matching then fails in the chemical fragments table, leaving the remainder LEROV. Eventual main dictionary lookup of this remainder finds no such entry in the dictionary. The whole operation is therefore cancelled, and the original textword is simply transliterated and printed out in the translation as *Butlerov*, which is in this instance the proper treatment.

Example IV: BROMKAMFORSUL'FONOVAYA.—BROM is matched, then matching fails, and the remainder is eventually looked up in the main dictionary. There KAMFORSUL'FONOV- is not found (although KAMFOR and SUL'FONOV- are present). The treatment is cancelled, and the original textword remains untranslated; in this example our program fails, although the cancellation rule prevents any erroneous translation from being printed out.

Example I is a rational name; Example II a half-rational name with the non-rational part UKSUSN- at the right-hand end. These are the types the program is expected to translate. Example IV is a half-rational name with the non-rational part KAMFOR not at the extreme right. This type is fortunately less frequent. It is obvious that, by extension of the program along the same lines, and by extension of the dictionary and chemical fragments table, such types might be handled.

Thus our program will translate a large fraction of Russian organic chemical names, and in case of failure does not produce false translations. We believe that, with enough labor on the control lists and with extension of the programs on the basis of the same principles, translation of organic chemical names could be accomplished, not only from Russian to English, but in general from any language into whatever other form of representation might be desired.

REFERENCES

(1) A. M. Tsukerman and A. P. Terent'ev, Proc. Int. Conf. for Standards on a Common Language for Machine Searching and Translation, Vol. I, Interscience Press, New York, 1961; others have used this classification.

(2) L. Summers, Proc. 1st Intl. Conf. on Machine Translation of Languages and Applied Language Analysis, Natl. Physical Lab., Teddington, England, 1961.

(3) *Cf.* E. Garfield, "An Algorithm for Translating Chemical Names to Molecular Formulas," Inst. for Sci. Information, Philadelphia, 1961, p. 35.

(4) J. H. Wahlgren, Proc. 1st Intl. Conf. on Machine Translation of Languages and Applied Language Analysis, Natl. Physical Lab., Teddington, England, 1961.

A New Method for the Search of Scientific Literature Through Abstracting Journals*

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A new method of literature search using abstracting journals is presented. A model is adopted and by mathematical analysis relations are obtained which yield quantitative results. Statistical experiments are conducted on the literature covering the area of thermophysical properties of all matter to verify the analytical results. The experimental results are found to be in agreement with the theoretical predictions. The costs of literature search by the proposed method and another method (consisting of going through the volumes of abstracting journals page by page) are compared. It is found that the proposed literature search method gives a considerable cost reduction. Some statistical data pertinent to the research literature on thermophysical properties are given.

I. INTRODUCTION

The object of this study is to present a method for literature search using abstracting journals. A model is used for this purpose and by mathematical analysis useful relations are obtained which are verified experimentally. The reason for the investigation of the new method of search is to reduce the time and search cost in comparison to the cover-to-cover search method.** The proposed model is the following: An investigator starts searching the abstracting journal beginning with the most recent issue and goes back number of years a. Then, he searches the bibliographies of the papers that were located in the a years interval for new references. In this second step, a period of $(b-a)$ years is covered. Next, he starts using the abstracting journal again for a direct search of another a years starting from the year b. This may be repeated in cycles until the desired period of years is covered. The details of the approach and the derivations of the resultant equations are not presented in this paper. The reader interested in the mathematical procedures employed in the derivations may refer to the two studies on this subject.[1,2]

* The study reported here was conducted at the "Thermophysical Properties Research Center," School of Mechanical Engineering, Purdue University, and was sponsored in part by the National Science Foundation—Science Information Service.

** The cover-to-cover search method consists of going through the volumes of the abstracting journals page by page. It can be noted that there is also a method of literature search by the use of indexes, but in this study it is not considered as a basis for comparison, since the literature search by the use of indexes does not give the most nearly complete yield on publications.

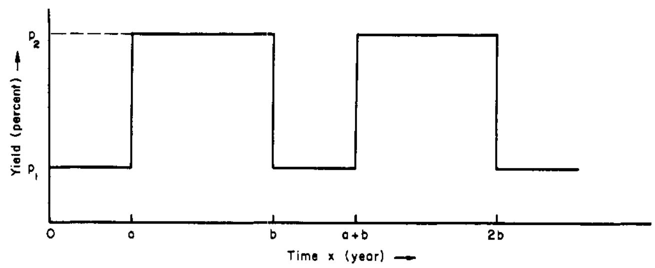

Fig. 1.—Search cycle which is being analyzed.

II. GENERAL TIME DISTRIBUTION CURVE OF ARTICLES OBTAINED FROM THE REFERENCES OF PAPERS PUBLISHED IN A GIVEN YEAR

Consider the model represented by Fig. 1. The year at which the search starts is denoted by $x = 0$. Consider that p_1 is the yield defined by the ratio of useful abstracts found (those pertinent to the subject matter under investigation) to the total number of abstracts searched in the interval of a years which represents the time of direct search through the abstracting journal. The quantity p_2 is the yield for the interval of $(b-a)$ years which represents the time interval where articles are located through the search of the references of papers found in a years interval. The quantities p_1 and p_2 are two important parameters for the computation of the relative cost between the two methods of literature search.

For purposes of quantitative analysis, it is essential to know the time distribution of useful references obtained from papers published in a given year falling in the interval of a years.

In Fig. 2 the area ABCD represents the number of references falling in the year 1953 and, similarly, each of the other rectangular areas represents the number of references falling in the year indicated by the abscissa. Since the base of each rectangle is unity, the ordinates are numerically equal to the areas of the rectangles.

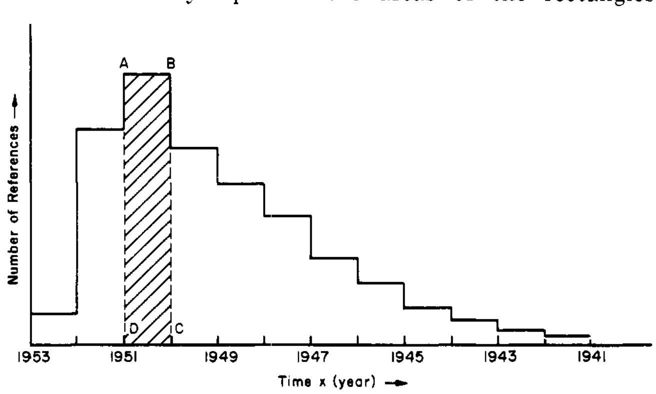

Fig. 2.—Sample distribution by date of useful references obtained from papers published in a given year, 1953.

As will be seen later, for the computation of the yield p_2 and also parameters a, b, c, and d (for the meaning of c and d see Fig. 4) it is necessary to know the equation of the distribution curve. In the above case, it is a step function, first increasing and then decreasing with equal base intervals and unequal jumps. The equation of such a curve can be approximated with satisfactory accuracy by the method of Fourier series. Since the use of Fourier

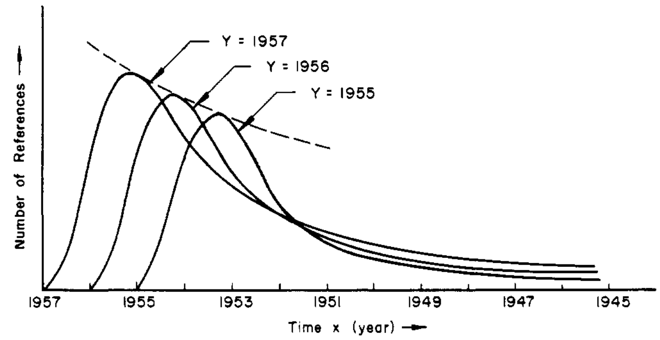

Fig. 3.—Distribution by date of useful references obtained from papers published in given years, Y.

series gives mathematically involved equations in the case of curves having more than two steps, it is desirable to have a smooth and continuous curve to represent the same distribution. Some typical distribution curves of this type are given in Fig. 3.

It is seen from Fig. 2 and 3 that the point corresponding to the maximum number of references obtained per year decreases in magnitude as the search year of the papers goes back. This means that the total number of articles obtainable from the references of papers published in a certain year decreases as the year of publication of the papers goes back. The distribution curves in Fig. 3 can be normalized by dividing the ordinates by the total number of articles represented by the areas under the curves. From available statistical information, it is concluded that the peak of the distribution curve falls two years back. This corresponds to $c = 2$.

For purposes of mathematical simplification of the treatment of the problem, the curves in Fig. 3 are approximated by straight lines such that the area under each curve is represented by a right triangle, (Fig. 4). The condition is that areas under each of the distribution curves of Fig. 3 are equal to the areas of the triangles of Fig. 4, corresponding to the same year of search. According to the process of normalization, P_i represents the ratio of the maximum ordinate of the curve i in Fig. 4 to the area under the same curve.

According to the definition of P_i and the significance of triangular areas, it can be seen that

$$P_i d/2 = 1 \tag{1}$$

As is seen from Fig. 4, the tails of the original distribution curves are cut at points corresponding to the years where the yields become small relative to the maximum yield.

For the present model it is assumed that the rate of change of the maximum ordinates of the triangles is linear with respect to time. This is seen in Fig. 4. The angle,

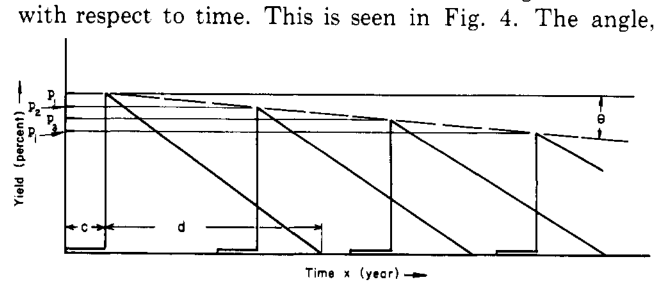

Fig. 4.—Simplified distribution curves corresponding to the ones shown in Fig. 3.

θ, is a parameter establishing the rate of change. The angle θ is measured from the horizontal line passing through P_1 (hereafter P_1 will be referred to as P) and the straight line which is the envelope of the maximum points of the triangles 1, 2, 3, . . . , i. It should be observed that θ is measured in the negative direction; thus there is a minus sign associated with the angle θ. This should be noted in all of the forthcoming calculations. It is further assumed that the bases of all triangles are equal.

The actual physical meaning of the preceding model is the following: it is considered that the number of references obtained through the search of papers for one year is decreasing linearly as the dates of publication of the references go back. It is further considered that the number of references obtained through the papers published in different years is decreasing linearly as the publication year of the papers located by direct search of the abstracting journal goes back.

III. FACTORS AFFECTING THE YIELD p_2 AND THEIR EVALUATION

The yield p_1 is directly obtainable from experiments (reading the abstracting journal and finding the ratio of the useful abstracts to the total number of abstracts searched). Thus, there are no mathematical factors affecting p_1. On the other hand there are four principal factors that influence the numerical value of p_2. One may express p_2 as

$$p_2 = J_I J_{II} J_{III} J_{IV} \tag{2}$$

These four J factors are defined in the following paragraphs.

Factor J_I: is the ratio of articles pertinent to the subject of interest to the total number of articles listed in the bibliography section of papers found through the search of the abstracting journal.

Factor J_{II}: in the process of plotting the distribution curve (Figure 3), for papers published in a given year, there may be duplications of articles. Therefore, the ordinates of the distribution curve drawn on the basis of gross information (regardless of the number of duplications) will not represent the true useful information, which is the number of references excluding the duplicates. Under these conditions, the original distribution curve should be modified. The factor J_{II} is introduced to take care of this modification.

Factor J_{III}: a certain percentage of the references listed in the bibliographies of papers located during the a years of search of the abstracting journal will be dated within the same period and consequently will already have been located. On the other hand, a certain percentage of these references will be dated more than b years back, which means that probably they will be located again during the second and perhaps third cycle of the abstracting journal search. The factor J_{III} is introduced to account for the duplication of the same information (paper) as explained above.

Factor J_{IV}: a certain percentage of the references, falling in the time interval $(b - a)$ years, listed in the bibliographies of papers located during a certain year of the abstracting journal search will be found in the bibliographies of papers located during another year of the abstracting journal search. The factor J_{IV} is introduced to eliminate the possible duplications of information (papers) as explained above.

Since for many physical and mathematical reasons none of the J's can be unity, it follows that p_2 is always less than one.

Based upon the model presented earlier, mathematical expressions are derived for the J factors that affect the yield p_2, with the exception of J_I. From the definition of J_I it can be seen that it is not possible to determine J_I analytically, and its numerical value must be established through the statistical analysis of a representative sample of the literature.

The analytical relations obtained for the various J's in terms of the parameters a, b, c, d, and θ are given. For the derivations of these equations the reader may consult references 1 and 2.

$$J_{II} = 1/(kd^2 + 1) \tag{3}$$

where k is a proportionality constant to be determined experimentally.

$$\begin{aligned} J_{III} = [1/3ad^2(P + (a/2)\tan\theta)]\{ & P[(b-d-c)^3 \\ & - c^2(3d+c) + 3a(b-a)(2d+2c-b)] + (\tan\theta/4) \\ & [(b-c)^4 + (c+d)^4 + (d-b)^4 + 4a^3(2b-3d-3c) \\ & + 6a^2b(-b+2c+2d) + 12bcd(b-d-c) - 4c^3 \\ & (-a+d) - (12ac^2d + 2a^4 + b^4 + d^4)]\} \end{aligned} \tag{4}$$

In this equation $\tan\theta$ is negative since θ is measured in the negative direction.

It is verified experimentally that for most of the cases θ can be assumed to be zero, thus

$$\begin{aligned} (J_{III})_{\theta=0} = (1/3ad^2)\,[& (b-d-c)^3 - c^2(3d+c) \\ & + 3a(b-a)(2d+2c-b)] \end{aligned} \tag{5}$$

$$J_{IV} = 1 - (sU/4R) \text{ for the case where } d > (b-a) \tag{6}$$

$$J_{IV} = 1 - (sU'/4R) \text{ for the case where } d < (b-a) \tag{7}$$

where

$$\begin{aligned} U = [& (b-c)^4 + (c+d)^4 + (d-b)^4 \\ & + 4a^3(2b-3d-3c) + 6a^2b(-b+2c+2d) \\ & + 12bcd(b-d-c) - 4c^3(-a+d) \\ & - (12ac^2d + 2a^4 + b^4 + d^4)] \end{aligned} \tag{8}$$

$$\begin{aligned} U' = [& (b-c-d)^4 + (a-b-d)^4 + 4a^3(3b-4c-3d) \\ & + 4b^3(3a+c) + 8d^3(a-2b+c) \\ & + 6a^2(4bc - 3b^2 + 2bd - 2d^2) \\ & + 12d^2(ab+ac-bc) - 3a^4 - 12ab^2c - 4b^4 + 4d^4] \end{aligned} \tag{9}$$

$$R = [(b-d-c)^3 - c^2(3d+c) + 3a(b-a)(2d+2c-b)] \tag{10}$$

and s is a proportionality constant to be determined experimentally.

IV. ESTIMATION OF RELATIVE COSTS BETWEEN CONVENTIONAL AND PROPOSED LITERATURE SEARCH METHODS

In Section III it was shown that the factors J_I, J_{II}, J_{III}, and J_{IV} had to be known for the evaluation of the yield p_2. The above-mentioned factors are expressed in terms of the parameters a, b, c, d, and θ. In this section the criteria for the selection of these parameters are summarized.

The values of c and d are determined by analyzing the simplified distribution curve (Fig. 4). A number of experiments performed on a statistical basis show that c has a value of approximately two years. The value of d remains constant for each triangle and is not a function of the number of years covered by the search. Therefore, it can be said that c and d are fixed parameters for the literature search on a certain subject. It is experimentally verified that for practical purposes θ can be assumed to be zero (Ref. 2). On the other hand, the selection of a and b is much more critical. Out of a large number of possible choices one should select a pair of values which will give the optimum cycle for a desired overall yield. This optimization is dependent on factors such as cost for search and yield. For instance, small values of a give low cost; on the other hand, relatively greater values of a are necessary in order to obtain a greater yield.

Based upon the criteria of the percentage available information in a given year, relations are obtained for a and b after considerable mathematical manipulations (Ref. 1 and 2):

$$a = d(1 - \sqrt{1-M}) \tag{11}$$

$$b = c + d[2 - (M+N)/2(1 - \sqrt{1-M})] \quad \text{for } (a+c) < b < (c+d) \tag{12}$$

with the relationship

$$(M+N)/(1 - \sqrt{1-M}) \geqq 2 \tag{13}$$

and

$$b = c + d[2 - \sqrt{1-M} - \sqrt{N}] \text{ for } (c+d) < b < (a+c+d) \tag{14}$$

with the relationship

$$(M+N)/(1 - \sqrt{1-M}) \leqq 2 \tag{15}$$

where M is the cumulative number of references found in the year $(a + c)$, and N the cumulative number of references found in any other arbitrarily selected year. Both M and N are normalized relative to the maximum number of possible available references.

In the previous sections, the factor affecting the yield and the parameters necessary to determine the J's were presented. The objective of all these steps was to be able to find the ratio, R, of the cost of the proposed literature search method to the cost of the cover-to-cover literature search method, using abstracting journals. The following expression is found for R

$$R = (a/b) + [1 - (a/b)][p_1/p_2] \tag{16}$$

By substituting the known and determined values for the quantities on the right-hand side of the above equation, one finds that the proposed method is more economical than the cover-to-cover search method. In the next section, experimental results are given to verify the theoretical predictions.

V. EXPERIMENTAL VERIFICATION OF THE PROPOSED METHOD FOR LITERATURE SEARCH IN ABSTRACTING JOURNALS

A direct search of certain sections (those containing thermophysical properties) of the journal *Chemical Abstracts* is made for four years (January 1954–December 1957) for seven thermophysical properties (thermal conductivity, specific heat, viscosity, diffusion coefficient, emissivity, thermal diffusivity, and Prandtl number) for all matter. By this process, 2193 published papers are located. Then, the bibliographies of these 2193 papers are searched, and 24,621 papers are obtained.

The parameters a and b are determined on the basis of the arbitrary M and N values, and are found to be 4 and 18, respectively. From the experimental results the parameters c and d are calculated to be 2 and 19, respectively. Various kinds of duplicate searches are conducted to supply the necessary information for the determination of the factors J_{II}, J_{III}, J_{IV}, and p_2. Some of the experimental results are given in Figs. 5 and 6.

The experimental p_2 was found by taking the product of the experimentally found four J factors. The theoretical p_2 was found by taking the product of the theoretically found J factors. A summary of the results is given*:

Quantity	Theoretical	Experimental	Per cent. deviation based on theory
J_I	...	0.842	...
J_{II}	0.813	0.830	2.09
J_{III}	0.861	0.572	33.50
J_{IV}	0.816	0.802	1.71
p_2	0.482	0.321	33.40

The proportionality constants k and s appearing in equations (3) and (6) are found to be 6.38×10^{-4} (year)$^{-2}$ and 1.08×10^{-1} (year)$^{-1}$, respectively.

By a direct search of the abstracting journal, the value of p_1 is determined to be 0.1. Using the above information, the ratio R (given by equation 16) is calculated to be 0.46. This means that, for the case investigated, the cost of the proposed method of search is only 46% of the cost of the cover-to-cover search method, using the abstracting journal only. In other words, a 54% reduction in cost is realized.

VI. CONCLUSIONS

From the evidence at hand it can be concluded that the results obtained from the proposed theoretical model are in substantial agreement with the experimental results. It is seen that the analytically obtained p_2 is somewhat higher than the experimentally obtained result. This is

* For the complete set of data and detailed calculations, the reader should consult ref. 2.

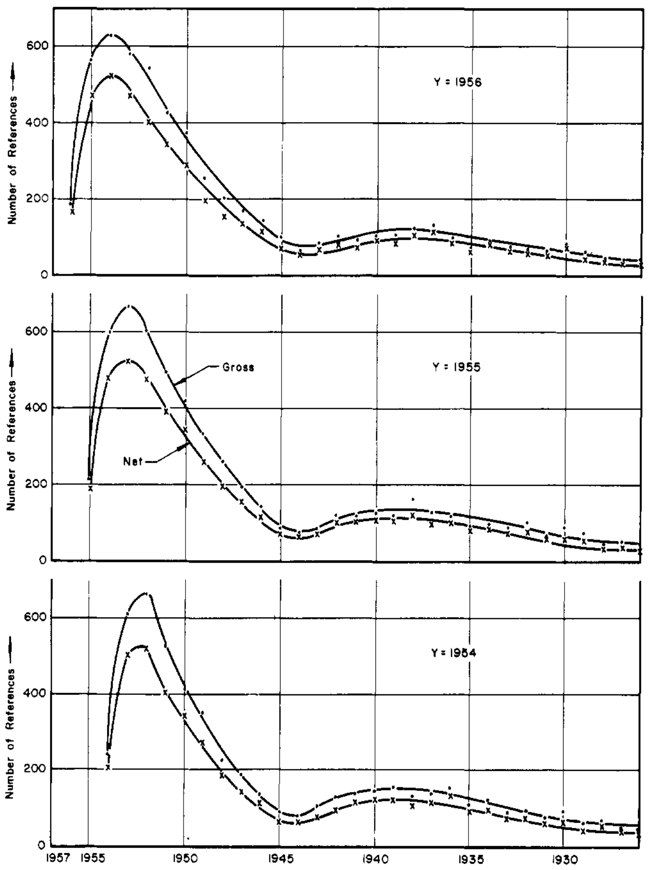

Fig. 5.—Distribution by publication date of useful gross and useful net number of references obtained from papers published in given years, Y.

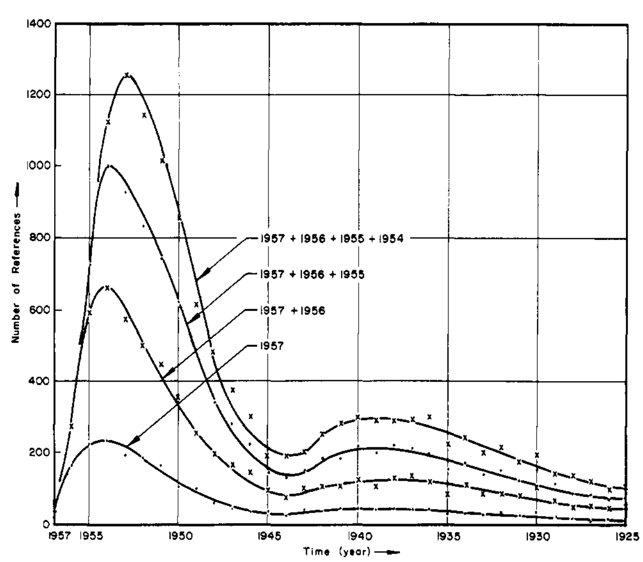

Fig. 6.—Distribution by date of the total cumulative net number of useful references obtained from papers published in the years 1954, 1955, 1956, and 1957.

attributed to the assumed triangular distribution of references (Fig. 4), which does not represent accurately the experimental data presented in Fig. 5, as the latter shows that the smoothly increasing function is distorted during the war years. Also, the triangular distribution cuts off a portion of the tail of the distribution curve of Fig. 5.

The method of literature search presented in this work is primarily applicable to those subject areas whose literature is increasing uniformly in time. Literature on thermophysical properties is an example of this kind. On the other hand, for literature search on a subject such as thermoelectric properties or thermoelectricity in general, the proposed method would not be very useful since publications in this field are spread thinly over a period of nearly a hundred years (with the exception of the last ten years).

To the extent that thermophysical properties research is representative of most of the research done in the pure and applied sciences, one may apply the results presented herein to a wide number of subject areas, with the exception of the specialized fields of study that have been developed recently. The statistical data presented in the following section will prove useful for most of the branches of the physical sciences and technology.

VII. STATISTICAL DATA PERTINENT TO THE LITERATURE ON THERMOPHYSICAL PROPERTIES

A. The Rate of Growth of Research on Thermophysical Properties. The search of *Chemical Abstracts* over the period 1940–1958 yielded 7548 papers on thermophysical properties appearing in periodicals throughout the world. Figure 7 shows the variation of the number of published papers as a function of their publication years. It is seen that for the years corresponding to the Second World War there is no definite pattern of the variation of publications. On the other hand, after 1945 the publications are increasing almost linearly with time.* It is found that the number of publications on thermophysical properties is being doubled every eight years.

B. The Comparative Research Activities in Various Countries in the Field of Thermophysical Properties. Using a sample of 9810 published papers (over the period 1940–1958) on thermophysical properties the contributions of various countries are studied and the results are presented in Table I.

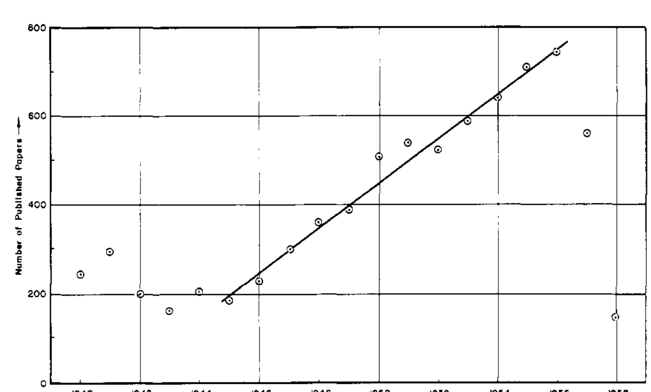

Fig. 7.— The variation of the number of papers on thermophysical properties as a function of their publication years (obtained from *Chemical Abstracts*).

* It must be noted that the values corresponding to the years 1957 and 1958 (Fig. 7) are not representative. The reason is that there is always a time lag between the publication date of a paper and the citation of its abstract in the abstracting journal.

It is seen that 1282 journals published in 41 countries gave a yield of 9810 papers. Furthermore, the top** seven countries (U.S.A., USSR, England, Germany, Japan, France, and Holland) are investigated separately. These seven countries have published 76.5% of the total number of journals (out of 41 countries). Also, the same seven countries have published 88.5% of the total number of papers.

C. The Top Twenty-Five Scientific Journals of the World Based on Papers on Thermophysical Properties Research.—Using a sample of 9810 published papers (over the period 1940–1958) on thermophysical properties in 1282 journals the contributions of various scientific journals are studied and the results are presented in Table II and in Fig. 8. It is seen that about 2% of all journals (the given percentage corresponds to the top twenty-five journals) contains about 39% of all publications on thermophysical properties.*

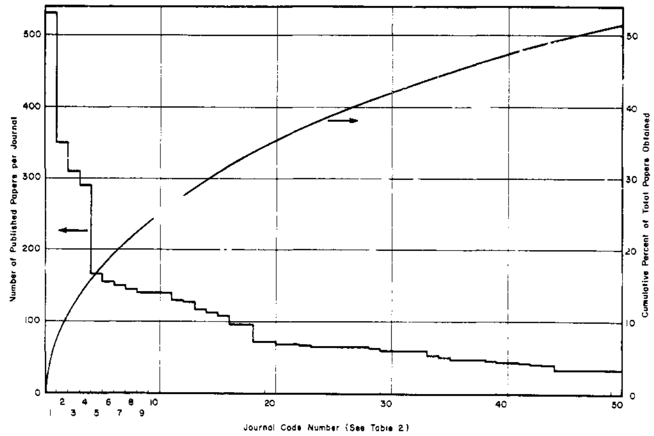

Fig. 8.—Variation of the Number of Published Papers per Journal and Cumulative Percentage of Total Papers Obtained as a Function of Journals.

Table I. The Number of Journals and the Number of Published Papers on Thermophysical Properties in Various Countries (for the Period 1940–1958)

	Country	Number of journals	Number of papers	Per cent. of total number of papers
1	Argentina	7	8	0.082
2	Australia	14	37	0.377
3	Austria	9	45	0.459
4	Belgium	15	36	0.367
5	Brazil	7	14	0.143
6	Bulgaria	3	3	0.031
7	Canada	17	131	1.337
8	Chile	5	6	0.062
9	China	6	11	0.112
10	Czechoslovakia	16	59	0.601
11	Denmark	5	55	0.562
12	England	121	1027	10.480
13	Finland	7	22	0.225
14	France	67	390	3.980
15	Germany	142	949	9.680
16	Holland	20	258	2.632
17	Hungary	10	18	0.184
18	Iceland	1	1	0.001
19	India	24	189	1.930
20	Indonesia	1	3	0.031
21	Ireland	1	1	0.001
22	Italy	48	138	1.406
23	Japan	107	677	6.920
24	Malaya	1	3	0.031
25	Mexico	2	2	0.002
26	New Zealand	1	1	0.001
27	Norway	2	2	0.002
28	Pakistan	1	1	0.001
29	Peru	2	3	0.031
30	Poland	16	28	0.286
31	Rumania	9	13	0.133
32	U. S. S. R.	186	1358	13.850
33	Scotland	7	118	1.211
34	Spain	14	43	0.439
35	Sweden	16	44	0.449
36	Switzerland	17	62	0.633
37	Turkey	1	1	0.001
38	Union of S. Africa	5	13	0.133
39	U. S. A.	340	4025	41.050
40	Venezuela	1	1	0.001
41	Yugoslavia	8	14	0.142
	Total	1282	9810	100.000

** From the standpoint of the number of published papers.

D. Average Number of Authors, Average Number of Pages, and Average Number of References per Paper on Thermophysical Properties.—Using a sample of 2193 published papers on thermophysical properties the following information is obtained concerning the number of authors attached to a paper.

Number of authors	Number of papers	Percentage of the total
1	916	41.80
2	855	38.95
3	307	14.00
4	57	2.60
5 or more	58	2.65
Total	2193	100.00

Using the tabulated figures it is found that the average number of authors per paper is 1.85. The average number of pages per paper is found to be 6.9.

The bibliographies of 2193 papers are investigated and 29,250 general and 24,621 useful (pertaining to thermophysical properties only) references are found. This information shows that the average number of general references and the average number of useful references cited per paper are 13.4 and 11.3, respectively.

VIII. NOMENCLATURE

Symbol	Definition
a	Number of years of literature search through abstracting journals.
b	Number of years covered by a complete search cycle.
c, d	Search parameters.
J_I	Ratio of the useful references to the total references listed in the bibliography of a paper originally located from abstracting journal.
J_{II}	Ratio of the net number (no duplicates) of useful references to the total number of useful references obtained from the bibliographies of papers published.
J_{III}	Ratio of the useful references to the total number of references located in the bibliographies of all papers found during search of abstracting journals for a period of a years.

* From Fig. 8 it is seen that 3.9% of all journals (the given percentage corresponds to the top fifty journals) contain 51.31% of all publications. For the details concerning the top fifty journals the reader may consult Ref. 2.

Table II. Various Scientific Journals and Their Publication Yield on Thermophysical Properties (Listed in Decreasing Order of Yield) [for the Period 1940–1958]

*These sources of information are recognized to be different in character from all others listed here. They are included in this tabulation since they constitute important sources of information even though their coverage may not be systematic or complete.

Journal No.	Name of journal	Number of papers: Per journal	Number of papers: Cumulative	% Yield of the journal based on all papers	Cumulative % of: All journals	Cumulative % of: All papers
1	Journal of the American Chemical Society	529	529	5.390	0.078	5.39
2	Journal of Chemical Physics	348	877	3.550	0.156	8.94
3	Physical Review	309	1186	3.150	0.234	12.09
4	Industrial and Engineering Chemistry	291	1477	2.970	0.312	15.06
5	Zhurnal Fizicheskoi Khimii (Journal of Physical Chemistry)	165	1642	1.680	0.390	16.74
6	Proceedings of the Royal Society, London	156	1798	1.590	0.468	18.33
7	Doklady Akademii Nauk SSSR	152	1950	1.550	0.546	19.88
8	Journal of Applied Physics	145	2095	1.480	0.624	21.36
9	Comptes Rendus hebdomadaires des seances de l'academie des sciences, Paris	141	2236	1.437	0.702	22.80
10	Journal of Polymer Science	141	2377	1.437	0.780	24.24
11	Armed Services Technical Information Agency, ASTIA and Aeronautical Systems Div., ASD (formerly WADD), (tech. rept.)*	141	2518	1.437	0.858	25.68
12	Journal of Physical Chemistry	128	2646	1.304	0.936	26.98
13	Physica	126	2772	1.284	1.014	28.26
14	Philosophical Magazine	117	2889	1.192	1.092	29.45
15	Proceedings of the Physical Society, London	114	3003	1.162	1.170	30.61
16	Zhurnal Tekhnicheskoi Fiziki (Journal of Technical Physics)	108	3111	1.100	1.248	31.71
17	Transactions of the Faraday Society	96	3207	0.978	1.326	32.69
18	Kolloid-Zeitschrift	96	3303	0.978	1.404	33.67
19	Journal of the American Ceramic Society	73	3376	0.744	1.482	34.41
20	Annalen der Physik	73	3449	0.744	1.560	35.16
21	Zhurnal Obshchei Khimii (Journal of General Chemistry)	70	3519	0.714	1.638	35.87
22	Zhurnal Prikladnoi Khimii (Journal of Applied Chemistry)	70	3589	0.714	1.716	36.58
23	Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki (Journal of Experimental and Theoretical Physics)	68	3657	0.693	1.794	37.27
24	University Microfilms Publications*	66	3723	0.673	1.872	37.95
25	Nature (London)	66	3789	0.673	1.950	38.62

J_{IV} Ratio of the net number (no duplicates) of useful references to the total number of useful references located in the bibliographies of all papers found during the search of abstracting journals for a period of a years.

k Proportionality constant.

M, N Cumulative number of references (normalized) corresponding to particular years.

p_1 Per cent of useful abstract yield in searching through abstracting journal.

p_2 Per cent. of useful abstract yield in searching through bibliographies of technical papers.

P Ratio of the maximum ordinate of Fig. 3 divided by the total number of papers.

s Proportionality constant.

x Time in years.

θ Angle giving the variation of P_i with respect to time.

Refers to the i'th item of a series of consecutive numbers.

IX. REFERENCES

(1) Lykoudis, P. S., Liley, P. E., and Touloukian, Y. S., "Analytical Study of a Method for Literature Search in Abstracting Journals," Proceedings of the International Conference on Scientific Information, National Academy of Sciences-National Research Council, Washington, D. C., pp. 351–375, 1959.

(2) Cezairliyan, A. O., Lykoudis, P. S., and Touloukian, Y. S., "Analytical and Experimental Study of a Method for Literature Search in Abstracting Journals," Document PB 171478, Office of Technical Services, U. S. Department of Commerce, Washington, D. C.