have kept Gn, and checked in the chain index for everything he could trace on that.

The document would have been traced at Gn Vi - Tests: fuel systems.

(184) 39-06. With a question on the use of thrust reversal in reducing the air speed of a jet transport in flight, the searcher in Facet tried Bhg (Turbojet aeroplanes) in the classified section, but did not check in the chain index. If he had done so, the document would have been traced under B(Abb)Bhg Vff - Stopping: turbojet aeroplanes: passenger carrying: aircraft.

In Alphabetical, the searcher tried AEROPLANES, JET, but did not go through the types of aircraft, subdivided by the adjective 'jet'. If he had done so, the document would have been found.

(185) 64-06. The searcher of the Alphabetical catalogue to trace the required document for the question "Effect of aspect ratio on the lateral stability of swept (30-60) wings", made twelve attempts, yet in my opinion, did not make a systematic search. He tried many subheadings under WINGS, SWEPTBACK (35) and WINGS, SWEPTBACK (+ speeds), but did not go to the whole section of WINGS, SWEPTBACK (30-60). In such a question, where the degree of sweptback covers such a large range, to pick out one degree (35) and ignore the rest, is to make an illogical search.

The document would have been traced under:

WINGS, SWEPTBACK (45) - Stability
WINGS, SWEPTBACK (45) - Aspect ratio

(186) 64-07. The question "Would deflecting the jet exhaust from a turbine engine permit increases in lift with double slotted flap wings or order of magnitude of thrust", prompted the searcher in Facet to check under (1) Cd Crf - Slotted flaps: wings, and (2) Crf - Slotted flaps, in the classified catalogue. However, instead of checking the chain index under these elements, the searcher changed them in her next search programme.

Had she been consistent, and checked under Crf in the chain index, plus Cd, the document would have been traced under Cd(Ikb)Crf Ngx Nq Nrb Okd Vn - Wind tunnel tests: blowing: pitching moments: lift: jets: slotted flaps: rectangular wings, at the first attempt.

(e) Incorrect searching:-

(187) 24-09. With a question on the calculation of damping in roll at supersonic speeds, the searcher in the Facet catalogue chose to express 'roll' in the notation under Aerobatics Kp, which is obviously the wrong place. He should have checked Nud Rolling moments, which more expresses the aerodynamic aspect. If he had checked Nud Rolling moments and Nbk Supersonic flow, the document would have been traced, that is, if he had made this one of his search programmes. In actual fact, he included 'Rolling', 'Supersonic flow' and 'Damping' in his first search programme, but in his second and third, he insisted on 'Damping' and other elements.

(188) 29-07. In a question on the advantages and uses of leading edge slats, the searcher in U.D.C. checked 533.694.25 Leading edge flaps, instead of 533.694.26 Leading edge slats. If the searcher had been correct, the document would have been traced.

(189) 55-08. Although a question was on the formulae for calculating the effect of local modification in structural matrices, the searcher in U.D.C. insisted on checking aircraft structures at 629.13.012, instead of the more obvious place, 624.072.2. If this number had been checked, the document would have been traced without difficulty.

(190) 71-08. With a question on the weight of cabin pressurisation equipment, the searcher in Alphabetical looked under CABINS, PRESSURISED, and PRESSURISATION. Had he looked under CABINS, Pressurisation, the document would have been traced. As the article is about the pressurisation of cabins, rather than information on pressurised cabins as such, the proposed search programme appears the more logical.

(191) 39-14. A question on "Ignition qualities of aluminium borohydride" remained untraced in U.D.C., Alphabetical and Facet, because the searchers thought that aluminium borohydride is a solid fuel, whereas it is actually a liquid fuel. If the searchers had checked in the catalogue under liquid fuel, the document would have been traced.

In Uniterm, the document was traced because 'combustion: ignition: propellants' were successful Uniterms.

(f) Insufficient searching:-

(192) 26-06. With a question on hydrogen in metals, the searcher in Uniterm tried Metals: Hydrogen: Molecules: Alloys and Atoms. Hydrogen was the only Uniterm to be traced. The searcher should then have tried 'Steels', because she knew that there is much written on the effects of hydrogen in steels, and 'Embrittlement', as one of the effects of hydrogen is to cause embrittlement.

In the Alphabetical search, the searcher also failed to check under 'Steels', where the article was indexed, with the subheading 'Embrittlement'.

(193) 31-06. With a question on the photoelastic investigation of stress concentration, the searcher in the Alphabetical system tried only PHOTO-ELASTICITY and STRESS DISTRIBUTION. He ignored the possibility of the entry being under STRESSES - Photoelastic tests, where in fact, it had been indexed.

(194) 35-10. With a question on the calculation of heat flow in a cylinder surrounded by a radiation shield, the searcher in Facet in his first search required Stg (Conduction) with Fq (Cylinders), and when this was unsuccessful, he checked Radiation. As 'Conduction' was not specifically mentioned in the question, I think that the search could logically have tried 'heat transfer' and 'temperature' before going on to the aspect of radiation.

The document would have been traced at Fq Ilf(Ipc)Ssb Ya. (Calculation: temperature: circular: cross-section: cylinders). Better indexing would have had an added entry with 'heat transfer' instead of 'temperature'.

(195) 36-10. The searcher in the Alphabetical system failed to trace the required document from the question "Measurement of surface pressure on thin bodies", although she formulated five search programmes.

If she had considered looking under 'pressure distribution' the document would have been traced at the fifth attempt.

(196) 51-06. With a question on the structural influence coefficients for thin low aspect ratio wings, the searcher in the Alphabetical catalogue tried 'aspect ratio' as a subheading with many types of wing, but did not check the same concept as a main heading. If he had done so, the document would have been traced.

(197) 56-08. With the question "Supersonic flow over a step", the searchers should, with thought, have realised that 'Wedge' was a possible entry. This applied to U.D.C., Alphabetical, Facet and Uniterm, where there were places for the concept. However, the principal cause of the total failure is due to indexing.

(198) 57-08. The searcher in the Alphabetical system for this question, on flexure-torsion flutter characteristics of aerofoils, tried 'Aerofoils' and 'Aerofoil sections' in her four search programmes, but did not try 'Wings'. The terms 'Wings' and 'Aerofoils' were used rather loosely in the papers, and hence the indexers themselves tended to do the same.

In this particular instance, the entry was under WINGS, OSCILLATING - Damping. It would probably have taken several search programmes to eventually trace this via WINGS - Flutter, etc. Also, the term 'WINGS, OSCILLATING', tended to be overlooked by the searcher. It was used in indexing quite frequently, but there appears to be such a fine difference between WINGS, OSCILLATING and WINGS - Flutter, that if the term 'flutter' is used in the question the searcher tends to look under the subheading rather than the compound term.

(199) 57-09. With the question "Influence of human engineering factors in forecasting of load spectrum of aeroplanes", the searcher in Alphabetical and Uniterm failed to check all possible places.

In Alphabetical, the searcher compiled only two programmes, one 'HUMAN ENGINEERING', and the other 'AEROPLANES - Loads'. If the searcher had thought one step further, under 'STRUCTURES, AIRCRAFT - Loads', the document would have been traced.

In Uniterm, the searcher could have checked 'spectrum', which was actually mentioned in the title, also 'calculation' is a logical Uniterm to express the concept 'forecasting'. Had this happened, the successful Uniterms would have been 'Loads', 'Aircraft', 'Spectrum' and 'Calculation' - sufficient to warrant a success.

(200) 71-06. The searcher in U.D.C., with the question "Jet deflection by auxiliary air injection" formulated two search programmes - the first 532.525.2 (Jets - hydrodynamics) and 621.438.067.6 (Exhaust devices, gas turbines) but did not check 533.697.4 (Jets - Internal aerodynamics). If he had done so, the document wold have been traced at the first attempt.

(201) 72-08. With a question on the design of blow-down wind tunnels, the searcher in the Alphabetical system tried WIND TUNNELS, BLOWDOWN and WIND TUNNELS (subdivided by speed of flow). However, he did not try

WIND TUNNELS, INTERMITTENT, which he should have done, knowing that a 'blowdown wind tunnel' is a type of 'intermittent wind tunnel'. The document would have been found under WIND TUNNELS, INTERMITTENT, SUPERSONIC - Flow problems.

(202) 75-08. The searcher in the Facet catalogue, from the question "Rate of shrinkage of phenolic-mineral moulding compound at 125 'C' ", tried only 'phenolic resins' and 'phenolic plastics', at Phyb and Pia respectively. He did not try 'plastics' at Ph. If he had done so, the document would have been traced at Ph Rab Ssb(Zqn)(Zb) Stability: high; temperature: dimensions: plastics.

(203) 34-12. A question "Design information on wind tunnel corner 90° bend with turning vanes", remained untraced in all systems. The document actually referred to wind tunnel diffusers. In none of the searching programmes was the concept 'diffuser' thought of. This should have been checked and would have caused a successful result, except in U.D.C., and Alphabetical, where the indexer placed the document under DIFFUSERS, instead of DIFFUSERS, WIND TUNNEL.

(204) 21-12. A document which was not traced in Alphabetical or Facet, could have been found if the indexer had included the concept of 'wedges' - though with the question on wave drag at zero lift of two body arrangements consisting of two surfaces of delta planform, it is doubtful whether the searcher would have considered 'wedges' a suitable concept for searching. As the subject of the document is so difficult to express, the term 'wedges' appears to be the only way the document could have been traced.

4. SYSTEM

(a) Number of places for the same subject:-

(205) 29-08. From the article entitled "Beam strength and curvature under combined tension and bending in the plastic range", the question was phrased thus "Effect of combined tension and bending on curvature of beam in the plastic range".

In both indexing and searching, difficulty was found because of the concept 'bending'. In U.D.C. there are the following entries in the Alphabetical index:-

1.	539.384	Bending. Deformations. Physics.
2.	621.772.31	Bending, pipe. Workshop practice.
3.	621.774.63	Bending, tube. Workshop practice.
4.	539.413	Bending strength. Resistance to stress. Physics.
5.	620.174	Bending strength tests. Materials testing.
6.	620.174.251. 224	Bending strength tests. High temperature. Materials testing.
7.	531.224	Bending stresses. Resolution of forces. Mechanics.
8.	620.178.74	Bending tests, impact. Materials testing.

Of those, 2 and 3 - Workshop practice can be eliminated for this particular document and question, and numbers 5, 6 and 8 on Bending strength tests can be placed on one side for later search programmes if required, but numbers 1, 4 and 7 are all from the Physics section, under 'deformation', ' resistance of stress' or 'resolution of forces'. It is sometimes extremely difficult when indexing to decide into which of the last two sections a particular aspect should be placed.

From the above question there is little indication which place should be searched.

In Alphabetical, 'Bending' is used as a main heading, and as a subheading. 'Bending stresses', as the heading and subheading 'Stresses, bending', are also permitted, but there is not much difficulty caused by this, as by the U.D.C. schedules.

(206) 72-08. The search programme for this question, on the design of blowdown wind tunnels, points out two possible headings in the Alphabetical catalogue, WIND TUNNELS, BLOWDOWN, and WIND TUNNELS, INTERMITTENT. As a blowdown tunnel is a type of intermittent tunnel it would be better either to include them both under the more general heading, or to have a 'see also' reference from one to the other.

In this particular document, the title as "On the choice of working fluid for intermittent supersonic wind tunnels", and the question referred to 'Design of blowdown wind tunnels'. Hence, the indexer used the heading WIND TUNNELS, INTERMITTENT, and the searcher, WIND TUNNELS, BLOWDOWN.

(207) 49-06. From a question on starting flow characteristics in feed systems of liquid propellant rocket motors, the number of possible places which can include types of rocket engines are discovered.

Under Gj Rocket engines, one finds subdivisions Gjb Liquid propellant rocket engines, and Gjd Solid propellant rocket engines.

It is also possible to describe liquid propellant rocket engines by : (a) Gj Pck(Pre) Liquid: propellant: rocket engines, and solid propellant rocket engines by: (b) Gj Pck(Prb) Solid: propellant: rocket engines. Finally, one can also classify by type of fuel, e.g. (a) Gj Pce Liquid fuels: rocket engines, and (b) Gj Pcg Solid fuels: rocket engines.

Although, when one is used to the indexing system, it is quite apparent that Gjb and Gjd are the most useful places, a person who is unused to indexing or searching could, quite legitimately, make entries under either of the other two methods.

(208) 49-07. Again, the question on conical flow at supersonic speeds over non-symmetric bodies, brings out two places in Facet, under which the aspect 'conical flow' may be placed. One can either use the adjective 'conical'(Igr) with 'flow' (Nbf), hence reading Nbf(Igr) Conical: flow; or one can use speed of flow or Nbh Subsonic, Nbj Transonic, Nbk Supersonic or Nbm hypersonic, together with Fr Cones, hence reading: Fr Nbk Supersonic flow: cones.

In this particular question, the indexer indexed the document under Fr Nbk Nvf Pressure distribution: supersonic flow: cones, whilst the searcher checked only 'conical' (Igr) in the chain index.

(209) 52-15. A question "Description of an optical method of measuring surface finish in which the sample is notated," threw up the problem in U.D.C. of the number of possible places for measurement of surface defects. From the Alphabetical index, the following entries are seen :-

620.191	Surface defects. Materials defects
621.795	Surface finishing, mechanical
620.179.6	Surface tests
539.211	Surface texture. Physics

Under 'Measurement', the searcher found:

53.082.5	Optical phenomena.Principles of measurement
531.74	Measurement of geometrical magnitudes.

The combination of these six places deterred the searcher, who was not able to trace the document although it was at 620.191:531.715.

(210) 36-15. The question on the descent of winged orbital vehicles was found in U.D.C. and Facet because 'Satellites' is the obvious place (and only suitable place) in which to index and search. In Alphabetical there are the following headings:

SATELLITES, ARTIFICIAL
SPACE VEHICLES

A 'see also' reference may have helped in this particular case, but the material is split up under two headings. In some cases, it is obvious which one to choose, but in others, less obvious.

(211) 36-13. A question "A shell theory for cylinders" showed that in the Facet catalogue, material on hollow cylindrical shells, or cylinders, is divided between

Fq(Iyh) Hollow: cylinders
Ffm(Igq) Cylindrical: shells

Some decision should be made as to which is the more suitable, and material placed under one heading, with a 'see' reference in the chain index from one to the other.

(b) Lack of places in the schedules:-

(212) 72-08. Although this failure has been blamed in part to lack of place for 'blowdown' wind tunnels in the U.D.C. schedules and one must state that there actually is provision in the printed schedules, for subdivision of types of wind tunnel by Alphabetical order under WIND TUNNELS (TYPE). The indexers in the project decided early in the indexing programme that this subdivision would not be used.

Thus, the question 'design of blowdown wind tunnels' did not trace the correct document because the indexer would not make an entry simply under 533.6.011, presumably because he thought this number too general, but used 533.6.071.46 - Humidity of wind tunnels. Although this is referred to in the text, the question gives no indication of this aspect.

(213) 72-09. From a question on the description of plant for testing aircraft equipment and components under simulated high altitude conditions, it has been found that there is really no adequate place for 'testing plant' in U.D.C., Alphabetical or Facet. In U.D.C., the most suitable number is 533.6.07 (Ground testing techniques). In Alphabetical, the heading TESTING EQUIPMENT is not adequate, as one wishes to emphasise the aspect of the plant used for testing - which counts more than the aspect of 'equipment'.

In Facet, the only place provided in the schedules is Ez 'Model-testing equipment', which is quite unsuitable.

(214) 76-06. With an article on the manufacture of supersonic wind tunnel models, the indexer found difficulty in placing the aspect 'wind tunnel models'. There is no place in Facet to be used generally for models, but one can use Zs (Models), as an adjective to be attached to the substantive. In this particular case, the use of the adjective is quite unsatisfactory, as the article covered the manufacture of several types of model, and so should have been placed at a general heading.

(215) 31-13. A document on laminar boundary layers at the surface of co-current parallel streams was untraced in U.D.C., and the failure can be partly considered to be due to lack of place in the U.D.C. schedules for the aspect 'parallel flow'.

As the question was "The hydrodynamics of fluid-fluid interaction at the interface of parallel streams", the searcher had few concepts to try. In Facet, the search was attempted via 'parallel' in the chain index, plus boundary layer. In Uniterm, the successful concepts were 'parallel: flows: boundary: laminar'. The question also failed in Alphabetical.

The document was indexed only under 532.526.2 Laminar boundary layer, which the searcher considered too general.

(216) 36-11. A document on the estimation of wave drag of forebodies and afterbodies with conical and parabolic shapes, had the question "Supersonic drag of a parabolic nose cone".

In U.D.C., there is no place for 'parabolic' shapes'. Hence the searcher was able only to check under 'cones', etc. with 'drag'. With inversion, it was not possible to trace the document, as 533.6.013.129 'wave drag' had been used.

The same applies for the Alphabetical system, as no heading had been made under parabolic shapes.

(217) 73-12. There is no place in the present list of Alphabetical headings for 'linear systems'. A question "Calculation of natural frequency of damped vibration of a linear system", failed because of the lack of heading. The searcher checked under VIBRATIONS, FREQUENCY and RESONANCE.

The document was actually indexed under SERVOMECHANISMS - Calculation, plus three other headings not applicable to the present question.

The same restriction applies also in Facet.

(218) 35-14. In Facet, there is no place generally for 'performance', which can be applied to engines, etc. The only place is at Ja under Aerodynamics and this is hardly suitable.

A question "How to determine the value of the turbojet engine time constant from experimental data", was not traced, partly because of the inability of the searcher to try the concept 'performance'.

(219) 76-11. A document on the response time of transductors with negative voltage feedback was not traced in Facet because no place was provided for 'transductors'. The indexer used 'amplifiers' which is not satisfactory.

As transductors had been placed in the Zz schedules, it would have been better to have used this place.

(c) Lack of subdivision, causing the placing to be too general:-

(220) 25-09. In this particular example, the criticism is of the U.D.C. schedules used by the indexers, and not of the printed schedules.

With an article on intermittent wind tunnels, the only place in which to place this concept is at 533.6.071, as the indexers did not use the subdivision by alphabet provided for in the printed schedules.

(221) 26-07. The indexer dealing with the article on reciprocity relations in aerodynamics, was unable to adequately index 'reversed flow' as there is no place provided in the schedules. As the flow in this case is supersonic, he was able only to make an entry at 533.6.011.5 'Supersonic flow'.

(222) 26-12. A document on annular flow between concentric cylinders was not traced in U.D.C. One of the reasons for failure, was that there is no sub-division under 'cylinders' into types of cylinder. Alternatively, it can be said that a place under material shapes at 621-4 ... schedules for 'concentric', would have sufficed.

As it was, the searcher was not able to trace the document under 'Annular flow: cylinders', and decided that to check under 'cylinders' generally would be too general a search.

In the other systems, there is ability to include 'concentric' and so the document was traced in all but U.D.C.

(d) Bad choice of heading:-

(223) 31-15. A heading used in Alphabetical of AEROPLANES, HYDROSKI, is not the best that could be chosen. A more accurate heading would be FLYING BOATS, HYDROSKI, as any aeroplane with hydroskis, must of necessity, be a flying boat. In this particular search, from the question "Model experiments related to impact loads on hydro-skis on aircraft", if the searcher had checked under FLYING BOATS, HYDROSKIS, he would have widened his search to include FLYING BOATS, and hence would have traced the document.

(e) Synonyms:-

(224) 20-08. Confusion often arises in the use of 'Plates', 'Panels' and 'Sheets' in technical writing and hence in indexing and searching. For example, in the paper now being discussed, the author used the words 'panels' and 'plates' indiscriminately throughout.

Unfortunately, the indexer has followed his example. In Alphabetical, he uses the heading PLATES, SUPPORTED, and in Facet Ffh Panels. In neither of these systems was the document traced - in Alphabetical because the questioner used 'Panels', and in Facet because of the multiplicity of entries in the chain index under 'Plates'.

In U.D.C., there is no choice - 'Plates', 'Panels', and 'Sheets' go at 621-415 - hence no difficulty in searching. In Uniterm, also a success, because 'Plates' and 'Panels' are considered the same Uniterm. 'Sheets' have a separate entry, which should, I feel, be included with the other two near-synonyms.

(225) 72-06. There is even more confusion in the use of propellants and fuels.

The indexer has indexed under 662.75 in U.D.C., under which both liquid fuels and liquid propellants are placed. In Alphabetical, he has used the heading PROPELLANTS, LIQUID, yet in Facet he has used Pce Liquid fuels. There is provision in Facet for the use of Pck Propellants and (Pce) Liquid, reading: Pck(Pre) Liquid: Propellants.

Therefore, the indexer has been inconsistent in his use of the terms 'Propellants' and 'Fuels'. The failures were principally due to the fact that the article was about 'gaseous' not 'liquid fuels'. The searchers naturally limited their search to this concept.

In Uniterm, the indexer included 'gaseous' thereby causing a success.

Also from the article (39-07) on the design of a miniature solid propellant rocket, there are the following places under which the article can be placed.

U.D.C.	Solid propellants	662-3
	Solid fuels	662-8
Alphabetical	PROPELLANTS, SOLID (but there is a note under Propellants to the effect that only reacting mixtures that do not draw on atmospheric oxygen for combustion should be included here - however, it is often difficult to tell from an article whether this condition applies or not).	
	FUELS, SOLID.	
Facet	Even more confusion here.	
	Pcg = solid fuels, but for someone unused to the system, it is possible to index and check under Pc(Prb) = Solid fuels.	
	Pck = Propellants	
	Pck(Prb) = Solid: propellants.	
Uniterm	'Fuels' and 'Propellants' are under the same Uniterm, therefore, no difficulty.	

It is obvious, from the above two examples, that this confusion between the possible places for propellants and fuels must be cleared up in U.D.C., Alphabetical and Facet. As the two nouns are under the same uniterm, the confusion has not arisen in this system.

(226) 41-12. In the Uniterm system, the terms 'overhaul inspection' and 'maintenance' each have a different number. It would be better to combine them under one, preferably 'maintenance', with references from the other two.

A question on inspection and overhaul of components of a gas turbine, failed because the document had been indexed under 'maintenance'.

(227) 63-11. A question on the downwash characteristics of delta wings in the transonic region was traced in Alphabetical and Uniterm, because the terms 'delta' and 'triangular' are considered synonyms, and one thus included under the one heading. As the document referred to triangular wings, the indexer included this concept in U.D.C. and Facet, but was forced to use 'delta' in Alphabetical and Uniterm.

A combination of these synonyms in the two systems would reduce such errors in future.

(f) <u>Inability to combine particular concepts:-</u>

(228) 31-12. A question on the effect of shock waves on laminar and turbulent boundary layers, failed in the Alphabetical system because of the inability to combine 'Shock waves' and 'Boundary layer'.

The document was indexed under:-

1. BOUNDARY LAYER, LAMINAR
2. BOUNDARY LAYER, TURBULENT
3. SHOCK WAVES

As the sections under each heading were so large, the searcher refused to make such a general search by looking under any of these three.

APPENDIX 5B

EXAMPLES OF ANALYSIS OF FAILURES

QUESTION 29-08 "Effect of combined tension and bending on curvature of beams in the plastic range".

Assessment A fair question which should have enabled the document to be traced without difficulty.

DOCUMENT P12956. Beam strength and curvature under combined tension and bending in the plastic range. Jnl. of Aero.Scs., 1955, pp 70-72.

Assessment $1\frac{1}{4}$ page article under 'Readers Forum' in Jnl. of Aero. Sciences. No summary or conclusions. The title is actually a good precis of the article. However, the first paragraph refers to an article on the analysis of bending moments of rectangular beams, and goes on to discuss the Ramberg-Osgood form of stress-strain curve. As, presumably, the stress-strain curve can be used for the analysis of moments of other types of beam than rectangular, I feel that the indexer was quite correct in leaving out 'rectangular'.

FAILURES U.D.C.

INDEXING

Main system Alphabetical

Assessment

U.D.C.
A 624.072.2 Beams
B 539.413 Bending strength
C 539.42 Tensile strength
AB : BA : AC : CA

Should have included Plasticity at 539.214.

ALPHA.
BEAMS - Bending strength. Calculation
BEAMS - Tension. Calculation
BEAMS - Deformation. Calculation

As in U.D.C., should have had an entry 'Plasticity', but as a subheading under BEAMS.

FACET Fhb Rp Rqe Rwm Ya Calculation: bending: tension: strength: beams. Again, should have included 'Plasticity'.

UNITERM
Calculation Sections
Strength Crosses
Bending Curves
Tension

Included 'Rectangular' but did not include 'Plasticity'. Otherwise the same aspects included as the other three systems.

ASSESSMENT OF SEARCHING

U.D.C.
(1) A. 624.072.2 B. 621-402 C. 531.222 ABC
(2) B
(3) D 539.374 AD
(4) E 539.384 AE
(5) AC
(6) E

The searcher tried 531.224 Bending stress, 539.38 Bending, deformation and 539.374 Plasticity, combined with Beams at 624.072.2. See 'General Comments' for further notes on the search programme.

ALPHA. BEAMS - Bending.
Good; the document was found at the first attempt under BEAMS - Bending.

FACET
(1) Fhb Rqe Rwm Bending: Tension: Beams. No. (Classified catalogue).
(2) Fhb Rqm Bending: Beams. No. (Classified catalogue).
(3) Fhb Rp Rqe Rqm Curvature: Tension: Bending: Beams. Found.

The searcher tried the classified catalogue only, in his three search programmes. If, with his first programme, he had used the chain index, the document would have been traced.

UNITERM				
	Beams	Yes	Curvature	Yes
	Bending	Yes	Plasticity	No
	Tension	Yes		

Adequate. The Uniterm Beams: Bending: Tension: Curvature, were all successful.

SUGGESTED RE-INDEXING

U.D.C. Plus D 539.214 Plasticity
Ad : DA

ALPHA. Plus BEAMS - Plasticity

FACET Fhb Rip Rqe Rqm Ya Calculation: Bending: Torsion: Plasticity: Beams

UNITERM Plus PLASTICITY

COMMENTS

Time allowance An 8 minutes allowance, but 11 minutes used by the indexer. He should have had time to add 'Plasticity' in all four systems.

General Searching failure in U.D.C. because the searcher did not try 'Bending strength' at 539.413. Under the word 'Bending' in the Alphabetical index are 9 entries:-

(1) 539.384 Bending: Deformation: Physics
(2) 621.772.31 Bending: Workshop practice
(3) 621.774.63 Bending, pipe: Workshop practice
(4) 621.774.63 Bending, tube: Workshop practice
(5) 539.413 Bending, strength: Resistance to stress: Physics.
(6) 620.174 Bending strength tests: Materials testing
(7) 630.174.251 Bending strength tests: High temperature: Materials testing
(8) 531.224 Bending stresses: Resolution of forces: Mechanics
(9) 620.178.3 Bending tests, impact: Materials testing

Although the references numbers 2, 3, 4 on Workshop practice can be eliminated, and numbers 6, 7 and 9 Bending strength tests put on one side for a later search programme, numbers 1, 5 and 8 are all in the Physics section under Deformations, Resistance of stress or Resolution of forces. It is sometimes extremely difficult, when indexing, to decide in particular, into which of the last two sections a particular aspect should be placed. However, with a question such as the one herewith, there is really little indication which number one should try first.
The section 'Resistance to stress' and 'Resolution of forces' always involved difficult decision when indexing. Therefore reason for failure actually searching, due to multiplicity of possible places in alphabetical index.

REASONS FOR FAILURE

U.D.C. Searching.

QUESTION 49-06 "Starting flow characteristics in feed systems of liquid propellant rocket motors".

Assessment Appears to be a fair question which should trace the document.

DOCUMENT P14927. Analysis of flow-system-starting dynamics of turbopump-fed liquid propellant rockets. NASA Memo. 4-21-59E.

Assessment NASA Memo of 18 pages plus 17 pages of figures, etc. 14-line summary. Gives the methods of calculation of the speed response time of the turbopump, the flow response time and the maximum dynamic line loss. The analysis is based on work done in rocket starting at the Lewis Research Center.

FAILURES Facet.

INDEXING

Main system Alphabetical

Assessment

U.D.C. 621.45.032. Fuel systems. Rocket engines
621.45.057.54 Starting. Rocket engines.

Quite sufficient, without going into too much detail.

ALPHA. (1) FUEL SYSTEMS, ROCKET - Analysis
(2) ENGINES, ROCKET - Starting
(3) FLOW PROBLEMS

The last heading, I think, is rather too general for application here.

FACET Gf Pce Vfd Starting: liquid fuels: rocket engines. An incorrect entry. Gf should read Gj. The document would then have been traced. However, there is a place at Gjb for liquid propellant rocket engines which should have been used instead. (See General Comments).

UNITERM

Flow	Rockets
Systems	Engines
Fuels	Starting
Liquids	Turbopumps

Includes the same aspects as the other systems, plus the addition of 'Turbopumps', which was a Uniterm used for the first time.

NASA INDEXING ENGINES, ROCKET
ENGINES, CONTROL - Rocket
FUEL SYSTEMS
TURBOPUMPS

ASSESSMENT OF SEARCHING

U.D.C. (1) A 621.45.018.5 Performance. Rocket engines
B 662.75 Liquid fuels
AB. No.
(2) 621.45.032 Fuel systems. Rocket engines. Found.

Document found at the second attempt under 621.45.032. Fuel Systems. Rocket engines. If the searcher had, at the first attempt, used the concept 'Starting' she would have traced the document immediately under 'Starting . 'Rocket engines'. 621.45.057.54.

ALPHA. (1) ROCKETS, LIQUID PROPELLANT - Starting. No.
(2) ENGINES, ROCKET - Starting. Found.
Document found also at the second attempt.

FACET (1) Gjb Liquid propellant rocket engines. No. (Classified catalogue).
(2) Gj Rocket engines. No. (Classified catalogue)
(3) Gn Fuel systems. Checked in chain index for combination of Gj or Gjb. No.
Adequate searching, and the document should have been found had the indexer not made a clerical error.

UNITERM

	Engines	Yes	Fuels	Yes
	Rocket	Yes	Systems	Yes
	Starting	Yes	Liquid	Yes

Success all the way through.

SUGGESTED RE-INDEXING

U.D.C. A 662.75 Liquid fuels
AB : AC : BA : CA

ALPHA. Could add entry under ROCKETS, LIQUID PROPELLANT but as the document is on the starting of the rocket engine, I feel this the more accurate entry.

FACET (1) Gjb Vfd Starting: Lquid propellant rocket engines
(2) Gjb Gn Fuel systems: liquid propellant rocket engines

UNITERM Unnecessary

COMMENTS

Time allowance 8 minutes allowance but 9 minutes taken. The clerical error in Facet may have been caused by haste through shortage of time.

General

(1) Facet. On occasions, I think there is too much subdivision, i.e. under Rocket engines one finds Gjb Liquid propellant rocket engines, and Gjd Solid propellant rocket engines, although it is possible to describe liquid propellant rocket engines by:-
(a) Gj Pce Liquid fuels: rocket engines
(b) Gj Pck(Pre) Liquid: propellants: rocket engines
Therefore there are three possible ways of indexing this document, each of which is admissible by the schedules.

(2) Indexing failure because of clerical error (presumably because the indexer made the entry without checking the schedules). In any case, perhaps Gjb Liquid Propellant Rocket Engines would have been better.

REASONS FOR FAILURE

Facet Indexing.

<u>QUESTION</u> 51-06 "Structural influence coefficients for thin low aspect ratio wings".

<u>Assessment</u> Fair question, but one which may well be difficult to search. 'Structural influence coefficients' are difficult to define in most systems. Many possible places to check. If this question had been presented in a library, further details should have been asked for.

<u>DOCUMENT</u> P15110. A method for deflection analysis of thin low-aspect ratio wings. NACA Tech. Note 3640.

<u>Assessment</u> A 65-page NACA Technical Note, with an 11-line summary. Refers also to the idealized structure of box beams. Also includes deflection of wing-body combinations.

<u>FAILURES</u> Alphabetical. Facet.

<u>INDEXING</u>

<u>Main system</u> Uniterm

<u>Assessment</u>

<u>U.D.C.</u> A 539.384 Bending. B 533.693 Wings. C 533.69.031 Aspect ratio. BAC : ACB : ABC. Insufficient permutation. Should also have added BCA : CBA.

<u>ALPHA.</u> WINGS - Deflection. Analysis. ASPECT RATIO. Fair indexing which covered the same aspects as U.D.C.

<u>FACET</u> Cd Ogt Rwm Xy Analysis: Bending: Aspect ratio: Fair indexing which covered the same aspects as U.D.C. and Alphabetical.

<u>UNITERM</u>	Deflections	Ratios	Computers
	Analysis	Wings	Machines
	Slender	Parabolic	Loads
	Low	Linear	Spars
	Aspects	Chords	Stringers

Adequate indexing.

<u>ASSESSMENT OF SEARCHING</u>

<u>U.D.C.</u> (1) A 533.69.031 Aspect ratio. B 533.693 Wings BA. No.
(2) A Found at A 539.384 : 533.693.

Adequate as far as the question goes. The document was found at the second attempt. If, however, the indexer had made sufficient permutations, the document would have been found at the first attempt.

<u>ALPHA.</u>
(1) WINGS - Aspect ratio. No.
(2) WINGS, SWEPTBACK - Aspect ratio. No.
(3) WINGS, DELTA - Aspect ratio. No.
(4) WINGS, TRIANGULAR - Aspect ratio. No.
(5) WINGS, SUPERSONIC - Aspect ratio. No.
(6) WINGS, SUPERSONIC - Aspect ratio. No.
(7) WINGS, SWEPTBACK, SUPERSONIC - Aspect ratio. No.
(8) WINGS, SWEPTBACK, TRANSONIC - Aspect ratio. No.

The searcher tried 8 types of wing - aspect ratio. If he had gone to Aspect Ratio as main heading, the document would have been traced.

FACET (1) Cd Wings, Oqt Aspect ratio, (Zqj) Low. Checked chain index under 'Low' plus other two aspects. No.
(2) (Iv) Thin. Checked classified catalogue under Cd(Iv)Oqt. No.

The searcher insisted upon Wings: Aspect ratio: Low, which was quite realistic. If the indexer had added (Zqj) Low, to the entry, the document would have been traced.

UNITERM				
	Wings	Yes	Thin	Yes
	Low	Yes	Design	No
	Aspect	Yes	Structures	No
	Ratio	Yes		

Adequate.

SUGGESTED RE-INDEXING

U.D.C. A, B and C as before, but BC and CB.

ALPHA. WINGS - Aspect ratio (although this was rarely used as subheading).

FACET Cd Oqt(Zqj)Rqm Xy Calculation: Bending: Low: Aspect ratio: Wings. Plus (Zqj) Low.

UNITERM Unnecessary.

COMMENTS

Time allowance 8 minutes allowed and 8 minutes taken. This is a long article to read and presumably the indexer had no time for more detailed indexing.

General Searching failure in Alphabetical because the searcher did not check under 'Aspect ratio' as main heading. Also an indexing failure because the indexer did not use 'Aspect ratio' as subheading under WINGS. Indexing failure in Facet. If the indexer had added (Zqj) Low the document would have been traced.

REASONS FOR FAILURE

ALPHA. (1) Searching (2) Indexing

FACET Indexing.

<u>QUESTION</u> 63-08 "Three dimensional boundary layers on slender wings".

<u>Assessment</u> Misleading question. The document refers to a <u>delta</u> wing - admittedly a thin delta wing, but the term 'slender' usually is associated with thin low-drag wings and has been so interpreted by the searchers.

<u>DOCUMENT</u> P16338. An approximate method of calculating the laminar boundary layer on a delta wing. R.A.E. Tech. Note 2595.

<u>Assessment</u> 19 pages of text. R.A.E. Tech. Note 2595 plus 9 pages of figures. 9 line summary. The article concerns a method of calculating the laminar boundary layer on a delta wing, with assumed conical irrotational flow.

<u>FAILURES</u> Alphabetical. Facet.

<u>INDEXING</u>

<u>Main system</u> Uniterm.

<u>Assessment</u>

<u>U.D.C.</u>
A 532.526.2 Laminar boundary layer
B 533.693.31 Delta wings
AB : BA

Appears to cover the subject of the article adequately, even though only two entries have been made.

<u>ALPHA.</u>
WINGS, DELTA - Flow distribution
BOUNDARY LAYER, LAMINAR - Calculation
Summary as U.D.C.

<u>FACET</u>
Cd(Ij)Ncd Nfk Ya. Calculation: boundary layer: laminar flow: delta: wings.
Summary as U.D.C.

<u>UNITERM</u>

Calculation	Layers
Laminar	Triangular
Boundaries	Wings

<u>R.A.E. INDEXING</u> 532.526.2: 533.693.3 Laminar boundary layer. Delta wings. Same as the project indexer.

<u>ASSESSMENT OF SEARCHING</u>

<u>U.D.C.</u>
(1) A 533.693+ Wings, including all subdivisions
B 532.526 Boundary layer
BA No.
(2) A
B 532.526.2 Laminar boundary layer
BA Found at BA. 533.693.31

Document found at the second attempt because the searcher tried 532.526.2 : 533.693+ Therefore checking laminar boundary layer: wings of all types.

<u>ALPHA.</u>
(1) WINGS, LOW DRAG - Flow distribution. No.
(2) WINGS - Flow. No.
(3) BOUNDARY LAYERS. No.

Not found because the searcher tried Boundary layer and considered that to go through the whole section of Boundary layer, laminar and Boundary layer, turbulent, etc. would be unrealistic. As far as the question went, she made an adequate search.

FACET (1) Cd(Iv)Nfk (Classified catalogue) Boundary layer: Slender: Wings. No.
(2) Cd(Iv) (Classified catalogue) Slender: Wings. No.

Searcher tried whole section of Cd(Iv) Slender: Wings in the classified section. Considered any further search too involved but she should have gone to the chain index to see if Cd(Iv) were included with any type of aircraft, etc., higher up the schedules. Would not have traced the document.

UNITERM	Calculation	Layers
	Laminar	Triangular
	Boundaries	Wings

Considered a success, but as only Wings, Layer and Boundary came out, I do not think it really sufficient.

SUGGESTED RE-INDEXING

U.D.C. A 533.693 Wings B 532.526.2 Laminar boundary layer. Would still have been found at the second attempt.

ALPHA. WINGS, LOW DRAG - Flow distribution. Would have been found at first attempt.

FACET Cd(Iv)Nfk Boundary layer: Slender: Wings

UNITERM Slender.

COMMENTS

Time allowance 16 minutes allowance. 16 minutes taken.

General The document has been re-indexed above so that the term 'slender' has been included. In all fairness to the original indexer, I feel that it would not have been included by most people.

REASONS FOR FAILURE

In both cases, the misleading question. If the enquirer had been at the librarian's side when the search was made, the misunderstanding would have been cleared up.

Summary

ALPHA. Question

FACET Question

QUESTION 75-08 "Rate of shrinkage of phenolic-mineral moulding compounds at 125°C".

Assessment Fair question. Phenolic resins are specifically mentioned in the second paragraph.

DOCUMENT P17553. Plastics at high temperatures. Machine Design, April 16th 1959, pp 171-174.

Assessment One page of text plus three pages of charts. Discusses temperature effect on shrinkage of phenolic, melamine and polyester resins. The subheading 'Previously unpublished data on the shrinkage of thermo-setting molded plastics after thermal ageing', is in itself sufficient to enable the indexer to index the document accurately without further assessment.

FAILURES Alphabetical. Facet.

INDEXING

Main system Uniterm

Assessment

U.D.C.
A 678.5 Plastics
B 621-181 Dimensions
C 536.45 High temperature
ABC : ACB

The indexer has made permutations under Plastics only.

ALPHA.
PLASTICS - Temperature effect
PLASTICS - Dimensions. Temperature effect

Has indexed the same material as U.D.C.

FACET Ph Rab Ssb(Zqn)(Zb) Stability: high: temperature: plastics.
The same as U.D.C. and Alphabetical plus 'stability'.

UNITERM

Plastics	Stability
High	Dimensions
Temperature	Shrinkage

Has included the same aspects as Facet plus 'shrinkage'.

ASSESSMENT OF SEARCHING

U.D.C.
(1) A 678.632 Phenolic resins
B 620.192.52 Shrinkage
AB No.
(2) A 547.56 Phenols. No.
(3) A 678.632.32.21 Phenol formaldehyde. No.
(4) A 678.5 B 620.192.52 AB No.
(5) A 678.5 B 536.45 AB Yes.

The searcher found the document at the fifth attempt, after searching through 'Phenolic resins', 'Phenols', 'Phenol formaldehyde' (all next to each other in the alphabetical index). She then tried Plastics and shrinkage, finally plastics and high temperature, where the document was traced.

ALPHA. (1) PLASTICS - Forming. No.
(2) PLASTICS - Moulding. No.
(3) FORMING. No.
(4) MOULDS. No.

Inadequate. The searcher tried only the aspects of moulding and forming and ignored the reference to temperature in the question. At his third attempt he should have checked under PLASTICS - Temperature effect, which would have traced the document.

FACET (1) Phenolic plastics (chain index). No.
(2) Phenolic resins (chain index). No.
(3) Shrinkage (chain index). No.

The searcher tried 'Phenolic plastics', 'Phenolic resins' and 'Shrinkage'. I think he should have tried 'Plastics' plus 'Temperature' as his next search programme.

UNITERM	Moulding. No.	Shrinkage Yes
	Phenol. No.	High Yes
	Minerals. No.	Temperature Yes
	Plastics. Yes.	

Good. The searcher tried 'Plastics' after trying 'Phenolic', 'Mineral', 'Mouldings'.

SUGGESTED RE-INDEXING

U.D.C. A, B, C, as before plus D 620.192.52 Shrinkage
ACD : ADC : DAC

ALPHA. PLASTICS - Shrinkage

FACET Plus Ph Rji Ssb(Zqn) High: Temperature: Shrinkage: Plastics

UNITERM Unnecessary

COMMENTS

Time allowance 4 minutes allowance, but only 3 minutes taken. I feel that the indexer would have had time to add 'shrinkage' to U.D.C., Alphabetical and Facet. If he had done so, the document would have been a success with the Facet system.

General (1) What is the difference between phenolic resins and phenolic plastics ? In Facet, there is a place for each. Phyb and Pia respectively. Yet the article is on plastics, and refers to phenolic resins.

(2) Searching failure in Alphabetical, as the searcher tried only one of the three concepts shown in the question. Also, in Facet, because the searcher did not try 'Plastics' at all, but limited his search to 'Phenolic resins' and 'Phenolic plastics'.

(3) Indexing failure in Facet, because the indexer should (and had time to) have included 'Shrinkage'. If he had done so, the document would have been traced. The inclusion of 'shrinkage' in Alphabetical would have made no difference to the results, as the searcher did not try this aspect, although the word is included in the lists as a recognised subheading. There was provision for 'shrinkage' in all systems, but the indexer included it only under Uniterm.

REASONS FOR FAILURE

ALPHA. Searching

FACET (1) Searching (2) Indexing.

QUESTION 41-07 "Pilotless aircraft autostabilizer response to an impulsive pitching moment".

Assessment Appears a fair question, which should have enabled the document to be traced.

DOCUMENT P14116. A method of optimising aircraft autostabilizer systems. College of Aeronautics Report 113.

Assessment College of Aeronautics Report. 61 pages. Full report, but it is adequately summarized on the first half-page. In 16 minutes, the indexer should have been able to index sufficiently and accurately.

FAILURES U.D.C. Facet. Uniterm.

INDEXING

Main system Alphabetical.

Assessment

U.D.C.
A 533.6.013.4 Stability
B 518.12 Method of numerical calculation
C 533.694.5.001.1 Design of controls
CAB : AB.

Bad. Indexer indexed stability of control surfaces under aerodynamic section and ignored the aircraft engineering section which should have been indexed.

ALPHA.
STABILISERS - Application
STABILISERS - Design
AEROPLANES, PILOTLESS - Stability. Control
STABILITY - Control. Calculation
INTEGRALS - Solution
RESPONSE, TRANSIENT
STABILITY DERIVATIVES - Calculation

Adequate. Document found at first attempt under STABILISERS.

FACET Cp: Ob: Vbd: Yz. Calculation: Design: Stability: Control surfaces. The indexer indexed the stability of control surfaces only. Did not mention autopilots, pilotless aircraft which would have been sensible places.

UNITERM

Calculations	Systems
Stability	Equations
Optimum	Pilotless
Nonlinear	Pilots
Design	

As Facet.

ASSESSMENT OF SEARCHING

U.D.C.
1. A 629.13.014.59+ Automatic Pilots+ No.
2. A 629.135.27+ Pilotless aircraft+ No.
3. A 533.6.013.15 Pitching moments
   B 533.665 Aeroplanes
   AB+ No. BA+ No.
4. A 533.6.013.412 Longitudinal stability
   B 533.665 AB+ No.
5. A 533.6.013.412
   B 629.135.27 AB+ No.

Adequate.

ALPHA. STABILISERS. Found under subheading 'Application', at the first attempt.

FACET Bn Ewm Nub Pitching moments: Autopilots: Pilotless aircraft. Checked chain index under Pitching moments plus either Autopilots or Pilotless aircraft. No.

Bn Pilotless aircraft. Checked in classified section. No.

Ewm Autopilots+ Ob Stability. Checked in chain index under Stability + Autopilots. No.

Ewm Autopilots. Checked in classified section under Autopilots. No.

Adequate.

UNITERM	PITCHING	No	PILOTLESS	Yes
	MOMENT	No	AIRCRAFT	No
	STABILISERS	No	STABILITY	Yes
	AUTOMATIC	No	RESPONSE	No
	MISSILES	No		

Adequate.

SUGGESTED RE-INDEXING

U.D.C. D 629.13.014.59 Automatic pilots
E 629.135.27 Pilotless aircraft
D. E.

ALPHA. Adequately indexed. Perhaps plus PILOTS, AUTOMATIC. MOMENTS, PITCHING.

FACET Ewm Nub Autopilots: pitching moments
Bn Nub Ob Stability: pitching moments: pilotless aircraft.

UNITERM STABILISERS PITCHING
AUTOMATIC MOMENTS

COMMENTS

Time allowance 16 minutes, although the indexer took 19 minutes. Appears she spent too long on indexing the main system adequately and not enough time in the subsidiary system.

General I have noticed that, with all the indexers, there is a tendency in Uniterm to translate the words used in Facet (which is on the same side of the card), and to forget other terms used in U.D.C. and Alphabetical. Frequently a document has to be 'squeezed into' Facet in a rather unsatisfactory way. Indexing failure throughout. It appears that the indexer must have spent too much time in reading the document and indexing by the main system and too little time in the subsidiary systems.

REASONS FOR FAILURE

U.D.C. Indexing

FACET Indexing

UNITERM Indexing

QUESTION 56-07 "Value of model testing for predicting instability of structural elements".

Assessment Rather a vague question. Further information would have been asked for had the question been posed in a library. What structural elements particularly are meant ?

DOCUMENT P15606. Study of size effect in sheet-stringer panels.

Assessment NACA Technical Note. 8 pages of text, 20 pages of figures, tables and photographs. Good summary, but the emphasis in the report is on the effect the difference in size has upon calculations made in sheet stringer panel models. This emphasis appears to have been ignored by the indexer.

FAILURES U.D.C. Facet. Uniterm.

INDEXING

Main system U.D.C.

Assessment

U.D.C. A 669.715 [7075-T6] B 621.415 C 620.173
Ignored model testing and stringer panels but managed to include aluminium alloys [ ] .

ALPHA. Ignored the same subjects as U.D.C. PANELS and SHEETS are two separate headings which I think should be made one.

FACET Ignored the same subjects as U.D.C.

UNITERM Ignored the same subjects as U.D.C.

ASSESSMENT OF SEARCHING

U.D.C. Tried only analogies 530.17. Ignored 'structural elements' part of the question.

ALPHA. Searcher's train of thought led from MODELS, STRUCTURES to PANELS - Stability and PANELS, ALUMINIUM ALLOY to SHEETS, ALUMINIUM ALLOY.

FACET Searcher gave up without trying, or he said that the question was too general to be attempted with the Facet chain index.

UNITERM Adequate.

SUGGESTED RE-INDEXING

U.D.C. D 530.17 Analogies
E 629.13.012.723 (do not like this number but only place for Stringers)
DBA: BD: ED: DE

ALPHA. MODELS, STRUCTURAL

FACET Fbk Ffh(Zs)Rqg Vi Tests: compression: model: panels: stringer.

UNITERM MODELS
STRINGERS

COMMENTS

Time allowance 2 minutes only. Obviously influenced the indexer, but I feel that he should have realised the importance of the size effect.

General A difficult rather vague question for which to search. It should have been supplemented with further information. The importance of size effect should have been sufficiently indexed as it surely can be applied to different structural elements. Generally the indexer failed to bring out 'Model tests'.

REASONS FOR FAILURE

U.D.C. (1) Indexer
(2) Searcher
(3) Question

FACET (1) Searcher
(2) Question
(3) Indexer

UNITERM (1) Indexer
(2) Searcher
(3) Question

QUESTION 57-08 "Flexure torsion flutter characteristics of aerofoils".

Assessment Fair question which should have traced the document.

DOCUMENT P15724. Measurement of the derivative z_w for oscillating wings in cascade. College of Aeronautics Report 93.

Assessment College of Aeronautics Report. 14 pages of text and figures. Purpose of experiment to measure the damping derivative for rectangular wings in cascade. Describes the apparatus and methods of test.

FAILURES U.D.C. Alphabetical. Facet.

INDEXING

Main system Alphabetical.

Assessment

U.D.C. Bad. 534.14 Methods of exciting vibrations, used instead of 533.6.013.422 Flutter. Presumably careless due to lack of time. (2 minutes).

ALPHA. Fair indexing, but the use of WINGS, OSCILLATING and WINGS - Flutter is rather ambiguous. In this case the first was used when the second could have been used equally as well.

FACET Adequate.

UNITERM Adequate.

ASSESSMENT OF SEARCHING

U.D.C. Adequate. If document indexed correctly, should have been traced.

ALPHA. Inadequate. Searcher tried AEROFOILS only - did not try WINGS.

FACET Searcher gave up as too many entries in the chain index under Flutter and Wings.

UNITERM Found.

SUGGESTED RE-INDEXING

U.D.C. B and A 533.6.013.422
AB BA
Document would have been traced.

ALPHA. WINGS - Flutter. Better searching, document would have been found.

FACET Nothing to add.

UNITERM Nothing to add.

COMMENTS

Time allowance 2 minutes. Careless indexing in U.D.C. presumably due to this.

General

U.D.C. Indexing failure because of carelessness in finding the correct place for Oscillations.

ALPHA. Inadequate searching.

FACET Searching failure due to the multiplicity of entries in the chain index under Flutter and Wings.

REASONS FOR FAILURE

U.D.C.	Indexing
ALPHA	Searching
FACET	Searching

QUESTION 57-10 "High strength alloys".

Assessment General question, which would have brought out sufficient other documents to satisfy the enquirer if he were not able to give more details. Should also have traced the document indexed, if very general headings had been used. (Against our usual indexing procedure of indexing as specifically as possible). A too general question for a specific article.

DOCUMENT P15760. High strength aluminium casting alloy 40E DTD 5008, latest developments and foundry experience. Metallurgia, Vol. 55, Jan-June 1957, pp 79-85.

Assessment 6 pages from Metallurgia. The article is specifically on the method of melting, casting, moulding, application and properties of aluminium alloy 40E. Most of the article concerned with casting the alloy. Has a good summary.

FAILURES U.D.C. Alphabetical. Facet.

INDEXING

Main system Alphabetical.

Assessment

U.D.C.
A 669.715 (DTD 5008) Aluminium alloys (DTD 5008)
B 669.715 (40E) Aluminium alloys (40E)
C 621.746 Casting
AC : BC : CA : CB

Indexed under DTD number, 40E and casting. Fair. (On actually checking U.D.C., I find three more places in which this could have been placed:

1. 669.018.28 Casting alloys
2. 669.715-141 Sand cast aluminium alloys
3. 669.018.45 High strength alloys.

ALPHA.
ALLOYS, ALUMINIUM (DTD 5008) Casting
ALLOYS, ALUMINIUM (40E) Casting

As in U.D.C. there are two other possible places for entry:

1. ALLOYS, CASTING, ALUMINIUM
2. ALLOYS, HIGH TEMPERATURE

FACET
1. Peal-a (DTD 5008) Qb Casting: aluminium alloys (DTD 5008)
2. Peal-a (40E) Qb Casting: aluminium alloys (40E)

Found under Facet, but no more details entered. Searcher, who was also indexer, apparently had remembered indexing several articles in high strength aluminium alloys, and so she went to the classified section under Peal-a where she found document.

UNITERM		
	Alloys	400
	Aluminium	Casting
	500	DTD

ASSESSMENT OF SEARCHING

U.D.C. 669.018.45+ No. High temperature alloys.
Tried 669.018.45 only. Went as far as question stated, obviously expecting general article on high strength alloys.

ALPHA. ALLOYS, HIGH TEMPERATURE+ No.
ALLOYS + No.
MATERIALS, HEAT RESISTANT No.
The searcher tried the obvious headings.

FACET
1. Rp(Zqn) High: strength. Checked the chain index at strength and found four places with Rp(Zqn)+ either Pe-a (Alloys) or Pf (Steels) No.
2. Ssd (High temperature). Checked the chain index at (High temperature) + Pe-a (Alloys) and Pf (Steels). Too many to check. Searcher had a vague recollection of seeing articles on high strength aluminium alloys, therefore checked first, the cards with combination of Peal-a (Aluminium alloys) and Ssd (High temperature). Document found.

Found, because searcher knew she had indexed several articles on high strength aluminium alloys.

UNITERM	ALLOYS	Yes	STRENGTH	No
	ALUMINIUM	Yes	PROPERTIES	No

Went as far as question suggested.

SUGGESTED RE-INDEXING

U.D.C. D 669.018.45 Heat resistant alloys
CD

ALPHA. ALLOYS, HIGH TEMPERATURE

FACET Ssd, which is High Temperature to make indexing even with other systems, but actually could use Rp(Zqn) High: strength. Answer would be to index under both.

UNITERM STRENGTH
HIGH
TEMPERATURE

COMMENTS

Time allowance 2 minutes. In the time allowed, the indexer indexed the document adequately and specifically. Would have taken another 2-3 minutes to add the entries required to trace the document.

General
1. The variance between classification schemes shown. Very often the indexer is undecided whether to classify each document separately and specifically to the best of his ability with each scheme, or to give even indexing throughout by the use of the same terms. e.g. High strength alloys in U.D.C. go under High temperature alloys. The same with Alphabetical. Facet can be put under Rp(Zqn) meaning High: Strength: or under Ssd, High temperature to equal indexing with other systems. Uniterm - Ability to do either or both.

2. A general question prepared from a specific document which has been indexed specifically. The question would have been better answered by other documents, or a chapter in a general work on metallurgy.

3. Indexing insufficient. If entries had been made under High strength alloys throughout or where there is no place, 'high temperature alloys', the document would have been traced. Due to time control of 2 minutes.

REASONS FOR FAILURE

U.D.C.	(1)	Question
	(2)	Indexing
ALPHA.	(1)	Question
	(2)	Indexing
UNITERM	(1)	Question
	(2)	Indexing

QUESTION 75-06 "What are the aerodynamic characteristics of an 'arrow-wing' at high Mach numbers".

Assessment Misleading question. Mach 3 is not a high Mach number. 3 of the searchers checked the indexes under 'hypersonic' instead of 'supersonic'.

DOCUMENT P17501. Idealized wings and wing-bodies at a Mach number of 3. NACA TN.4361.

Assessment NACA Technical Note. As the first paragraph states, the purpose of the paper is to describe the theoretical possibilities for obtaining high lift-drag ratios at Mach 3 .... for delta, arrow wings, and wing-body combinations. No summary. 6 pages of text.

FAILURES U.D.C. Facet. Uniterm.

INDEXING

Main system Uniterm

Assessment

U.D.C.
A 533.693 Wings
B 533.685.12 Wing-body combinations
C 533.6.013.13 Lift
D 533.6.011.5 Supersonic flow
ACD : ADC : BCD : BDC

Would have been better to have indexed 533.693.34 (Arrowhead wings) 533.693.31 (Delta wings) but probably had no time.

ALPHA.
WINGS, SUPERSONIC - Lift-drag ratio
COMBINATIONS, WING-FUSELAGE, SUPERSONIC - Lift-drag ratio

Should also have indexed under arrowhead wings and delta wings.

FACET
1. Cc Cd Ea Nbk Nq Lift: supersonic flow: fuselages: wings: combinations
2. Cd Nbk Nq Lift: supersonic flow: wings

Should also have indexed under arrowhead wings and delta wings.

UNITERM

Wings	Supersonic
Bodies	Lift
Fuselage	Drag
Combinations	Ratios

Should also have indexed under arrowhead wings and delta wings.

ASSESSMENT OF SEARCHING

U.D.C.
1. A 533.693.34 Arrowhead wings
B 533.6.011.55 Hypersonic flow
AB No.
2. A No.

Adequate, although misled by high Mach numbers.

ALPHA.
WINGS, ARROWHEAD, SUPERSONIC - Aerodynamics. No.
WINGS, ARROWHEAD, No.
WINGS, HYPERSONIC. No.
WINGS, SUPERSONIC. Found at subheading Lift-drag ratio.

Should have been indexed under arrowhead wings and delta wings.

FACET Cd WINGS (Imd) ARROWHEAD
Cd (Imd)+ No.

Adequate, although ignored Nbm Hypersonic Flow.

UNITERM

ARROWHEAD	No	TRIANGULAR	No
WINGS	Yes	HYPERSONIC	No
AERODYNAMIC	No	CHARACTERISTICS	No

Adequate.

SUGGESTED RE-INDEXING

U.D.C. Instead of 533.693 should have
A 533.693.34 Arrowhead wings
E 533.693.31 Delta wings

Document would then have been found.

ALPHA. WINGS, ARROWHEAD, SUPERSONIC

FACET Cd(Imd)Nbk Nq Lift: supersonic flow: arrow: wings
Cd(Ij)Nbk Nq Lift: supersonic flow: delta: wings

UNITERM Arrowhead. Delta.

COMMENTS

Time allowance 4 minutes. Obviously the indexer felt that he had no time to index delta and arrowhead wings separately.

General Three concepts in the question: (1) Aerodynamic characteristics (general). (2) Arrow wings (specific). (3) High Mach numbers (specific).

1. Too general as article indexed specifically under 'lift'.
2. Specific - not mentioned by indexer.
3. Misleading - should have been 'supersonic'.

REASONS FOR FAILURE

1. Question. The searchers checked 'hypersonic', as the question refers to high Mach numbers.
2. Lack of indexing. If the indexer had indexed 'arrowhead' and 'delta', the documents would have been found in all cases.

Summary

U.D.C. (1) Question
(2) Indexing

FACET (1) Question
(2) Indexing

UNITERM (1) Question
(2) Indexing

QUESTION 78-08 "Required: equation for stresses and deflection produced by a single concentrated load (not at the centre) on a clamped circular plate".

Assessment On the surface, and in comparison to the title, this appears a misleading question but on reading the article, the theory of stresses in a circular plate is given at the beginning, followed by an extension to the theory for semi-circular plates.

DOCUMENT P17855. Displacements and stresses of a laterally loaded semicircular plate with clamped edges. Jnl. Applied Mech. Vol. 26, June 1959, pp 224-226.

Assessment As the title suggests, plus the theory on stresses in circular plates. A three page article, with approximately only one full page of text, the remainder being equations, tables and figures.

FAILURES Alphabetical. Facet. Uniterm.

INDEXING

Main system Facet.

Assessment

U.D.C. A 621-415 Plates
B 531.22 Stress analysis
AB

There is only one place for semicircular plates.

ALPHA. PLATES, SEMICIRCULAR - Stress analysis
Should have made entry under 'Plates, circular' too.

FACET Ffe(Iqb)Rm Xy Analysis: stresses: semicircular: plates.
Indexed 'semicircular' plates and ignored 'circular' plates.

UNITERM Displacement, Stresses, Semicircular, Plates, Analysis

As Facet.

ASSESSMENT OF SEARCHING

U.D.C. 1. 621-415 Plates
531.22+ Stress distribution
AB+ Found

ALPHA. 1. PLATES, CIRCULAR - Stresses No.
2. PLATES, CIRCULAR - Deflection No.

Adequate from question. No reason for the searcher to check under semi-circular plates.

FACET 1. Ffe Plates (Ipc)Circular Ffe(Ipc) No.
2. Fqd Discs. No.

Adequate from question. No reason for the searcher to check under semi-circular plates.

UNITERM	PLATES	Yes	DEFLECTION	No
	CIRCULAR	No	EQUATIONS	No
	FIXED	No	LOADS	No
	STRESSES	Yes		

Adequate from question. No reason for the searcher to check under semi-circular plates.

SUGGESTED RE-INDEXING

U.D.C. Not necessary

ALPHA. PLATES, CIRCULAR - Stress analogy

FACET Ffe(Ipc)Rm Xy Analysis: stresses: circular: plates

UNITERM CIRCULAR

COMMENTS

Time allowance 2 minutes. Obviously limited the indexer, but I feel that he might have had time for the extra entries.

General Presumably lack of time was the reason for the inadequate indexing although I feel that the indexer should have been able to include the above. Though perhaps he read only the title and indexed this. (Circular plates are mentioned in the summary too).

REASONS FOR FAILURE

ALPHA. Indexer

FACET Indexer

UNITERM Indexer

QUESTION 79-06 "Effect of Reynolds number on measurements of pitching moment at transonic speeds".

Assessment Appears to be a fair question, though one would expect a document generally on the methods of measuring pitching moments to be traced, rather than an article on the stability of a particular type of model aircraft. Normally an indexer is careful to index as completely as possible, including the type of wing, body, etc. with which the aerodynamic characteristics occur.

DOCUMENT P17912. Longitudinal stability and control characteristics of a semispan model of a supersonic airplane configuration at transonic speeds from tests by the NACA wing-flow method. NACA RM LG830.

Assessment A NACA RM. 8 pages of text with 22 pages of figures. A good, very detailed summary. The aeroplane model specified has a long fuselage, straight wing and tail of low aspect ratio with double-wedge aerofoils - 4.6% chord thickness. Describes apparatus and tests.

FAILURES U.D.C. Alphabetical. Uniterm.

INDEXING

Main system Uniterm.

Assessment

U.D.C.
A 533.6.013.412 Longitudinal stability
B 533.694.53 Longitudinal control
C 533.6.057 Wing flow method
D 533.6.011.35 Transonic flow
ACD : ADC : BCD : BDC : CAD : CBD

Has covered longitudinal stability and control in transonic flow and model tests (533.6.057) very well, but has ignored types of model, etc.

ALPHA.
CONTROL, LONGITUDINAL - Wing flow tests
STABILITY, LONGITUDINAL - Wing flow tests
WING FLOW TESTS

As U.D.C.

FACET
1. Nbj Oak Vi Tests: longitudinal control: transonic flow
2. Nbj Ocb Vi Tests: longitudinal stability: transonic flow

As U.D.C.

UNITERM

Longitudinal	Flows
Stability	Wings
Control	Tests
Transonic	

As U.D.C.

ASSESSMENT OF SEARCHING

U.D.C. 1.
A 533.6.013.15 Pitching moments
B 533.6.011.12 Reynolds number effect
C 533.6.011.35 Transonic flow
ABC No.

2. BA No.
3. A No.
4. B No.

Inadequate.

ALPHA.
1. REYNOLDS NUMBER No.
2. MOMENTS, PITCHING No.
3. WINGS - Moments, pitching No.
(a) WINGS, TRANSONIC - Moments, pitching No.

Inadequate.

FACET
1. Nbj Njm Nub Pitching moments: Reynolds number: Transonic flow.
2. Nbj Ocb Found. Longitudinal stability: Transonic flow.

Found because searcher thought of trying 'longitudinal stability', which is the next logical step from 'pitching moments'.

UNITERM				
	REYNOLDS	No	MOMENTS	No
	NUMBER	No	TRANSONIC	Yes
	MEASUREMENT	No	FLOW	Yes
	PITCHING	No	AERODYNAMICS	No

Found. As Facet.

SUGGESTED RE-INDEXING

General Not necessary to re-index for the form of question, as it should have been found by the searcher. Would take too long to index adequately the whole of the document.

COMMENTS

Time allowance 2 minutes which I think for the question in adequate. If the indexer had been allowed any more time he would probably have indexed in much more detail and omitted the general headings he made.

General In this case, I feel the time allowance was sufficient to enable the document to be traced from the question. A general question for a specific paper. Searching failure throughout. The searchers should have tried 'longitudinal stability' and if they had done so they would have traced the document without any trouble.

REASONS FOR FAILURE

U.D.C. Searching

ALPHA. Searching

UNITERM Searching

QUESTION 30-06 "What is the average decrease in gas consumption per horse power hour for reciprocating engines in the course of their history".

Assessment A fair question on the surface. Yet, after reading the paper (15 minutes) I found a single sentence upon which the question is based. "It must be remembered that the gas consumption of reciprocating engines used to be 1/10 of a gallon per horse power hour which amounted to about 0.6 lb. per h.p. hour and yet today this has been reduced to almost half this figure". This information is certainly not sufficiently exact to satisfy the questioner. A 'trick' question.

DOCUMENT P13059. The Economics of large aircraft. Aero. Eng. Review, Vol. 15, April 1956, pp 48-55.

Assessment 7 pages in length. An article about the history of flying boats, present and future uses, together with costs, capabilities, fuel consumption, etc. A quite detailed, meaty article, with the single sentence upon which the question is based tucked away on page 6.

FAILURES U.D.C. Alphabetical. Facet. Uniterm.

INDEXING

Main system Facet.

Assessment

U.D.C. A 533.655.2.001.1 Design of float seaplanes
B 629.135.52.001.1 Design of flying boats
A : B

He should have made entries under the economics of flying boats, etc. This would not have traced the document, but it would have been better indexing.

ALPHA. FLYING, BOATS - Design
AEROPLANES, TRANSPORT - Design

Assessment as U.D.C.

FACET (1) B(Abd)Vbd Design: cargo: aircraft
(2) Bef Vbd Design: flying boats
(3) B(Aba)Vbd Design: transport: aircraft

Assessment as U.D.C.

UNITERM Design, Flying boats, Transports, Aircraft, Freight, Weight, Payload

Assessment as U.D.C.

ASSESSMENT OF SEARCHING

U.D.C. A 621.43.018.35 Fuel consumption
B 629.13.055.7 Fuel consumption meters
C 621.432 Piston engines
(1) A - No
(2) B - No
(3) C - No

Adequate searching.

ALPHA. (1) Engines, piston - No
(2) Fuels - No
(3) Fuel consumption - No

Adequate searching.

FACET (1) Gb Piston engines - No
(2) Gc Piston engines, by cycle - No
(3) Gdg Radial engines - No

Adequate searching.

UNITERM Engines - No
Reciprocating - No
Piston - No
Aeroplanes - No
Petrol - No
Consumption - No
Life - No

Adequate searching.

SUGGESTED RE-INDEXING

U.D.C.)
ALPHA.)
FACET)
UNITERM) Could not re-index to trace document without being completely unfair to the indexer.

COMMENTS

Time allowance 8 minutes. Could not possibly have indexed information at all unless he did word by word indexing.

General A 'trick' question. Obviously the questioner was determined to find a part of the paper that would not have been indexed.

REASONS FOR FAILURE

Mean question on material that could not have been indexed without spending all day on one article.

Summary

U.D.C.	Question
ALPHA.	Question
FACET	Question
UNITERM	Question

QUESTION 44-10 "Cooling the engine in high speed flight".

Assessment On the surface, and when searching, the question appeared to be too vague. One wanted to know what type of engine was meant. However, the article is about the use of fuel in any type of supersonic engine and so one can see why the question was thus phrased.

DOCUMENT P14478. Fuel systems for supersonic engines. Royal Aero. Soc. Jnl. Vol. 60, 1958, pp 654-658.

Assessment An article is about fuel systems, and the control and use of fuel for cooling supersonic engines. It is a full article which would take ten minutes to read carefully. There is a good introduction, which adequately summarizes the contents and in this introduction the use of fuel for cooling purposes is mentioned. Injection methods are mentioned, and graphs of fuel temperature at different altitudes are given.

FAILURES U.D.C. Alphabetical. Facet. Uniterm.

INDEXING

Main system U.D.C.

Assessment

U.D.C. A 629.13.012.525 Fuel systems, aircraft structures.
Incorrect. Caused by bad printing in the alphabetical index. Should have added 3.

B 621.43.032 Fuel systems, heat engines
C 629.13.072.2 High speed aircraft
AC : BC : CA : CB

No mention of cooling or engines in general.

ALPHA. Only entry FUEL SYSTEMS - Design.
Inadequate.

FACET Gn Vbd Design. Fuel systems
Inadequate.

UNITERM DESIGN ENGINES
FUELS DEVELOPMENT
SYSTEMS INJECTION-ORS
SUPERSONIC

Inadequate.

ASSESSMENT OF SEARCHING

U.D.C. (1) A 621.438 Gas turbine engines
B 621-71+ Cooling
AB - No
(2) C 621.438.086.4 Ducted fan engines
CB - No
(3) D 621.438.085.5 Free turbine engines
DB - No
(4) E 621.438.084 Jet engines
EB - No
(5) F 621.438.086.2 Propjet engines
FB - No

(6) G 621.439.2 Pulsejet engines
GB - No
(7) H 621.439.4 Ramjet engines
HB

Adequate searching from the information obtained from the question.

ALPHA.	(1) ENGINES, GAS TURBINE - Cooling	No
	(2) ENGINES, ROCKET - Cooling	No
	(3) ENGINES - Cooling	No
	(4) ENGINES, RAMJET - Cooling	No
	(5) COOLING SYSTEMS	No

Adequate searching from the information obtained from the question.

FACET (1) Nbm Stc Cooling: Hypersonc flow. Checking in the chain index under Cooling. No entry.
(2) Stc Cooling. 22 places - No.
(3) Gt Cooling systems - No.

Adequate searching from the information obtained from the question.

UNITERM	Cooling	No	Flight	No
	Engines	Yes	Supersonic	Yes

Adequate searching from the information obtained from the question.

SUGGESTED RE-INDEXING

U.D.C. A 621.438 Gas turbine engines
B 621-71 Cooling
AB : BA

ALPHA. ENGINES - Cooling
COOLING SYSTEMS

FACET Ga Stc Cooling: Engines

UNITERM Cooling

COMMENTS

Time allowance 12 minutes. In this time, I think the indexer should have covered the use of fuel for cooling purposes.

General The indexer obviously felt that the question asked from this document would be covered by entries under 'Fuel systems' only and ignored the possibility of entry under methods of cooling the engines.

REASONS FOR FAILURE

Fault of the indexer entirely. She had time to index this particular aspect of the paper, although if she had indexed other aspects, such as flow rate of fuels, temperature of fuel, etc., all of which are dealt with in the paper, she would have spent approximately 20 minutes in indexing.

Summary

U.D.C.	Indexing
ALPHA.	Indexing
FACET	Indexing
UNITERM	Indexing

QUESTION 57-09 "Influence of human engineering (pilot) factors in forecasting of load spectrum (load statistics) of aeroplanes".

Assessment Quite a fair question which was lifted from the last sentence of the half-page summary.

DOCUMENT P15744. Some aspects of prediction of load spectrum for airplanes. AGARD Report No. 106.

Assessment This is not about aerodynamic loads, as the indexer has implied, (probably due to lack of time (2 mins.) in which to assimilate a 50 page document), but about load spectrum and fluctuations. It has taken 10 minutes to read the introduction, main headings, conclusions and one or two other necessary sections to clear this matter up. A full and detailed report.

FAILURES U.D.C. Alphabetical. Facet. Uniterm.

INDEXING

Main system Alphabetical.

Assessment

U.D.C.
A 533.69.048.1 Aerodynamic loads
B 519.2 Statistics
C 629.13.012 Aircraft structures
CAB : ACB

Should not have used 533.69.048.1 Aerodynamic loads.

ALPHA.
STRUCTURES, AIRCRAFT - Loads, aerodynamic
STRUCTURES, AIRCRAFT - Loads, manoeuvring
LOADS, AERODYNAMIC - Statistical analysis

Should not have used 'Loads, aerodynamic' but 'Loads, manoeuvring' was quite in order.

FACET C Npb Yd Analysis (math.): Aerodynamic loads: Aircraft structures. Npb also incorrect.

UNITERM Loads: Aircraft: Structures: Spectrum: Calculations. Missed 'Aerodynamic' out for some reason, but added 'spectrum', therefore should have been found.

AGARD INDEXING 629.13.012 Aircraft structures.

ASSESSMENT OF SEARCHING

U.D.C.
A 624.042 Calculation of loads
B 611 Human engineering
C 629.13.012 Aircraft structures
D 624.046 Permissible loads
(1) AB - No. (2) B - No. (3) CAB - No. (4) D - No.

Good - if the document had been indexed properly, it would have been found.

ALPHA.
(1) HUMAN ENGINEERING - No.
(2) AEROPLANES - Loads - No.

Bad - if it had been searched for adequately, under STRUCTURES, AIRCRAFT-Loads, it would have been found.

FACET	(1) Mup Pilots (in chain index). 11 searches - No.			
	(2) Zz (Human engineering) - No.			

Bad - concentrated on human engineering - ignored all other aspects.

UNITERM	PILOTS	No	STATISTICS	No
	HUMAN	No	AIRCRAFT	Yes
	LOADS	Yes		

Bad - should have tried 'spectrum' and 'calculations' and document would have been found.

SUGGESTED RE-INDEXING

U.D.C.
A 629.13.012 Aircraft structures
B 624.040 Loads, permissible (not happy about this number, but appears to be the best place)
C 611
AB : BA : CAB : BAC : ABC

ALPHA.
STRUCTURES, AIRCRAFT - Loads
HUMAN ENGINEERING

FACET
C Rq Yn Statistics: Loading: Aircraft structures

UNITERM
HUMAN
ENGINEERING

COMMENTS

Time allowance 2 minutes - only allowing time to read the title and index. This is a 40 page report. Although the indexer made a mistake in assuming ' load spectrum' referred to aerodynamic loads, this would have probably been corrected if more time had been allowed for indexing.

General Without touching on the pilot factor in the question, this document would have been found for reasons below. To index it to include the pilot factor would have taken approximately 20 minutes, as one would have included manoeuvre of aircraft, stresses in structures, military transport, etc.

REASONS FOR FAILURE

A combination of bad indexing, which shows up particularly in U.D.C. and Facet and bad searching, in Alphabetical and Uniterm. The document would have been found under these last two systems if the searcher had been thorough enough, but would not have been found in U.D.C. or Facet because of the incorrect indexing.

Summary

U.D.C.	Indexing	
ALPHA.	(1) Searching	(2) Indexing
FACET	Indexing	
UNITERM	(1) Searching	(2) Indexing

QUESTION 21-08 "Comparison of calculated and experimental performance of an axial compressor stage having constant stator inlet air angle of 50% reaction at mean stage radius".

Assessment A detailed question, which if the document were indexed and searched for adequately, would give the required document.

DOCUMENT P12136. The design and testing of an axial compressor having a mean stage temperature rise of 30°C. N.G.T.E. Report 148.

Assessment N.G.T.E. Report with 11 pages of text and 12 pages of figures. A half-page summary. The report describes a compressor designed to give a mean stage temperature rise of 30°C. Details of the six stage characteristics are given. A full description of the design of the compressor, performance and testing are given.

FAILURES Alphabetical

INDEXING

Main system Alphabetical

Assessment

U.D.C.
A 621.438.031.3 Axial compressors
B 533.69.048.2 Pressure distribution
C 536.5 Temperature
D 621.438.031.3.018.5 Performance of axial compressors

D : AB : BA : AC : CA. Covered the performance of axial compressors with 621.438.031.3.018.5 also pressure distribution, temperature and axial compressors at 621.438.031.3.

ALPHA. COMPRESSORS, AXIAL - Pressure distribution. Tests.
COMPRESSORS, AXIAL - Temperature. Tests.

An important implication of the paper is the design of the axial compressors. If an entry had been made under COMPRESSORS, AXIAL - Design, the document would have been found at the second attempt. Also 'performance' should have been included as a subheading.

FACET Gf Gwd Gyb Ssb(Zdb)Vi Tests: rise: temperature: six-stage: axial flow compressors: gas turbine engines. Ignored 'design' of axial flow compressors. Also went up to Gf Gas turbine engines. I do not think this essential.

UNITERM

Tests	Compressors
Temperature	600
Rise	Blowdown
Engines	Performance
Gases	Design
Turbines	Pressure
Axial	Distribution
	Blades

Adequate.

ASSESSMENT OF SEARCHING

U.D.C. Good; the searcher tried 'Performance of compressors' at 621.438.031.3.018.5 and traced the document immediately.

ALPHA. Good; the searcher used the same search programme as U.D.C. but drew a blank. She then tried 'Compressors - Design' and finally the whole section under INTAKES. She did not try the complete section - COMPRESSORS, AXIAL as she thought that either of the two subheadings already tried should have traced the document. Also there would be over 150 cards to check.

FACET The searcher tried 'Axial flow compressors' whole section of 150, and then looked in the chain index. Document was traced under Gf Gwd plus 16. I think that he should have insisted upon some qualification before checking under whole section.

UNITERM Found under 'Compressors: Axial: Performance: Stages'.

SUGGESTED RE-INDEXING

U.D.C. Unnecessary.

ALPHA. COMPRESSORS, AXIAL - Performance
COMPRESSORS, AXIAL - Design

FACET Gf Gwd Gyb Vbd Design: Six-stage: Axial-flow compressors: Gas turbine engines.

There is no placing for 'Performance' in Facet, other than the section referring to performance of aircraft.

UNITERM Unnecessary.

COMMENTS

Time allowance 16 minutes allowance. 17 minutes taken. In this time, I feel that the document should have been indexed in more detail in Alphabetical. The indexer should have had time to equate the entries in each system. (It is impossible to enter 'Stages' in Alphabetical or U.D.C., as there is no suitable place).

General

(1) Although Alphabetical was the main system, the indexer included more in his U.D.C. entries. If he had covered the same, i.e. by the addition of the sub-heading 'Performance' in Alphabetical, the document would have been traced at the first attempt.

(2) The searcher in Facet checked the whole section in the classified catalogue under Axial flow compressors at Gwd, although the searcher in Alphabetical would not try the general heading COMPRESSORS, AXIAL, as she considered it should have been traced under the subheadings chosen.

REASONS FOR FAILURE

ALPHA. Indexing.

APPENDIX 6A

LETTER TO THOSE ASSISTING IN COMPILATION OF BIBLIOGRAPHIES

We have recently sent to you a copy of the interim report on the test programme of the investigation into the comparative efficiency of indexing systems. As is discussed in Section 5 of this report, we wish to test the basic test programme. The purpose of doing this is to attempt to discover whether the methods used in the basic test programme have any factors which unduly influence the results that have been obtained.

The supplementary test procedure which has been devised to do this is of a kind for which we are again seeking co-operation of those interested in the project. One hundred questions have been selected from those which were originally prepared for the basic test programme. We are sending to you and to all those whom we hope might be willing to help, five of these questions, and would ask you to prepare lists of references to all documents that might conceivably be of use to anyone requiring information on these questions.

When these lists are returned to us, we will check them against the documents that have been indexed during the project, and hope that we shall have for each question one or more references to documents which have been indexed. Such documents will be submitted to a subject specialist, who will be asked to review them and decide which are relevant to the question, at the same time denoting the degree of relevance in a scale from 0 to 4. We shall then search in the catalogues with these questions and the objects of the search will be those documents which the subject specialist considers to have some relevance. This method of testing will differ from our original method in that the language of the document will not be tied in to the language of the question, and in that we shall not know how many references should be retrieved. It may be that there will be no other relevant documents or possibly, for a general question, there may be one hundred or more.

It will not only be a measure of the success of each search as to the retrieval of relevant documents but also the non-retrieval of documents which have been adjudged irrelevant. Therefore we ask those compiling the original lists not to be too selective; in other words we do not ask you to ensure that every document included in the list is definitely relevant to the question. It is sufficient if, from the title, it appears to deal with the subject.

If you are willing to help, I would add the following points:-

1. Do <u>not</u> include in your lists any documents published prior to 1952 or after February, 1960.

2. Do <u>not</u> include any documents that have any security restriction.

3. Do <u>not</u> include any documents that are not written in English.

4. Please <u>do</u> include in the list all reference (with the exceptions given above) that you can locate by any means; in other words, they shall not

only include entries from the index which you yourself might compile, but also from any published abstracts, annual indexes, other bibliographies, etc.

5. It is unnecessary to quote in the lists anything more than the source references and the author, e.g.

NACA TN. 3765 by Wong
Jnl. Aero/Space Sciences, 1956,
pp 16-22 by Griffith.

We have an index filed according to sources and authors, and can therefore easily find by this method whether any documents have been included in the project indexes.

I can assure you that the assistance which you have already given to us has proved of value; if you are able to undertake this additional task, we shall be equally grateful. If you do not think that you can spare the time, please could you let me know as soon as possible so that the questions may be redirected to somebody else. If, however, you are able to help, I should be grateful if you could return the lists to me by the end of January, 1961.

PQ 71 Panel flutter analysis.

PQ 72 Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading.

PQ 73 Effect of shear lag on transverse oscillations of thin-walled cylindrical beams.

PQ 74 Vibrations in 45° delta wings - deflectional behaviour under static tests.

PQ 75 Types of failures of pressure cabins.

APPENDIX 7A

ANALYSIS OF RESULTS OF TEST ON ENGLISH ELECTRIC FACET CATALOGUE

The reasons for failure have been divided into four main sections as follows:-

1. Question
2. Indexing
3. Searching
4. System

Within each section there are a number of sub-divisions which in the main correspond to those used for the analysis of the test of the Aslib Cranfield Project, but it has not been necessary to use all these sub-divisions. However, some new sub-divisions have been added to cover reasons for failure applicable only to the English Electric tests. In many cases the reason for failure to find a particular document can be traced to two or three causes, and therefore the analysis will show the same failure coming up under different headings.

The first part of this appendix is a summary of the analyses grouped according to the main reasons for failure and it is followed by a few examples of the detailed analysis.

PART 1. SUMMARY OF REASONS FOR FAILURE

1. QUESTION

Too detailed.

34. This one search failed because the question was too detailed to enable a reasonable search to be made. The article dealt with friction and wear occuring in nickel-alloy solid lubricant systems which the indexer placed at Lcd (Solid lubricants). The question, however, required specific properties of graphite, and the searcher insisted upon "graphite" as an essential concept.

Misleading.

64. With a document entitled "Commutator:Logimag" which was written in French, with a brief abstract in English, the questioner required information on the application of magnetic logical elements to the automatic control of machinery. As the question was phrased, the searcher, after trying "automatic control" and "logical elements",

gave up the search, presuming the document would be indexed under the automatic control of a particular type of machine. In fact, it was indexed at Hq "Commutator" only.

183. With a question requiring information on contamination produced by fast bursts in gas circuits of graphite reactions, the searcher presumed that information on failure of gas circuits was required. As she concentrated on this aspect, the document was not traced. It actually concerned burst cartridges in fuel systems, and had been indexed as such.

189. With a question, "Is it possible adequately to grain refine high purity uranium?", one of the searchers was unable to trace the document, as he insisted on the concept "uranium". Actually the document was about uranium alloys, and had been indexed under Nud.

2. INDEXING

Insufficient indexing

5. With a document on the Happurg Pumped Storage System, which gave details of the electrical equipment, the indexer made a single entry under

Bpmp 43 - (Germany) Pumped storage power systems.

The indexer should have realised that the document would be useful as a description of the particular types of electrical equipment used.

7. With a document on the low-energy neutron cross section of U235 and PU239, the indexer made an entry under Plutonium (239) but did not make an entry under Uranium (235), although each was of equal importance in the article.

9. With an article entitled "A double-delay line linear amplifier employing transistors", the indexer made one entry only, under Zmh 66: Amplifiers, Scintillation counters. Had he considered the concept "transistors", and made an entry under that, the document would have been traced.

20. A document entitled "Stress analysis in the presence of creep", was actually a review of literature. As such, it is obvious that any too specific placing would be unrealistic, but the three entries made by the indexer were not adequate. He treated the three concepts "Stress analysis", "Creep" and "Bibliographies", but did not combine

the first two.
As the question required information on the creep deformation of components under multiaxial stresses, the searcher insisted on more than a single concept. Thus the document remained untraced.
36. With an article entitled "Some elastic and thermal properties of zirconium and tungsten", the indexer ignored the concept of "elasticity", which should have been included in the indexing. As the searcher checked all material in the chain index under "Elasticity", which also included metals of any type, the document would have been traced if "elasticity" had been included.
54. With an article entitled "A double deck resistance strain gauge", which included information on the particular application for the measurement of bending strain on the outside surface of a structure, the indexer's entry under Zgb (Strain gauges) is insufficient. Had the indexer indexed the concepts "bending stresses", and "plates", the document would have been traced.
60. With an article entitled "Cross stresses in the laminar flow of liquids", the main body was concerned with cross-elasticity effects observed on an instrument consisting of circular metal plates, one stationary and one rotating. The single entry under Qe (Laminar flow) was inadequate.
Had the indexer included the concept of "elasticity", the document would have been found by one of the searchers.
From the last sentence of the summary, the concept of "fluid bearings" was implied. This also, was ignored by the indexer. Had an entry also been made under this concept, the document would have been found under the search programmes of the other searcher.
74. In an article on the internal friction of germanium and silicon, the indexer made an entry under "Internal friction: silicon", but did not make a similar entry for germanium, although they were of equal importance.
78. In an article on the thermal and electrical properties of Armco iron at high temperatures, there was, presumably, reference to the application of the electrical properties of iron in the generation of electricity. This was not indexed but was used by one of the searchers. This omission was not entirely the cause of the failure, as, by searching

in another two concepts, the document could have been traced.

81. In a document entitled "A practical standard transistorized optimum response controller", particular reference is made to the feedback circuits of non-linear control systems. The indexer made a single entry:

Xge lg Transistors: Feedback control systems

Had he made an entry under "Non-linear control systems", the document would have been traced by the third programme of the searcher who failed.

85. An article describing probes for the measurement of pressure, yaw angle, temperature, etc., of operating axial compressors and turbines was inadequately indexed. Even if the indexer was short of time, he should have made an entry at Dh Zfg (Flow measuring instruments: Gas turbines) rather than at Dh Zfr (Pitot tubes: Gas turbines). Such an entry would have enabled both searchers to trace the document.

108. A document on the cooling of an SR 5(V) air receiver was adequately indexed as far as the main body of the report went. However, an important appendix gave a method of calculation of the rate of cooling by convection, radiation and conduction of a vessel containing a gas, from which the question was obviously taken. Had entries been made under these concepts, the document would have been traced by both searchers.

118. In a report on induction induced swirl in a 'U' engine parallel valve combustion chamber, the design of a lip to produce the maximum swirl with the minimum pressure drop is described. The only entry made by the indexer was:

De Jf Qk Swirl: cylinders: diesel engines.

If the indexer had made an entry under "pressure drop", the document would have been traced at the first attempt by the Project staff, and at the third attempt of English Electric staff.

129. In an article on Deuce programme 500/3 for the optimum design of guide-vanes, the only entry made was under Dd Jeg (Guide vanes: Hydraulic turbines). The concept of "Deuce programming" was ignored. As the question required information on Deuce programmes for designing blades, etc. (almost an exact correlation of the title), both

searchers insisted upon the concept of "Deuce computer". With adequate indexing, the document would have been traced by both searchers.

134. With an article assessing the relative performance of various types of no-load voltage breakdown tests, one of the conditions of test is that of compressed air. Had this concept been included in the indexer's entry, the document would have been traced, as the concept was one of those given in the question.

158. In an article on the metallographic preparation of beryllium, titanium and refractory materials, palladium was mentioned as one of the refractory materials. Presumably the indexer did not have time to mention each metal discussed in the paper.
The only two entries made were:

1. Nbe Xul Etching: beryllium
2. Nti Xul Etching: titanium

The other metals mentioned in the report were entirely ignored. Had the indexer, instead of making these two entries, simply made a general entry under Xul (Etching) the subject of the document would have been more adequately covered. Also, the two searches would have been successful.

160. In a report on the relationship between weldability and transformation characteristics in the welding of medium carbon low alloy steels, the indexer did not index the concept "transformation". His only entry was:

Nse Pdk Weldability: medium carbon steel

As the question referred to the transformation characteristics of ferritic steels, neither concept was indexed, therefore the document remained untraced.

<u>Incorrect indexing</u>

25. In a paper describing the spectrographic analysis of beryllium in air, the indexer placed the document under the sample of beryllium in polyesters. Had a correct entry been made under "Spectrographic analysis" the document would have been traced.

80. In a document on the machining of titanium alloys the indexer made an entry under "Cutting: Machining: Titanium". A correct entry would have traced the document.

123. In an article describing induction motors used in rolling mills, the indexer made an entry under Be-ve Rolling with A.C. motors, instead of Beb-ve Rolling with induction motors.

<u>Lack of entry, or incorrect entry in the chain index</u>

8. In an article on designing silicon diodes and gates, the indexer made an entry under Gf If Semiconductor diodes: switching circuits, but the equivalent card under "Semiconductor diodes", was not included in the chain index.

16. With a document on the cathodic protection of zirconium, the indexer made the correct entry in the classified catalogue, but no card was filed in the chain index.

39. An inaccurate cross-reference, to "Diffusion: hydrogen", instead of "Hydrogen: diffusion" was the cause of a failure.

74. In an article on internal friction in semiconductors, the correct entry was made in the classified catalogue, but no cards were filed under "internal friction" in the chain index.

111. The indexer classified an article correctly under Ig Qsf Xf Measurement: Thermal conductivity: Transistors, but the card reading "Thermal conductivity: Transistors", was not in its correct place in the chain index.

177. With a document classified at Amp Wd Economics: Atomic power, the equivalent card was missing from the chain index, hence the failure.

<u>Lack of cross references</u> (* denotes "see also" reference required)

3. A question on organic cooled deuterium moderated reactors failed because the searcher did not find his way to the entry in the chain index under "heavy water". Had there been a reference from deuterium to heavy water, the document would have been traced.

30. A question on the analysis of variance failed because the searcher did not check under this heading, but under "variance". A cross reference to "statistics", from "variance, analysis of" would have enabled the document to be traced. (There actually was already a cross reference from "analysis of variance" to "statistics").

51. In a question on the micro-analysis of weld metal constituents, the searcher failed to find the correct place in the chain index. A

reference from "micro-analysis" to "X-ray fluorescent spectroscopy" would have helped the searcher.

*78. With a question on the thermal properties of iron, the searcher did not find his way to the correct entry under "Thermal conductivity". A see also reference from "thermal properties" to "thermal conductivity" should have enabled the document to be traced.

*98. If there had been a see also reference from "wear" to "adhesive wear" (and the other subdivisions of wear) in the chain index, a document based on the wear of metals should have been traced by both searchers.

*105. As 182 - a failure because there was no see also reference under "Bradwell" in the chain index, to Dkcq carbon dioxide graphite reaction.

149. With a question on the creep strength of ATR, one searcher failed to trace the document because there was no entry in the chain index reading ATR see Zirconium-copper-molybdenum alloys.

*160. A question on the transformation characteristics of ferritic steels failed because the searcher was not able to find his way to the entry "medium carbon steels" in the chain index, under which the document was filed.
A see also reference from "ferritic steels" to "medium carbon steels" would have helped the searcher.

180. With a question on the determination of neutron flux fine structure, the searcher checked under "flux fine structure", but found no entry. There was an entry under "fine flux, structure" with a cross reference to "thermic utilisation", which she failed to find.
A cross reference from "flux fine structure" to "thermic utilisation", would have helped to trace the document.

*182. With a question on the Calder Reactor, the searcher checked under Dk (Calder Hall) in the classified catalogue, (after checking in the chain index), and presumed that she had found all material on the reactor. However, there were other entries under carbon dioxide graphite reactors at Dkcq.
A see also reference to this section would have implied that not all material was at the Dk notation.

*191. In a question on iodine filtration units, the searcher did not find her way from "Iodine" to "Iodine isotopes". A see also reference would have helped.

Also, in the same question, a see also reference from "filtration units" to "radio-active waste plant" would have helped another approach.

Clerical error

7. Although the searcher found her way to a card reading Npu(239)Sbh Ie rf wg in the chain index, she failed to find the document because Ie should have read Ic.

53. Again both of the searchers found a card in the chain index reading Hg Hwd Ie Ij Rwl, which should have read Rcl. Without this inaccuracy the document would have been traced.

109. Both searchers traced a card in the chain index reading Hg Kce Maie Lj, which should have read Hq Kce Maie Lj. With the correct entry, the document would have been traced.

Inadequate guiding of the classified catalogue

2. With a question on underground steam power stations, the searcher found his way to Bpd Steam power stations, but was not led to the required subdivision, Bpdasn Underground steam power stations. If there had been adequate guiding to this point, the searcher should have been able to find the document.

3. SEARCHING

Lack of understanding, including those search programmes in which the words of the question only were used

54. In a question on a method of determining bending stresses on a flat plate with access to one side only, one of the searchers failed to realise that a possible instrument for measuring such stresses was a strain gauge. Had he checked under this concept, the document would have been traced.

83. With a question "Inaccuracies in electron diffraction work using the electron microscope", one of the searchers checked by material under Zdt Electron microscopes, rather than under electron microscopy, at Xulme, where the document was filed.

113. With a question on a computer method of calculating various moments of a flyweight for a turbine or diesel engine governor, the searcher checked under "computers", but did not think further to

to computer programmes. Had he done so, the document would have been traced.

134. With a question "If two open contacts are situated in compressed air, is the electrical breakdown dependent mainly on the peak value of an alternating voltage ......", the searcher failed to check under interrupted air blast circuit breakers, through lack of subject knowledge.

183. With a question on fast bursts in gas circuits of carbon dioxide graphite reactors, the searcher from the Project Staff checked under failures in gas circuits and was unsuccessful. The searcher from English Electric realised that the question implied failure of cartridge cases in fuel elements.

<u>Failure to use all the concepts in the question</u>

3. With a question on organic cooled deuterium moderated reactors, both searchers ignored the concept "cooled". Had they checked under "organic coolants", the document would have been traced.

5. From a question on voltage regulators in pump storage schemes, one of the searchers checked only under the concept "voltage regulators", and ignored "pump storage". Had he checked under this concept, he would have been led to pump storage power stations at Bpmp, where the document was filed.

7. From a question on the neutron cross section of U235 and PU239, the searcher failed to check under either Uranium or Plutonium, the second programme of which would have traced the document.

78. From a rather detailed question, which included the aspect of direct generation of electricity by recycling iron, the searcher did not check under electrical properties of iron, under which the document was filed.

84. With a question on the estimation of sulphide inclusion content in steel, one of the searchers concentrated his search on sulphur and sulphide, and ignored the other two concepts (one implied) of non-metallic inclusions, and steel, from which he would have traced the document.

118. From a question on air swirl, pressure drop and flow rates in diesel engines, the searcher failed to use the concept "swirl",

which would have led him directly to the required document.

123. From a rather lengthy question on waveforms of rectifiers and alternators, and their effect on induction motors, the searcher did not use the concept "induction motors". (Actually, the document was inaccurately indexed also, but a search programme via "induction motors", would be necessary).

129. With a question on Deuce programmes for designing blades when subjected to pressure loading, the searchers ignored the concept of guide vanes (mentioned in the question.). This however would have involved a lengthy search.

159. With a question phrased thus "What happens when mixtures of $Fe_2 O_3$ and $Cr_2 O_3$ are heated together?", one of the searchers failed to check under either ferrous or chromium oxides, but searched under mixtures only.

189. With a question on the grain refining of high purity uranium, one of the searchers did not check under "grain refinement" which should have led him to the required document.

<u>Failure to search systematically, i.e. to take each search programme to the limits allowed</u>

5. In a question on voltage regulation when applied to pump storage schemes, one of the searchers found the section Bpmp in the classified catalogue, but failed to check all the cards in this section (approx. 50). If he had done so, he would have traced the document, at Bpmp 43.

42. With a question on the evaluation of the resistance of tools to interrupted cutting, the searcher managed to find his way to Vk Zuc Cutting tools, but checked the cards containing this notation only. He did not check the following cards, amongst which he would have found Vk Zuc Xh which was the one required.

63. With a question on the ignition of gaseous fuels, the searcher thought of the correct concepts, but did not take his search programme to the chain index. Had he done so, the document would have been traced.

66. A similar case - the searcher found his way to De Jf (Cylinders: diesel engines), but limited his search to the cards containing only this notation. A little further along, he would have traced the

required document at De Jf Kpj Pel.

69. In a question on the solution of partial differential equations using an analogue computer, one of the searchers failed twice in his search programmes to trace the document, although a thorough search in each case would have been successful. Firstly he thought of the correct concepts "Partial differential equations" and "analogue computers", but checked the classified section only, and did not take his search to the chain index. Also, in a later search programme, he tried "Partial differential equations" in the chain index, but on finding 13 places, neglected to check them all.

98. In a question on the relationship between friction and wear of metals without adhesion of the surfaces, one of the searchers checked only under "wear" in the chain index, from which he tried 7 places. Had he checked the general section "wear" in the classified catalogue (Pel), the document would have been traced, as the guiding should have led him to the section Pelb Adhesive wear.

109. In a question on adhesives used for fitting gaskets of different materials, one of the searchers checked in the classified catalogue under "Adhesives: felt" at Maie Lj. If he had checked the chain index at this point, he would have been led to the required document at Hq Kce Maie Lj.

157. In a question on the stresses in the plane of laminations in reinforced plastic materials, one of the searchers failed to follow up a <u>see also</u> reference to "Glass-reinforced plastics" which would have led to the required document.

<u>Incorrect searching, i.e. checked the wrong or least likely place</u>

2. With a question on underground steam power stations, one searcher traced the document immediately, whilst the other failed to check under the correct wording. Had he done so, the document would have been adequately traced.

<u>Insufficient searching, i.e. did not try all possible places</u>

17. With a question on high aluminium heat resistant steel alloys, the Project Staff found the document at the first attempt under "alloy steels", but the other searchers checked under "heat resistant steels", "aluminium steels","high alloys steels", and "steel".

80. With a question on cutting of titanium alloys, one of the searchers failed to find the document because he limited his search to this concept whilst the other searcher broadened his search to "titanium", thinking that the required document could refer to both titanium and titanium alloys. The document was traced under Nti Vk Cutting: Machining: Titanium.

81. A question on the feedback circuits of a non-linear control system failed because one of the searchers did not try under "feedback control systems", which would have led to the document, although he thought of the concept "feedback circuits" for which he could find no entry in the chain index. As "feedback control systems" was the next card, the searcher should have noticed it.

Lack of knowledge of indexing practice or of terms used in indexing (applying to Project Staff only)

51. With a question on the micro-analysis of constituents in weld metal structures, the searcher insisted on the concepts "welds" (or similar concept) plus micro-analysis, absorptiometric analysis, etc. Actually it is the practice at English Electric to ignore metals and generally to make an entry under the method of analysis. Had this been known by the searcher, the search programmes would have been extended.

98. A similar situation, as the English Electric indexers make an entry under "Wear" at Pel+, instead of adding the metal or material upon which the wear takes place. Thus the searcher for the question on the relationship of friction and wear of metals did not trace the document.

105. With a question on the spring arm spider of the Bradwell fuel element, the searcher presumed that all material in the Bradwell reactor was placed at Dk (Bradwell). After looking here, she abandoned the search.

Apparently it is the English Electric practice to place only general descriptions of reactors at the Dk (Type), notation, whilst other more specific material is classified exactly, and placed under the type of reactor, e.g. Dkcq Carbon dioxide graphite reactors.

168. With a question on the dissipation of heat by natural convection through oil, the searcher did not realise that the term "natural

convection" was used in the schedules. She checked only "heat convection".

182. As question 105 - a failure due to the practice of placing general material on reactors only at Dk (Type). The searcher checked only Dk (Calder Hall), expecting all material to be there.

194. Again, a lack of knowledge of the term used by English Electric indexers, was the cause of this failure. The term "reactivity change", was one that the searcher did not expect to be used in the chain index.

Failures by searching via the chain index, which would be successes by permutation

8. A document classified at Gf If Semiconductor diodes: switching circuits, would have been traced if the notation had been permuted to If Gf. The searcher was able to check only under If Silicon diodes.

25. If the notation Mrm Nbe Xk Sampling: Beryllium: Polyesters had been permuted to Nbe Xk, the document required by a question on the spectrographic analysis of beryllium would have been traced.

39. A document on the diffusion of hydrogen in mild steel, classified at Ns d Oq Nh, remained untraced. The question "The behaviour of hydrogen in steel", had only one concept in common with the subject of the document. If the notation had been permuted to read Nh Ns d Oq, the document would have been traced.

63. A document classified at De Onb Ignition: diesel engines, remained untraced, because the concept "diesel engines" was not included in the question, but the concept "gas/air mixtures" was included. If the notation had been permuted, the document would have been traced under Onb by both searchers.

69. A document classified at Dk Qv Yge Zp Analogue computers: partial differential equation: heat transfer processes: nuclear reactors, remained untraced partly because of unsystematic searching of the chain index. It would have been traced by permutation under Yge Zp at the second attempt.

109. A document on adhesives used for gaskets would have been found by permutation by both searchers. It was classified at Hq Kce Maie Lj, whilst the searchers checked under Maie Lj. Permutation under this would have traced the document.

151. An article on heat transfer after a rapid change in wall section, would have been traced if permutation of the elements Kkhapk Qvc, and Kkhapm Qvc, had been used, to bring Qvc to the head.

4. SYSTEM

Lack of sub-division, causing the placing to be too general

30. Ys "Statistics" appears to have too few subdivisions. This was pointed out by a question on the analysis of variance, for which there was no place. The document had been classified at Ys Statistics, and remained untraced because the searcher would not search at such a general heading.

Change in the schedules without adequate correction in the chain index or classified catalogue

124. With a question on glass braid insulation for industrial motor stator windings, the searcher found an entry in the chain index under "glass braid" which referred to two places containing the notation Mdj. She presumed from this that all material on glass braid would have been covered by her search.
However, on analysis, it appears that Mdj has been abolished, and included under Mdh "glass tape". Here the document was classified. If all material under "glass braid" had been transferred to "glass tape", with the appropriate cross reference the document would have been traced.

Ability to add, or omit concepts

63. This question, on the ignition of gas/air mixtures by a hot surface, shows up the difficulty of an indexer in being consistent. One of the searchers checked under "ignition - gaseous fuels", and amongst the entries from the chain index, he looked at De Lke Onb "Ignition: gaseous fuels: diesel engines".
This is the same subject as that covered by the document, but, because of the omission of Lke (gaseous fuels), the document remained untraced, and material on like subjects was separated. Permutations would enable such inconsistencies to be covered.

PART 2. ANALYSIS OF INDIVIDUAL QUESTIONS

Document No. 54

QUESTION "Can you please find me a possible means of determining bending stresses on a flat plate when I have access to one side only ?"

Assessment: It appears that the document describes an instrument, whilst the question refers to the application of the instrument. Perhaps a difficult question, but with adequate indexing and searching, the document should be traced.

DOCUMENT A double-check resistance strain gauge.
(Product Engg. vol. 31, 10th Oct. 1960, pp 55-57).

Assessment: Describes the "Flexigage", a new type of strain transducer, especially designed to separate bending strain from the total strain at any point in shell or plate structures. The device consists of two foil strain gauges mounted on opposite sides of a plastic spacer. The device can be mounted directly on the outside surface of the structure thus eliminating back-to-back arrangement.

SEARCH BY PROJECT STAFF Success

SEARCH BY E.E. STAFF Failure

ASSESSMENT OF INDEXING

Zgb. Strain gauges. One entry only.
If the indexer had also made an entry under plates and shells, the subject of the paper would have been indexed more adequately. However, with the English Electric search programme, the document would still not have been found unless the concept "bending stresses" had been included as well.

ASSESSMENT OF SEARCHING

English Electric Staff

The search programme consisted of

(1) Bending stresses: plates Kwe Pρg
(2) Bending: Plates Kwe Pjf (no entries)

As the Project searcher found the document at the second search, one can only assess the English Electric search as inadequate.

SUGGESTED RE-INDEXING

Kwe Ppg Zgb. Strain gauges: bending stresses: plates.

COMMENTS

The cause of the failure can be divided into two. Firstly, the indexer could have made a more detailed entry, as the article was specifically in the use of strain gauges to measure bending strain. Secondly, the searcher should have thought of the possible instruments to assess bending strains, and checked under those.

REASONS FOR FAILURE

(1) Searching (inadequate)

(2) Indexing (inadequate)

Document No. 60

QUESTION "Please supply information on cross-elasticity effects in a homogeneous liquid with respect to its possible application to fluid bearings".

Assessment: A clear question, which should enable the document to be traced without trouble.

DOCUMENT Cross stresses in the laminar flow of liquids. (Phys. Fluids. vol. 3, May/June, 1960, pp 427-437).

Assessment: Cross-elasticity effects in a simple homogeneous liquid manifest themselves in cross stresses observed in an instrument consisting of circular metal plates, one stationary, the other rotating opposite it. Stator can be displaced along axis of rotation against forces exerted by springs. Stator and motor at rest are in contact. On rotation, cross stresses in liquid separate stator from rotor, and a bearing effect is produced.

SEARCH BY PROJECT STAFF Failure

SEARCH BY E.E. STAFF Failure

ASSESSMENT OF INDEXING

One entry only Qe Laminar flow.

Quite inadequate indexing. The purpose and application of the theory appears to have been missed.

ASSESSMENT OF SEARCHING

Project Staff

The searcher found trouble in gaining entry to the chain index. Of his four search programmes, he only found one entry in the catalogue.

1. Fluid bearings (no entry)
2. Bearings Lc Jt (no card in classified catalogue)
3. Homogeneous liquids (no entry)
4. Liquids, homogeneous (no entry)

The concept of "cross-elasticity" he ignored.

English Electric Staff

The searcher tried:

1. Cross-elasticity (no entry)
2. Elasticity Pby (classified catalogue)
3. Homogeneous liquids
4. Liquids, homogeneous

SUGGESTED RE-INDEXING

1. Qe Qre Elasticity: Laminar flow
2. Jtahd Fluid bearings

COMMENTS

An indexing failure entirely. Had the indexer made adequate entries, the document should have been traced, at the first attempt with the Project staff, and the second attempt with English Electric staff.

REASONS FOR FAILURE

Indexing inadequate.

Document No. 63

QUESTION "The temperature required for the ignition of gas/air mixtures by a hot surface is different for different surface materials. Can you find any reports dealing with the mechanism of why this is so ?"

Assessment: Unless the document can be traced under the concept of ignition of gaseous mixtures, this question will be difficult to trace, as the next concept "surface" can be interpreted in many ways.

DOCUMENT Occurrence of surface ignition depends on surface temperature, local air-fuel ratio.
(S.A.E.Jnl. vol.68, Oct.1960, pp 58-61).

Assessment Investigates surface ignition, the mechanism of ignition by hot surfaces in the combustion chamber, which causes pre-ignition, wild ping and rumble. Surface ignition occurs when the mixture is heated about its ignition temperature and the mixture composition is within the limits of inflammability. The surface ignition process is independent of the type of surface.

SEARCH BY PROJECT STAFF Failure

SEARCH BY E.E. STAFF Failure

ASSESSMENT OF INDEXING

Dc Onb Ignition: diesel engines.

Not adequate indexing. Lke (gaseous fuel) should have been included, as the indexer should have realised the concepts of ignition of gaseous materials is important elsewhere than in diesel engines, and so may be searched for without this last concept. However, this does not help in tracing this particular failure.

ASSESSMENT OF SEARCHING

Project Staff

Adequate. The document should have been indexed to include Lke Onb. Ignition of gaseous fuels.

English Electric Staff

Apparently the searcher, although he tried the same search programme of ignition of gaseous fuels, did not refer to the chain index, but only to the classified catalogue.

SUGGESTED RE-INDEXING

De Lke Onb. Ignition: gaseous fuels: diesel engines.

COMMENTS

This question shows up the difficulty of an indexer in being consistent.

The Project searcher checked under "Ignition: gaseous fuels", and amongst the entries from the chain index, he looked at De Lke Onb. Ignition: gaseous fuels: diesel engines.

This is the same subject as that covered in the document, but, because of the omission of Lke (Gaseous fuels) the document remained untraced, and the material on like subjects was separated.

An apparently insurmountable difficulty unless permutation is used.

With permutation, the document would have been traced. (E.E. and Project staff).

REASONS FOR FAILURE

(1) System (ability to add or omit concepts).

Document No. 85

QUESTION "Can we find a description of an instrument to measure total pressure, total temperature and flow direction simultaneously in between the blade rows of compressors or turbines?"

Assessment: A question fairly based on the subject of the article - it should present no difficulty in searching.

DOCUMENT "Educated" probes get flow data.
(Gas Turbine, vol.1, Nov-Dec.1960, pp 22-23).

Assessment: New development tools and techniques for obtaining gas flow data remotely and automatically, on operating axial compressors and turbines. A two page article.

SEARCH BY PROJECT STAFF Failure

SEARCH BY E.E. STAFF Failure

ASSESSMENT OF INDEXING

Dh Zfr Pitot tubes: Gas turbines.

Inadequate indexing. The indexer has not covered the description given of the instruments for measuring pressure, yaw angle, temperatures, etc. If time was short, an entry should have been made at Zfg (+Dh as the application is specifically for measuring the flow between blades of turbines).

ASSESSMENT OF SEARCHING

Project Staff

The search programmes were thus:-

1. Pressure measuring instrument Zgh + (chain index)
2. Flow measuring instrument Zfg

The searcher should have taken the second search programme to the chain index, as the question specifically stated that the application was for measurement in turbines and compressors.

English Electric Staff

The search programmes were:-

1. Flow measuring instruments: blades: compressors (no card)
2. Flow measuring instruments: blades: turbines (1 card)
3. Pressure measurement: blades (5 cards)
4. Temperature measuring instruments and blades (6 cards)

Presumably the searcher did not check the chain index in any of the search programmes.

A sensible extension of each programme would have been to have dropped the concept "blades". However, the document still would not have been traced with the present indexing.

SUGGESTED RE-INDEXING

Dh Zfg Flow measuring instruments: turbines.

COMMENTS

This search points out the confusion arising in the minds of the indexer and searcher, about the use of various types of flow, pressure and temperature measuring instruments. Further directions in the schedules, and "see also" references in the chain index may help to sort this out.

The failure is due principally to lack of indexing. The indexer should have either made an entry generally at Dh Zfg (flow measuring instruments: turbines) or more specifically under "pressure measurement", etc.

Also, the searchersin each case did not follow their search programmes to their allowable conclusion. However, this would not have traced the document with the present indexing.

REASONS FOR FAILURE

(1) Indexing insufficient.

Document No. 152

QUESTION "What is the % free activity for various channels loaded in the Calder Reactors 1, 3 and 4, measured during commissioning".

Assessment: A clear question, which should have traced the document without difficulty.

DOCUMENT A re-assessment of the reactor parameters measured during the commissioning of the Calder reactors. (U.K.A.E.A. P.G. Memo 317(CR)).

Assessment: A report summarising the measurements of the reactor parameters taken during the commissioning of the Calder Reactors, together with an estimate of their errors. In the case of the pressure coefficients and super-critical control rod calibrations, results from the first Chapelcross Reactor are also included.

SEARCH BY PROJECT STAFF Failure

SEARCH BY E.E. STAFF Success

ASSESSMENT OF INDEXING

(1) Dkcq S Xcc

(2) Dkcq Xcc

According to the English Electric indexing rules, this appears to be adequate. However, an entry in the chain index under "Calder reactors" stating "for general description only, otherwise check under carbon dioxide graphite reactors", would have helped the searchers.

ASSESSMENT OF SEARCHING

Project Staff

1. Calder reactors. Dk (Calder Hall) in classified catalogue

The searcher made this his only search programme, because he presumed that all material on the Calder Hall reactors would be included at Dk. It appears that English Electric practice was to include only general material here. All other reports were indexed under Dkcq.

COMMENTS

A searching failure caused by two reasons:

1. A lack of cross-reference in the chain index under "Calder reactors" to the section "Carbon dioxide graphite reactors".

2. In a smaller way, lack of the searcher's knowledge of English Electric indexing rules.

REASONS FOR FAILURE

(1) Lack of cross reference

(2) Searcher's lack of knowledge of indexing practice

English Electric Search

Found at first attempt.

COMMENTS

Subject knowledge would appear to be useful here, to know to check under "commissioning" in the chain index, but possibly may be due to knowledge of indexing practice.

Document No. 158

QUESTION "What methods are available for metallographically preparing and etching Palladium (Pd) ?"

Assessment: A fair question, which should have traced the document.

DOCUMENT Procedures for the metallographic preparation of beryllium, titanium and refractory materials.
(B.M.I. Defence Metals Inf. Centre B6603).

Assessment: No abstract, but the paper presumably covers the metallographic preparation of several metals.

SEARCH BY PROJECT STAFF Failure

SEARCH BY E.E. STAFF Failure

ASSESSMENT OF INDEXING

(1) Nbe Xul Etching: Beryllium

(2) Nti Xul Etching: Titanium

Inadequate indexing. The indexer ignored the other metals contained in the report, and did not even cover them with an entry "refractory materials". He did not even make a general entry under Xul "Etching".

ASSESSMENT OF SEARCHING

Project Staff

1. Palladium - 3 places
2. Etching - 2 places (obviously ignoring any other metals specifically mentioned).

From the question the searching appears to be adequate. The searcher should have traced the document by these programmes had the indexing been sufficient.

English Electric Staff

1. Palladium Npd
2. Etching Xul+

Apparently the searcher did not go to the chain index - bad searching technique, but the document would still not have been traced with better technique.

SUGGESTED RE-INDEXING

Npd Xul Etching: Palladium

Xul Etching

COMMENTS

A complete indexing failure. The indexer covered only two of the metals referred to in the article, and then, presumably, only because they appeared in the title - not because they were of more importance. Even considering that the indexer made a general entry under Xul "Etching", which would have covered, somewhat, the remainder of the refractory metals discussed in the paper.

With this general entry, the document would have been traced by both searchers.

REASONS FOR FAILURE

Indexing inadequate.

APPENDIX 7B

ANALYSIS OF FAILURES FOR FACET INDEX IN W.R.U. TEST

QUESTION (6) "We are having a high incidence of porosity in iron castings. Chemical analysis gives satisfactory results. What might be the cause and the remedy ?"

TITLE (1240) Practical observations on mould stability as a factor in controlling the soundness of grey iron castings. British Foundryman, Vol. 54, 1961, Feb., pp 45-53.

INDEXING

Concept Analysis

Grey Iron Castings
Defects, Porosity, Soundness
Mould stability/Rigidity effects
Foundry Sand

Class Number Elements

(1) Nfecp (2) Vg (3) Vgs (4) Mce (5) Vgb (6) Pn (7) Pec (8) Teh
i.e. (1) Grey Cast Iron. (2) Castings. (3) Mould-making. (4) Foundry Sand. (5) Sand Castings. (6) Defects. (7) Porosity. (8) Stability.

Permutations

2:6:1	3:1:8
2:7:1	3:4:1
1:3:4	3:8:1
2:1:3	7:2:1
2:1:6	5:1:3
2:1:7	4:3:8

Assessment Concept analysis and class number elements adequate. Failure due to poor choice of permuted entries 1:7 1:6 6:1 7:1 required.

SEARCHING

1.	POROSITY Pec (A)	A:B
	IRON CASTINGS Nfec+ (B)	B:A
2.	IRON CASTINGS Nfec+ (A)	A:B
	DEFECTS Pn (B)	B:A

Assessment Could have tried further programmes, e.g.

3.	POROSITY Pec (A)	A:B
	CASTINGS Vg (B)	B:A
4.	DEFECTS Pn (A)	A:B
	CASTINGS Vg (B)	B:A

Document 1240 would have been found at
3. A:B B:A and at 4. B:A

RE-INDEXING

Add permutations:	Nfecp	Pec	Grey Iron Castings. Porosity
	Nfecp	Pn	Grey Iron Castings. Defects

REASON FOR FAILURE

Lack of permutation mainly the cause of failure, but insufficient searching contributed.

QUESTION (23) "What method can be used to identify the micro-constituents in alloy steels ?"

TITLE (1183) Intergranular precipitation of intermetal in compounds in austenitic alloys. A.I.M.E. Metallurgical Soc. Trans., Vol. 221, Feb. 1961, pp 28-34.

ASSESSMENT OF QUESTION

The question is too specific for this particular document. The paper is more concerned with the phenomena investigated than the method of investigation, which is dealt with in one paragraph only.

INDEXING

Concept Analysis
Austenitic alloys
Intergranular Precipitation
Ageing
Phase solubility limits
Microstructures

Class Number Elements
(1) N.1 (2) Ns.1 (3) Odj (4) Oev (5) Pgcb
i.e. (1) Austenitic alloys. (2) Steel. (3) Intergranular Precipitation (4) Phases, Transformations. (5) Ageing.

Permutations

1:3	4:1
1:4	4:2
2:3	1:5
2:	2:5
3:1	5:1
3:2	5:2

Assessment Omitted to translate the concept 'Microstructures' into the class number. If this had been done the document would have been found at the sixth search.

SEARCHING

1.	Microscopic Analysis	A:B
	Trace Analysis Xj.m	B:A
	Steel Alloys (B)	
2.	Microscopic Analysis, Metallography. Xulm+ (A)	A:B
	Steel Alloys Ns.g+ (B)	B:A
3.	Metallography Xuz+ (A)	A:B
	Steel Ns+ (B)	B:A
4.	Analysis Xj+ (A)	A:B
	Steel Ns+ (B)	B:A
5.	Impurities Odl (A)	A:B
	Steel Ns+ (B)	B:A
6.	Microstructure Od/e (A)	A:B
	Steel Ns+ (B)	B:A

RE-INDEXING

Translate concept Microstructures to class number Od/e.

REASON FOR FAILURE

Failure due to careless omission to translate concept into class number. Also the question too specific and misleading.

QUESTION (30) "Is it possible to approach the close tolerance of metal diecasting by any sand-type process for alloys of aluminium".

TITLE (1391) The permeable plaster casting process. Light Metals, Jan. 1961, pp 7-10.

INDEXING

Concept Analysis
Permeable plaster. Precision casting

Class Number Elements
Vgh Permeable plaster casting

Assessment Omitted concepts Aluminium
Sand casting
Plaster of Paris
Moulds
Permeable
Tolerances

SEARCHING

1.	(Aluminium Nal	
	(Aluminium alloys Nal.d (A)	A:B
	Sand casting Vgb (B)	B:A
2.	(Aluminium alloys Nal.d	
	(Aluminium Nal (A)	A:B
	Diecasting Vgc (B)	B:A
3.	(Aluminium Nal	
	(Aluminium alloys Nal.d (A)	A:B
	Casting Vg+ (B)	B:A
4.	Tolerances Xft (A)	A:B
	Castings Vg (B)	B:A

RE-INDEXING

Add concepts as listed above with necessary permutations.

REASON FOR FAILURE

Failure due to inadequate indexing. Important concepts in the document not recorded.

QUESTION (37) To what extent do stress concentrations affect the structural tensile strength of aircraft and space vehicles.

TITLE (1376) Structural significance of ductility. Jnl. of Metals, Vol. 13, March 1961, pp 201-203.

INDEXING

Concept Analysis

Missiles, Rockets
Space Vehicles
Pressure vessels
Ductility
Stress Concentration
Strength-to-weight
Titanium alloys

Class Number Elements

(1) Kct Pressure vessels. (2) Ed Missiles, Rockets. (3) Eg Space Vehicles. (4) Pb Mechanical properties, Strength. (5) Teb Weight. (6) Pbd Ductility. (7) Px Stress concentrations (8) Pjb Brittle fracture. (9) Nti.d Titanium alloys.

Permutations

1:2:6	1:5:3	1:9:3	7:1
1:3:6	1:6:3	9:1:6	8:1
2:1:6	1:7:3	5:1	6:9:1
3:1:6	1:8:3	6:1	9:6:1
1:4:3			

Assessment

(1) Omitted concepts Tensile strength and Aircraft structures. Also Aircraft.
(2) Should have made permutations for 2 and 3 with 5, 6, 7, 8 and 9.

SEARCHING

1.	Aircraft structures	Eb Fc (A)	B:A:C	C:B:A
	Stress Concentrations	Px (B)	B:C:A	A:B:C
	Tensile properties	Pbb (C)	C:A:B	A:C:B
2.	Aircraft structures	Eb Fc (A)		
	Stress concentrations	Px (B)	B:A	
3.	Aircraft structures	Eb Fc (A)	A:B	
	Tensile properties	Pbb (B)	B:A	
4.	Stress concentrations	Px (A)	A:B	
	Tensile properties	Pbb (B)	B:A	

Further searching of no avail even if extended search to missiles and space vehicles. Could not have broadened search to Px generally where document would have been found.

RE-INDEXING

Add concepts
1. Tensile properties Pbb
2. Aircraft Eb
3. Aircraft structures Eb Fc

Add permutations 2. Missiles Rockets and 3. Eg Spacecraft with phenomena at 5, 6, 7, 8 and 9.

REASON FOR FAILURE

Cause of failure equally due to omissions in indexing and lack of permutation.

QUESTION (45) "To what extent is calcium fluoride applied to iron and steel-making processes".

TITLE (1341) The kinetics of sulphur transfer from iron slag. Iron and Steel Institute Journal, Vol. 196, Dec. 1960, pp 393-405.

INDEXING

Concept Analysis

Steel-making, iron-making
Sulphur removal to slag from iron carbon saturated
Transfer rate

Class Number Elements

(1) Vc Metal production. (2) Vcd Physical methods. (3) Nfe Iron. (4) Ns Steel. (5) Nsf Sulphur. (6) N.wh Ores.

Permutations

4:1:5:1	5:2:3	1:2:5:2
4:2:5	5:3:2	2:5:3
3:2:5	6:3:5	2:3:5
3:1:5:2	3:6:5	

Assessment Omitted concept Calcium fluoride.

SEARCHING (1) Steel-making Ns Vc (A) B:A
Calcium fluoride MwCaF (B)
(2) Calcium fluoride MwCaF

Assessment Should have extended search to
(3) Steel-making Ns Vc
where document would have been found.

RE-INDEXING

Add concept Calcium fluoride MwCaF
Add Permutation Calcium Fluoride. Steelmaking.

REASON FOR FAILURE

Failure due to inadequate concept indexing and failure to search far enough.

QUESTION (54) "Are there any automatic installations producing laminations in the United Kingdom".

TITLE (1403) Quality production of laminations for transformer cores. Machinery, Vol. 98, Feb. 1961, pp 150-252.

INDEXING

Concept Analysis

Transformers
Cores
Laminations
Production
Cold rolled grain oriented steel
Strip
Slitting machines
Presswork

Class Number Elements

(1) He Transformers. (2) Hw Cores. (3) Mail Laminations. (4) Vhz Slitting. (6) Ns.hv Electric Steel - low alloy. (7) Kwh Strip. (8) Vj Presswork. (9) Vhp Slitting.

Permutations

1:2:3	2:6:4	9:7:6
1:2:4	6:7	6:1:2
1:2:6	7:6	8:2
2:4:6	8:7:6	9:2

Assessment

Careless permutation. Laminates and Laminations 3 and 4 are not brought to the front at all.

SEARCHING

(1) Laminations Mail
(2) Laminating Vhz

RE-INDEXING

Add permutations 4:2:1 Laminating: Cores: Transformers
3:2:1 Laminates: Cores: Transformers

REASON FOR FAILURE

Failure due to careless permutation.

QUESTION (59) "If the oxide film is removed from the steel strip by liquid fluxes, is the flow of liquid tin over the surface more satisfactory".

TITLE (1354) The spread of molten tin on mild steel reduced in hydrogen or treated with molten fluxes. Iron and Steel Institute Jnl. Vol. 197, March 1961, pp 233.

INDEXING

Con cept Analysis

Strips. Mild steel
Tinning. Surfa ce preparation and treatment
Oxide fi lm removal
Reduction in hydrogen, Hydrogen- argon
Zinc chloride- stannous chloride flux, molten.

Class Number Indexing

(1) Ns.d Mild steel. (2) Kwh Strip. (3) Vty Tinning, soldering.
(4) Vv Cleaning. (5) Nh Hydrogen. (6) MwZnClO Zinc chloride.
(7) MwSnClO Stannous chloride.

Permutations

2:3:1	3:4:5	4:3:1
1:2:3	2:1:3	5:3:1
1:3:4	3:6:1	6:3:1
3:1:2	3:7:1	7:3:1
3:2:1		

Assessment

Should have used notation for tin plating and not tinning: soldering.
Omitted permutations 2:1 Strip Cleaning
4:2:1 Cleaning steel strip
which would have retrieved the document.

SEARCHING

(1) (Tin plated Ldm Nsn	
(Tin plating Vwm Nsn (A)	
Steel Ns (B)	A:C:B:D
Strip Kwh (C)	C:B:A:D
Cleaning Vv+ (D)	D:C:B:A
(2) Cleaning Vv+ (A)	D:A:B:C
Steel Ns (B)	A:C:B
Strip Kwh (C)	A:B:C
	C:B:A
	C:A:B
(3) Strip Kwh (A)	
Steel Ns (B)	A:B:C
(Tin plating Vwm Nsn	A:C:B
(Tin plated Ldm Nsn (C)	C:A:B
	C:B:A
(4) Strip Kwh (A)	A:B
(Tin plating Vwm Nsn	B:A
(Tin plated Ldm Nsn (B)	
(5) Strip Kwh (A)	A:B
Cleaning Vv+ (B)	B:A

RE-INDEXING

(1) Use Vwm Nsn for Vty (Tinplating instead of Tinning (soldering))

(2) Add permutations

2:4	Kwh Vv	Strip. Cleaning
4:2:1	Vv Kwh Ns.d	Cleaning. Strip. Mild Steel.

REASON FOR FAILURE

Failure due to incorrect indexing and lack of permutation.

QUESTION (81) "Do stainless steels have any advantage over Al and Ti alloys as structural materials for rockets using liquid oxygen and hydrogen propellants".

TITLE (1450) Selection of metals for use at cryogenic temperatures. Metal Progress, Vol. 79, April 1961, pp 65-72.

INDEXING

Concept Analysis

Missiles, Rockets
Liquid propellants, Hydrogen, Nitrogen
Low temperatures, Cryogenic tests
Tensile, impact, hardness, fatigue, notch tensile, and charpy v tests.
Aluminium alloys, aluminium magnesium, aluminium copper alloys
Titanium alloys, titanium aluminium alloys
Stainless steels, cold rolled austenitic nickel alloys, cobalt alloys, sheet
Alloys by name.

Class Number Elements

(1) Ed Missiles, Rockets. (2) Pb Prd Low Temp. Mechanical properties. (3) N.tb Low Temperature Metals. (4) Lkf Liquid fuel. (5) Nh Hydrogen. (6) Nn Nitrogen. (7) Nti.d Titanium alloys. (8) Nal.d Aluminium alloys. (9) Nni.d Nickel alloys. (10) Pk Xh Fatigue testing. (11) Xtbb Tensile testing. (12) Xtbm Impact testing. (13) Xtbp Hardness testing. (14) Xtbb.n Notch tensile testing. (15) Nco.d Cobalt alloys. (16) Vhm Cold rolling. (17) Ns.1 Austenitic steel.

Permutations

7:2:1	2:7:5	10:2:4	15:2:4
8:2:1	2:8:5	11:2:4	1:2
9:2:1	2:9:5	12:2:4	5:4:1
4:2:1	2:17:5	13:2:4	6:4:1
17:2:1	4:2:1	14:2:4	

Assessment

Should have indexed Liquid fuel rocket engines Djt, and have added permutations Missiles 1 with Metals at 7, 8, 9, 15, 17.

SEARCHING

(1) Liquid fuelled rocket engines Djt (A)
Stainless steels Ns.j+ (B) A:B
B:A
(2) Liquid fuelled rocket engines Djt (A) A:B
Aluminium alloys Nal.d (B) B:A
(3) Liquid fuelled rocket engines Djt (A) A:B
Titanium alloys Nti.d (A) B:A
(4) Liquid fuelled rocket engines Djh/t (A) A:B
Metals N (B) B:A
(5) Rocket engines Djh/t (A) A:B
Stainless steels Ns.j+ (B) B:A
(6) Rocket engines Djh/t (A)

(7)	Missiles Ed (A)	A:B
	Stainless steels (B)	B:A
(8)	Missiles (A)	A:B
	Aluminium alloys Nal.d (B)	B:A
(9)	Missiles (A)	A:B
	Titanium alloys Nti.d (B)	B:A
(10)	Missiles Ed (A)	A:B
	Metals (B)	B:A

RE-INDEXING

(1) Add permutations Missiles 1 with Metals at 7, 8, 9, 15, 17.

(2) Add concept Djt Liquid fuelled rocket engines.

REASON FOR FAILURE

Failure due to lack of permutation.

QUESTION (82) "What is the best type of copper alloy to use in electrical appliances where high conductivity and good resistance to softening on heating is required".

TITLE (1452) Zirconium copper alloy ... high strength and conductivity. Metal Progress, Vol. 74, April 1961, pp 75-77.

INDEXING

Concept Analysis

Zirconium copper alloys (copper zirconium)
Applications: Electrical equipment, windings, motor commutators, risers.
Properties: High temp. tensile. Electrical conductivity. Strength, hardness.

Class Number Elements

(1) Zrcu Zirconium copper alloys. (2) Pb Prb High temperature mechanical properties. (3) Pcb Hardness. (4) Rvc Electrical conductivity. (5) Ht Windings. (6) Hq Commutators. (7) H Electric machines.

Permutations

1:2	4:1
1:3	5:1
1:4	6:1
2:1	7:1
3:1	

Assessment

Indexer forgot to make entry COPPER. Zirconium copper alloys, in the alphabetical index. Also, although the title of the paper was zirconium copper alloy the alloy concerned was copper xirconium as was stated in the concept indexing. The indexer should have indexed the content of the document rather than the title when the concept was translated into the class number.

SEARCHING

(1) (Copper Ncu
(Copper alloys Ncu.d (A) A:B
Electrical conductivity Rvc (B) B:A
(2) (Copper Ncu
(Copper alloys Ncu.d (A) A:B
Electrical properties Rv (B) B:A
(3) (Copper Ncu (A) A:B
(Copper alloys Ncu.d B:A
High temperature mechanical properties Pb Prb (B)
(4) (Copper Ncu (A)
(Copper alloys Ncu.d A:B
Mechanical properties Pb (B) B:A
(5) (Copper Ncu (A) A:B
(Copper alloys Ncu.d
Deformation Pg+ (B) B:A

SYSTEM

In classifying alloys the system allows only one direction synthesis. The major alloying element is given first followed by the other alloys in order of quantity. For example, zirconium copper alloys has the class number Nzrcu, where zirconium is the larger element. The minor elements are located by the index, i.e. Copper. Zirconium copper alloys. Nzcru.

The searcher may forget to search the index or the indexer may be wrong about the priorities of the elements. Therefore inverted entries are recommended, e.g. Ncuzr Copper - zirconium alloys as well as Nzrcu Zirconium copper alloys.

RE-INDEXING

Index alloy as Ncuzr Copper zirconium alloys with index entry Zirconium. Copper zirconium alloys. Ncuzr.

REASON FOR FAILURE

This search failed due to a careless indexing error - failure to make an index entry in the Alphabetical index. Also a cause of failure, indexing by the wording of the title although the subject matter was known to be otherwise. The failure also points to a weakness in the system - the construction of alloys without allowance for inverted entries.

QUESTION (85) "What kind of pretreatment should be applied to a steel base which is to receive a heavy vinyl plastisol coating (as a replacement for vitreous enamel)".

TITLE (1457) Phosphating in cold solutions. Metal Progress, Vol. 79, April 1961, pp 100-102.

INDEXING

Concept Analysis

Phosphating, cold
Cleaning, Coating
Steel
Spray coating.

Class Number Elements

(1) Vwec Phosphating. (2) Ns Steel. (3) Vww Spray coating.

Permutations

1:2 2:1 1:3 3:1

Assessment

Concept indexing omitted concept 'paints' and 'plastic coatings'.
Class number elements omitted concept 'cleaning', included in concept analysis.

SEARCHING

(1)	Plastic Coatings Ldkp, Vwkp (A)	A:B:C
	Steel Ns (B)	A:C:D
	Cleaning Vv+ (C)	C:A:B
		C:B:A
(2)	Plastisol	
(3)	Plastic Coatings Ldkp, Vwkp (A)	A:B
	Steel Ns+ (B)	
(4)	Plastic coatings Ldkp, Vwkp (A)	A:B
	Cleaning for Vv+ (B)	B:A
(5)	Plastic Coatings Ldkp, Vwkp (A)	A:B
(6)	Steel Ns+ (A)	A:B
	Cleaning Vv+ (B)	B:A
(7)	Vitreous enamel coatings Vwk Ldk (A)	
	Steel Ns+ (B)	A:B

RE-INDEXING

Add concepts Paints, plastic coatings
Add class number elements (4) Vv Cleaning
(5) Ldkp Plastic coatings
(6) Vwkp Plastic Coatings
(7) Le Paints
Add permutations 4:6 4:7 6:2:4 7:2:4 1:4:2 4:2:6

REASON FOR FAILURE Failure of search due primarily to a careless indexing error. If the concept Cleaning Vv had been translated from the concept indexing and the necessary permutations made, the document would have been found at the sixth search. The indexer also failed to note the concepts Paint and Plastic Coatings. If this had been done and the necessary permutations made, the documents would have been found at the first search.

QUESTION (112) "Is there any direct evidence that preferential precipitation on the non-coherent boundaries of the annealing twins is due to the presence of dislocations".

TITLE (1957) Electron-microscopic study of recrystallisation twins in copper. Acta Metallurgica, Vol. 8, Dec. 1960, pp 874-877.

INDEXING

Concept Analysis

Copper foils
Twinning, dislocations
Twins
Recrystallisation
Electron microscopy

Class Number Elements

(1) Ncu Copper. (2) Kwff Foils. (3) Oevp Recrystallisation, Twins, Recrystallisation. (4) Oej Twinning. (5) Xulme Electron microscopy. (6) Oevv Grain growth.

Permutations

1:2:3	2:1:6	5:3:1
1:2:4	4:1:5	5:4:1
1:6:5	3:1:5	5:6:1
1:3:5	6:1:5	1:5:6
1:4:5	5: 1:3	1:3:6

Assessment

Failed to translate concept 'dislocations' into class number. Failed to include the concept Precipitation boundaries.

SEARCHING

(1)	Twins. Oevp, Oevv (A)	A:B:C
	Precipitation: Boundaries Odj (B)	A:C: B
	Dislocations Oed, Oeb (C)	B:A:C
		B:C:A
(2)	Twins Oevp, Oevv (A)	A:B
	Annealing Vme (B)	B:A
(3)	Twins Oevp, Oevv (A)	A:B
	Precipitation Boundaries Odj(B)	B:A
(4)	Twins Oevp,Oevv (A)	A:B
	Dislocations Oed, Oeb (B)	B:A
(5)	Dislocations Oed,Oeb (A)	A:B
	Annealing Vme (B)	B:A
(6)	Precipitation Boundaries Odj(A)	A:B
	Annealing Vme (B)	B:A

Would have tried Twins Oevp,Oevv generally, but decided this would bring out too many irrelevant documents, since the place in the schedules for Twins includes all documents on recrystallisation and grain growth.

Assessment

Should have broadened the search to find document at Oevp, Oevv or tried the other number for Twinning Oej - ignored altogether by the searcher.

SYSTEM

There are too many places in the schedules for Twins, Twinning.Oej alone should have been used for twinning and recrystallisation twinning should have been expressed by the class numbers Oej, Oevp Twinning, Recrystallisation.

REASON FOR FAILURE

Failure due to careless searching. Searcher checked supplementary index to schedules for Twinning without also using the index to the schedules - consequently did not search the third possible place for Twinning. The failure also due to omitting to translate a concept into a class number. The three places in the schedules for Twinning were also partly to blame.

QUESTION (115) "What is the cross-sectional shape of extrusions formed on the surface of aluminium alloys subject to fatigue".

TITLE (2069) A study of fatigue deformation by reflection electron microscopy. Inst. of Metals Jnl. Vol. 59, March 1960/61, pp 253-254.

INDEXING

Concept Analysis

Fatigue, Deformation
Cracks. Extrusions. Electron microscopy
Deflection. Surfaces. Microstructures.

Class Number Elements

(1) Pk Fatigue. (2) Pj Cracks. (3) Xulme Electron microscopy.
(4) Pg Deformations. (5) Od/e Microstructure.

Permutations

1:3 3:2:1 3:4:2:1 4:1 5:1:3

Assessment

(1) Omitted to translate the concept Surface into class number Pej
(2) Omitted vital permutations 1:2 or 2:1
(3) Omitted concept Extrusions. (Stress raisers) from concept indexing.

SEARCHING

(1) (Aluminium Nal	A: C: B
(Aluminium alloys Nal.d (A)	A:B:C
Fatigue Pk (B)	B:A:C
Stress raisers Px (C)	C:A:B C:B:A
(2) (Aluminium Nal (A)	A:B
(Aluminium alloys Nal.d	B:A
Fatigue Pk (B)	
(3) (Aluminium Nal	
(Aluminium alloys Nal.d (A)	A:B
Stress raisers Px (B)	B:A
(4) Surface properties Pej (A)	A:B
Fatigue Pk (B)	B:A
(5) Fatigue Pk (A)	A:B
Stress raisers Px (B)	B:A

RE-INDEXING

Concept Analysis Add extrusions (Stress raisers)

Class Number Elements (1) Add Px Stress raisers with index entry Extrusions: Stress raisers Px
(2) Translate concept Surfaces to Pej Surface Properties.

Permutations Add entry 2:1 or 1:2 Cracks: Fatigue or Fatigue: Cracks

REASON FOR FAILURE

There are three causes of failure: careless permutation, omission to translate concept to class number and insufficient concept indexing.

<u>QUESTION</u> (131) "Is the crystal orientation of uranium affected by the previous history of the metal, and what effect does orientation have on the properties".

<u>TITLE</u> (1717) The recrystallisation of uranium during cold or hot forming. Jnl. of Nuclear Materials, Vol. 3, Jan. 1961, pp 115-119.

<u>INDEXING</u>

<u>Concept Analysis</u>

Uranium
Cold forging
Hot forging
Recrystallisation

<u>Class Number Elements</u>

(1) Nu Uranium. (2) Oevp Recrystallisation. (3) Vhc Forging.

<u>Permutations</u>

1:2:3 1:3:2 2:1:3 2:3:1 3:2:1

<u>SEARCHING</u>

(1) Orientation Oer (a) A:B
(Uranium Nu
(Uranium alloys Nu.d (B) B:A

Should have searched (Uranium alloys Nu.d
(Uranium Nu (A) A:B
Microstructure Od/e+ (B) B:A
where document would have been found.

<u>REASON FOR FAILURE</u>

Searching failure. Search could have been broadened to include microstructure of uranium.

APPENDIX 8A

INSTRUCTIONS FOR SUPPLEMENTARY INDEXERS

GENERAL INFORMATION

1. The documents to be indexed

The enclosed list of documents consists of 20 sheets (front and back pages), each of which has a minimum of 20 references, and it is from these lists that we ask you to make your selection of documents to be indexed. If the intention is to index a total of 20 documents, select one reference from each sheet. If 40 documents are being indexed, select 2 references from each sheet and so on for any further multiples of 20 documents.

Where indexing is to be done by more than one system, it is presumed that the same collection of documents will be used.

2. The indexing

Notes on indexing procedure are given separately for each system, but the following points are of general applications:-

(a) The depth of indexing which is normally done in an organisation is dependent on a number of factors, possibly the most important being the requirements of the users of the index and the type of documents being indexed. In this respect, the project indexers have been limited by time since they have had to complete a batch of 100 documents in a definite time which has varied from 26 hours to $3\frac{1}{2}$ hours. We do not wish to place any such restriction on those who are doing the supplementary indexing, and we feel that your contribution would be most valuable if the level of your indexing was that which you would normally do for your own organisation.

(b) The specificity of the indexing is a more difficult matter. In the notes on the various systems some examples are given of the degree of detail we believe necessary. In general we would suggest that you should attempt to be as specific as possible, bearing in mind that although the collection of documents is relatively small we are endeavouring to test the various systems in their ability to answer specific questions as well as more general questions. The project indexers would normally specify by name or type number such things as aircraft, engines, wing sections, proprietary materials, etc. Also we would, where appropriate give a numerical value to the sweep of a wing and to aerodynamic parameters such as aspect ratio, taper ratio, and thickness ratio.

3. Recording of indexing

A supply of indexing cards is enclosed, a separate set for each system that is being done. Already an identification number denoting your organisation has been put on each card and you are requested to enter the code reference (as shown in the first column on the document list, not the source reference) of the document being indexed. After recording your indexing decisions on the card we should like you to enter, in the spaces marked, an approximation of the time that has been spent on indexing the document, and also the name of the indexer, as shown below:-

ASLIB CRANFIELD PROJECT INDEXING CARD FOR				
ORGANISATION	DOCUMENT REFERENCE	TIME TAKEN	INDEXER	
99	80-08	15 mins.	A.B.SMITH	

THE UNIVERSAL DECIMAL CLASSIFICATION

The schedules which you are requested to use are as follows :-

B.S.1000A (1947)			Abridged English edition
(0)	:	1943	Generalities
(5/53)	:	1943	Mathematics and Physics
(54)	:	1943	Chemistry
(55/59)	:	1943	Geology
(621.3)	:	1947	Electrical Engineering
(622/623)	:	1955	Mining and Military Engineering
(669)	:	1949	Metallurgy
(678/679)	:	1954	Rubbers, etc.

Aslib Aeronautical Group Draft Revision 532.5 and 533.6 (copy enclosed)

We have also been using some draft revisions for other parts of 621, but these are not now obtainable. However, if you should have copies, the British Standard reference numbers are CM(OC)4942 and CR(OC)7325. Otherwise it is suggested that you use the number as shown in the alphabetical index or alternatively the number as given in B.S.1000A.

The enclosed list of terms is a copy of the alphabetical index to the classified catalogue which has been compiled during the indexing of the first 12,000 documents. We now find that one may expect that at least 95 per cent of the headings required for indexing new documents will be in this list, but we do not, of course, wish you to restrict yourself to the U.D.C. numbers which are contained in the alphabetical index. However, we would ask that you should not use different numbers for subjects that are given in the alphabetical index.

In general, each entry consists of the word or words representing the most specific elements of the class number indexed, followed by the super-ordinate classes in ascending order, to that level which it is considered will eliminate ambiguity by differentiating between homonyms and between entries for the same subject in different contexts. No attempt has been made at chain indexing.

Exceptions to this general rule are made where obvious inconsistencies appear. These arise because the U.D.C. schedules do not have a consistent method of breakdown, and the nature of the breakdown will be reflected in the form of index entries if the rule is rigidly followed. For instance, the entry for "Turbine blades" reads:

Turbine blades. Gas turbines. Internal combustion engines,

whilst the entry for 'Propeller blades", if given in the form dictated by the schedules would read:

Blades. Propellers. Aircraft engineering.

For consistency, therefore, the latter is changed so that the entries under "Blades" are in the same form:

Blades, turbine. Gas turbines. Internal combustion engines.
Blades, propeller. Aircraft engineering.

Although modifications of this kind have been made, we have not tried to find a formula which would provide entries of a standard form independently of the schedules. This would be tantamount to constructing a subject headings list and no example of such a list of even moderate complexity, which displays a standard structure, is known. The index is therefore a compromise, but the tendency has been to endeavour to preserve the form of entry which reflects the hierarchy displayed in the schedules, at the expense of some inconsistency.

There are occasions when the specific term which the schedules dictate should be the entry term, might be considered as unsought, as for example such terms as "Design", "Research", "Production", "Measurements", etc. In such cases entry is usually made both under the prescribed form and under the second term, the first in this case being transposed and underlined, e.g.

Measurement. Impedance. Vibrations. Physics.
Impedance. Vibrations. Physics. <u>Measurement.</u>

The index is not exhaustive in the sense that all complex numbers used to date have been indexed, and no indexing of compound numbers produced by the use of the colon has been attempted, except in a few special cases such as "Cermets" which take the number 666.3:669. All main numbers used are included, however, and it is hoped that a sufficiently representative selection of numbers synthesised by the use of common subdivisions, special analyticals, etc., has been included for consistency in indexing to be maintained. The following notes on procedure may also help in this respect.

1. Class numbers may be supplemented by the use of proper names, etc., in order to specify particular types of aircraft, particular wind tunnels, engines, etc. Such names are to follow the class numbers in brackets, and in the case of aircraft, the country number is to be interpolated. The

following is a list of numbers commonly treated in this way:

629.13(42) (De Havilland-Comet) (For all aircraft except helicopters)
629.135.45(42) (Westland-Whirlwind)
533.6.071 (N.P.L. -)
621.432 (Bristol-Pegasus)
621.438 (Bristol-Orpheus)
629.136.3 (Atlas)
669.14 (A.I.S.I. -)

Other numbers may be so treated, but the basic number for the subject should be used and not that number representing a "kind" of the thing concerned, e.g. a pure jet engine should be specified by the use of 621.438(---) and not by the use of 621.438.084(---). If desired, separate entry may be made under the more specific number. This procedure provides a simple list at a single number, and eliminates the risk of overlooking some of several entries scattered by the use of specific numbers.

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

3. Common subdivisions, special analyticals, points of view numbers, country numbers, etc., may be used freely with the numbers to which the schedules show they are appropriate, with the one exception of the 621-4 numbers. The reason for this exception is that entry is frequently required under 621-4 as such because shape is paramount. Where necessary, the shape number should be coloned to the other number concerned, e.g. 669.715: 621-415 for aluminium alloy sheet.

4. 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 is paramount. For three-dimensional aerofoils and wings in general, particularly when planform is paramount, 533.693 or its appropriate subdivision should be used.

5. Variable quantities such as angle of sweepback, aspect ratio, etc., may be specified by including the value in square brackets after the appropriate class number e.g.

533.69.031 [4]
533.693.1 [35]

6. 620.17, 533.6.071 etc., may be used for both descriptions of testing equipment and methods of testing. Also when attached by a colon to the things tested they will show the nature of the test carried out. This is preferred to the use of .001.5 because of the lack of detail the latter provides.

7. We find that the combination by colons of three numbers, (e.g. 533.693: 533.6.013.13:533.69.048.5) is normally sufficient to bring the number of entries to manageable proportions for searching.

ALPHABETICAL SUBJECT CATALOGUE

The enclosed list of headings for the alphabetical subject catalogue have been generated during the indexing of the first 10,000 documents. The first section of the list consists of main headings and the last five pages are of the sub-headings that can be used. A single asterisk against a main heading indicates that it can also be used as a sub-heading. A double asterisk indicates that we have used a further term to denote speed (i.e. transonic, supersonic or hypersonic) e.g. Wings, low-drag, supersonic.

We find that the headings given in the list now meet the very large majority of our requirements but no doubt you will have to use some new headings. We were unable to find any rules dealing with a method for forming headings that were applicable and published lists of headings were in general not suitable for our purpose. We therefore endeavoured to compile some simple rules for the formation of headings and they are given at the conclusion of these notes. We should be very interested in having critical comments on these rules and should be particularly pleased to have any such rules which you might use.

It will be noticed that we have not included any "see also" references in our list of headings. We intend to compile these at a later date and hope to be able to make some comparison of the effectiveness of various methods.

RULES FOR THE CONSTRUCTION OF ALPHABETICAL SUBJECT HEADINGS

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 uninverted form is used, e.g. GAS TURBINES. In cases 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.

FACET CLASSIFICATION

The notes concerning the Facet system are substantially those prepared by Mr. B. C. Vickery and Mr. J. Farradane who compiled the Facet schedules for the project. There are only a couple of minor points which it is necessary to add:

(1) There are certain places in the schedules where different terms have been given the same notation, e.g. Nns Surface tension, capillarity. In the chain index it is vital that there should be as much consistency as possible to terminology and often in such cases it will be noted that one term has been underlined, e.g. Surface tension. This is to show that the underlined term is to be used for chain indexing. In the alphabetical index (that follows after the schedules), there will be found cross references from such terms to the actual term to be used.

(2) In some cases the same word has two meanings, e.g. "Spinning" which may be a flying operation or method of mechanical working. Where this occurs, it is shown in the schedules, and the chain index should be made in the prescribed form "Spinning (Flying operation)".

Introduction

The Facet schedules attempt to provide a special classification for aeronautics and allied subjects. The field of aeronautics itself may be taken to include such subjects as the uses of aircraft, their types and components, their performance and operation, their instruments and ground services, and so on, and also to include their aerodynamic and aeroelastic characteristics. In order to allow of indexing other material of interest in aeronautics, the schedules also cover materials, their manufacture and properties, aviation hygiene, meteorology, general technical operations, electrical and electronic equipment, managerial operations, mathematics, etc. Some of these subjects are only sketched in. Others may prove to be in greater detail than is needed.

The classification has been constructed by dividing all the concepts arising in the field into categories - groups of items of like nature, e.g. aircraft types, aircraft parts, engines, flying operations, aerodynamic entities, forces, materials, processes, etc. The categories so obtained have been arranged in a preferred order whereby the relations between terms, or order of subordination of one concept to another, are expressed by the order of these categories. Thus terms which qualify other terms come in a later group than do those which are so qualified. The groups of terms so arranged are listed in the Synopsis at the end of these notes. In the schedules themselves, each new category introduced is underlined or CAPITALISED.

To the schedules is applied a simple alphabetical notation. Twenty-six blocks of terms are each identified by a capital letter, and the terms within each such facet are given small letters.

It will be seen from the Synopsis that the conceptual categories and notational facets are not in one-to-one correspondence, for two reasons: (1) there are more than 26 categories, (2) some categories - e.g. Physical properties - are very large. To overcome these problems, the capitals have been allocated more or less evenly over the whole schedule.

Forming compound subjects

To classify a specific subject, symbols representing its component terms are combined together, in the order in which they appear in the schedules.

Wedges:	flow:	vortex sheets:	calculation
Fnf	Nkf	Ngp	Yz

Al alloy:	strength:	high temperature
Peal-a	Rp	Sud

Sandwich structure:	metal:	high temperature
Fkd	Pe	Sud

For many specific subjects, the simple combination of symbols (such as Fnf Nbf Ngp Yz) is all that is required. However, a few other notational devices are also provided.

Use of curved brackets

It is not always possible to represent specific subjects satisfactorily by combining terms in the order in which they appear in the schedule. The most usual instance of this is when a "thing" - an aircraft, a component, a material, etc. - is adjectivally qualified. Provision is therefore made at certain points in the schedule, i.e. Igb-Iyw, Prb-Px and Za-Zvm for terms which can be used out of schedule order so that they can be placed adjacent to the terms which they qualify when compounding a class symbol for a document, e.g.

Plates:	laminated:	aerodynamic heating:	temperature:	distribution:	tests
Ffe	(Px)	Oi	Ssb	(Zf)	Vi

Boundary layer:	three-dimensional:	stability
Nfk	(Igb)	Ob

Use of square brackets

In some cases it is not possible to provide a notation for all possible sub-variants of a given term, e.g. for aircraft types by name, and such names can then be inserted, after the term they qualify, in square brackets, e.g. Bc [LOCKHEED - CONSTELLATION].

Use of numerals

A further method of specifying a term more closely is by numeralisation - adding a numeral which expresses an attribute quantitatively. The schedules specifically direct that this be done at the following places.

Bg	Aircraft, planes
Bi	Aircraft, engines
Brf	Aircraft, rotors
Dh	Propeller, blades
Gc	Engine, strokes
Gy	Compressor , stages
In	Polygon, sides
Nf	Flow, dimensions
Wk	Valve, electrodes
Wnc	Transistor, electrodes

Other instances may occur, e.g.

Surface:	rough:	Mach 3.12:	transition
Fw	(It)	Nbk 3.12	Nfn

Aerofoil:	flow:	thickness ratio 10%:	camber
Cc	Nbf	Oqw 10	Oss

Steel:	carbon, molybdenum:	strength:	temperature 850°F
Pf	cmo	Rp	Ssb 850°F

The "and" problem

One last problem of forming compound subjects is the "and" problem, in which two or more terms from the same category are co-ordinate with each other. Two methods of treatment are possible: (1) treat each term separately forming two or more independent subjects and therefore two or more separate entries. (2) Include the two or more terms in a single entry, in normal schedule order.

The first method is to be preferred, exception being made only when the two terms are felt to be interdependent as far as the particular document is concerned.

Form divisions

Only two form divisions have been allotted, Bibliography, symbolised by :b, and Charts by :c.

Comment on notation

The notation has been chosen with an eye to maximum brevity:

(1) for terms within each facet, a base of letters has been used rather than only 9 numerals; (2) in allocating symbols within a facet, no consistent attempt has been made to express hierarchical relations where this would lengthen the notation (e.g. Aw is subordinate to Av, but this is not shown in the notation, although the subordination of Avb to Av is shown).

The result of relying mainly on letters is to produce class numbers such as C Ntq Rkm Rp Rvc Vi, Bc(Zs)Om Vbd Vm, or Cd(Ihc)Nq Nr Ogt Ycd. Apart from their complexity (which is simply a reflection of the complexity of the subjects indexed), it may be that such blocks of letters are not the most acceptable and easily remembered symbols that could be devised. There is need for further study of this important psychological aspect of notation. Meanwhile, the proposed ordinal and letter notation will provide a contrast to the hierarchical and numerial notation of U.D.C., and some guidance as to their relative acceptability may result from the project.

Chain indexing

Since the object of faceted classification is to be able to express complex subjects by a single notation showing the terms involved in a preferred order (that which appears most logical and helpful to the user), it follows that provision must be made for finding the position of terms distributed in the subordinated positions. This is achieved by chain indexing. In this complementary alphabetical index the concepts in a given coded subject are cited (as words) in the reverse order of the code, together with the full code. Further entries are then made for each facet in turn, omitting one facet word on the left each time, whilst quoting the code number with one less facet code term on the right each time. The final card will thus be the first facet term (of the complete coded notation) alone, with its facet notation, and this is equivalent to the card appearing in a straightforward alphabetical index to all the terms in the classification. An example follows:

Classified index entry	Cd(Ij)(Iv)Ieb Nfp Nvf Ya	
Chain structure	Cd	Wings
	Ij	Delta
	Iv	Slender
	Ieb	Leading edge
	Nfp	Separation (Boundary layer)
	Nvf	Pressure distribution
	Ya	Calculation

Alphabetical index entries

1. Calculation: Pressure distribution: Separation (Boundary layer): Leading edges: Slender: Delta: Wings Cd(Ij)(Iv)Ieb Nfp Nvf Ya

2. Pressure distribution: Separation (Boundary layer): Leading edges: Slender: Delta: Wings Cd(Ij)(Iv)Ieb Nfp Nvf

3. Separation (Boundary layer): Leading edges: Slender: Delta: Wings Cd(Ij)(Iv)Ieb Nfp

4. Leading edges: Slender: Delta: Wings Cd(Ij)(Iv)Ieb

5. Slender: Delta: Wings Cd(Ij)(Iv)

6. Delta: Wings Cd(Ij)

7. Wings Cd

Although these seven entries for a single document may appear to be a large number, it should be realised that the more general alphabetical entries will cover a number of classified entries. For example "Wings" will not be required for any of the other many thousands of entries in the classified catalogue which commence with this subject. As the catalogue grows in size, the average number of alphabetical entries per classified entry is reduced and in a very large collection the ratio tends towards unity.

UNITERM INDEX

In this introduction a reasonable familiarity with the basic principles of the uniterm system of co-ordinate indexing is assumed.

During the past few years, a number of modifications and refinements have been made to the system as originally proposed by Dr. Mortimer Taube. The general trend of these changes has been to group the uniterms into categories or concepts and they appear to lead finally to one of two forms of co-ordinate indexing, either the thesaurus approach or facet classification.

In this project we have discarded all such developments and have indexed by uniterms in their basic form. This is partly to keep the system as far as possible removed from the other co-ordinate system being investigated and also because we believe that it will, by doing it this way, be possible to ascertain what, if any, improvement is caused by various types of modifications.

The list of uniterms which is enclosed consists of terms originated during the indexing of the first 10,000 documents. Synonyms are not directly cross-referenced, but it will be noted that, for instance, the terms "Manufacture" and "Production" are both given the number "900". These numbers represent the code that is used for putting the entries on to punched cards, so it is immaterial whether "Manufacture" or "Production" is used, since they will be brought together in the sorting.

This list is likely, we now find, to meet 95% of the requirements for uniterms, but it is probable that some new terms will come up in your indexing, and we certainly do not wish you to restrict yourself to the terms in the list. Proper names or numbers may be used as required.

No particular restrictions have been put on the indexers regarding the selection of terms. In some cases it may be that all the terms used will have occurred on the title of the paper or in the abstract but in other cases the terms may be entirely different.

Comments concerning desirable depth of indexing are given in the general introduction but it may be stated that the reported experience of compilers of uniterm indexes is that the general average is 10 uniterms for each document.

Our own indexing experience bears this out, although often it has been found necessary to have 25 or 30 uniterms for a single document.

Recording of Indexing

Would you please enter on the indexing cards the uniterms that you select. It would assist us if you could place a cross against any uniterms which you use which are not already included in our list.

	U.D.C.	J.F.HADLOW		15.8.60	RESULT 1	

25-07 P12514

Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading.

First search		Second search	
Programme	Documents	Programme	Documents
669.715 (A) AB +	12 No		
620.178.3+(B) BA	31 Doc. found at		
	(A):(B):621.884.057.2		

	ALPHA	B. WARBURTON		5.7.60	RESULT 6	

25-07 P12514

Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading.

First search		Second search	
Programme	Documents	Programme	Documents
SHEETS, ALUM. ALLOY - Fatigue.	12 NO	SHEETS, ALUM. ALLOY	7 NO
Third search		**Fourth search**	
Programme	Documents	Programme	Documents
ALUMINIUM ALLOY CLAD	3 NO	PANELS, RIVETED, ALUM. ALLOY	1 NO

FIG. 1A Search card for Alphabetical and U.D.C. for question 25-07

	FACET	C.W.CLEVERDON		31.10.60	RESULT 2	

25-07

P12514

Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading.

First search		Second search	
Programme	Documents	Programme	Documents
Peal-a Al. Alloy	— +1	Hvd Peal-a Rkm	12514 +1
Rkm Fatigue			3 searches
Hvd Rivets			
Ffb Sheets			

	UNIT.	B. WARBURTON		5.8.60	RESULT 3x	

25-07

Comparison of alclad and unclad aluminium sheets riveted together and subjected to fatigue loading.

P12514

First search		Second search
Programme		Programme
ALUMINIUM ✓	STRENGTH ✓	
SHEETS X	PLATES X	
RIVETED ✓		
ALCLAD X		
FATIGUE ✓		

FIG. 1B Search card for Facet and Uniterm for question 25-07

	U.D.C.	B.WARBURTON		12.10.60	RESULT |	

28-07 P12838

Theoretical calculation of the performance of half-delta wing-tip controls on the tips of delta wings.

First search		Second search	
Programme	Documents	Programme	Documents
A 533.693.31	AB		
B 533.694.5	Doc. Found		
	at AB.512		
	AB = 25		

	ALPHA	J.F.HADLOW		5.9.60	RESULT X	

28.07 P.12838

Theoretical calculation of the performance of half-delta wing-tip controls om the tips of delta wings.

First search		Second search	
Programme	Documents	Programme	Documents
WING TIPS, MOVING +	14 No.	WINGS, DELTA — Control +	22 No
		WINGS, DELTA, SUPERSONIC — Control +	4 No.
		WINGS, DELTA, TRANSONIC — Control +	2 No.

Third search		Fourth search	
Programme	Documents	Programme	Documents
WINGS, DELTA — Performance	1 No.		
WINGS, DELTA, SUPERSONIC — Performance.	—		
WINGS, DELTA, TRANSONIC — Performance.	—		

FIG. 2A Search card for Alphabetical and U.D.C. for question 28-07

	FACET	C.W.CLEVERDON		31.10.60	RESULT 1	

28-07 P12838

Theoretical calculation of the performance of half-delta wing-tip controls on the tips of delta wings.

First search		Second search	
Programme	Documents	Programme	Documents
Id Tips ✓	12838 + 4		
Cd (Ij) Wings, Delta			
Cp Control surfaces			

	UNIT.	B.WARBURTON		5.8.60	RESULT 2X	

28-07 P12838

Theoretical calculation of the performance of half-delta wing-tip controls on the tips of delta wings.

First search	Second search
Programme	Programme
WINGS ✓	
DELTA ✓	
TIP X	
CONTROL ✓	
PERFORMANCE X	

FIG. 2B Search card for Facet and Uniterm for question 28-07

ASLIB CRANFIELD PROJECT

INDEXING CARD FOR UNIVERSAL DECIMAL CLASSIFICATION

ORGANISATION	DOCUMENT REFERENCE	TIME TAKEN	INDEXER
79	12414	15 mins	B.G.

(A) 623.746.3 073	ABC	
(B) 533.6.013.423	BAC	
(C) 533.6.013.413	CAB	

ASLIB CRANFIELD PROJECT

INDEXING CARD FOR ALPHABETICAL SUBJECT CATALOGUE

ORGANISATION	DOCUMENT REFERENCE	TIME TAKEN	INDEXER
50	12414	15 mins	C.A.L

DAMPING – Stability. Flight tests	
STABILITY, LATERAL –	Damping. Flight tests
AEROPLANES, FIGHTER –	Effectiveness. Flight tests
–	Stability. Flight tests
FLIGHT TESTS – Stability,	damping
– Damping	

ASLIB CRANFIELD PROJECT

INDEXING CARD FOR FACET CLASSIFICATION

ORGANISATION	DOCUMENT REFERENCE	TIME TAKEN	INDEXER
32	12414	10 mins	B.P.

Bhg (An) Gvy (Zod) Dap Dch Sfu

Damping: Lateral Stability. Directional Control.

Fixed. Guns: Fighter: Turbojet aeroplanes

ASLIB CRANFIELD PROJECT

INDEXING CARD FOR UNITERM

ORGANISATION	DOCUMENT REFERENCE	TIME TAKEN	INDEXER
31	12414	16 mins	HT

FLIGHT	INVESTIGATION	STABILITY
LATERAL	DAMPING	NACA
FIGHTER	AIRCRAFT	
GUN	EFFECTS	
PLATFORM	EFFECTIVENESS	

FIG. 3. SUPPLEMENTARY INDEXING MASTER CARDS FOR DOCUMENT P12414

W.R.U. TEST. CRANFIELD INDEX MASTER CARD

Document No.	Indexer	Date	Total Time	Analysis	Notation
1455	JA	8.10.61	20 mins	10 mins	10 mins

Reference Metal Progress Vol. 79, April 1961 pp 88.
Non-destructive testing for management. 2. How to use magnetic particle methods.

ANALYSIS	NOTATION	INDEX ENTRIES	
MAGNETIC PARTICLE TESTING	1 Xu aed 2 Nfe	1:2 1:3	5:1 6:1
FERROMAGNETIC MATERIALS — IRON, NICKEL, COBALT	3 Nni 4 Nco	1:4 2:1	7:1 8:1
SURFACE DEFECTS,	5 Pej 6 Pj	3:1 4:1	9:1
CRACKS, INCLUSIONS, SEAMS	7 Od 8 Odk	1:5 1:6	
SUBSURFACE DEFECTS BLOWHOLES, POROSITY	9 Pec	1:7 1:8	
		1:9	

FIG. 4. MASTER INDEXING CARD FOR CRANFIELD FACET INDEX

IN W.R.U. TEST