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Twenty-Five Years of Pioneering Accomplishments by CINDAS—A Retrospective Review

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A brief presentation is given on the establishment and history of the Center for Information and Numerical Data Analysis and Synthesis (CINDAS), along with the scope of its activities and accomplishments. In line with the Center's prime involvement, special emphasis is given to the existence of discord in numerical data in the literature, and the role of critical data analysis and synthesis is provided through illustrations. Statistical data are presented showing the growth of the literature on thermophysical properties between 1780 and 1980.

KEY WORDS: CINDAS; data analysis; data synthesis; history of thermophysical properties; statistical data.

1. WHAT IS CINDAS?

The *Center for Information and Numerical Data Analysis and Synthesis* (CINDAS) is a national center with a mission to maintain an in-depth cognizance of the worldwide scientific and technical literature on the thermophysical, electronic, electrical, magnetic, and optical properties of all materials of technological and scientific interest.

CINDAS is a nonteaching department within the Schools of Engineering at Purdue University. It consists of the Divisions of Scientific Documentation, Data Evaluation, and Theoretical Research. As of 1974, the experimental research activities at CINDAS have been administratively transferred to the School of Mechanical Engineering, but the laboratory continues to operate within the CINDAS premises as the Thermophysical Properties Research Laboratory.

The primary mission of CINDAS is to critically evaluate, on a selective

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Table I. Scope of CINDAS Operations

Properties covered	
Thermophysical properties	
Thermal conductivity	Absorptance
Accommodation coefficient	Transmittance
Thermal contact resistance	Solar absorptance to emittance ratio
Thermal diffusivity	Prandtl number
Specific heat at constant pressure	Thermal linear expansion coefficient
Viscosity	Thermal volumetric expansion coefficient
Emittance	
Reflectance	
Electronic, electrical, magnetic, and optical properties	
Absorption coefficient	Magnetic susceptibility
Dielectric constant	Mobility
Dielectric strength	Refractive index
Effective mass	Work function
Electric hysteresis	Electron emission properties [4]
Electrical resistivity	Luminescence properties [5]
Energy bands	Magnetoelectric properties [4]
Energy gap	Magnetomechanical properties [2]
Energy levels	Photoelectronic properties [5]
Hall coefficient	Piezoelectric properties [2]
Magnetic hysteresis	Thermoelectric properties [3]
Materials covered	
Nearly all materials of scientific and technical interest. To date the materials directory cites over 57,000 materials plus some 9,000 synonyms and trade names.	
Physical parameters covered	
Full range of temperatures, pressures, wavelengths, physical states, languages, and subjects, retrospective to the year 1900, and often earlier.	

basis, the numerical data on the physical properties of materials with a view of generating what is referred to as "recommended" or "best" values for these properties. In order to enable it to accomplish this goal, CINDAS identifies, secures, and codifies in depth all available world literature within its scope of coverage and performs computerized special literature searches on demand. It also makes available its magnetic tapes for use by others. The scope of CINDAS's mission is summarized in Table I.

2. HISTORICAL BACKGROUND

In my early years of university research in heat transfer and thermodynamics, I soon became aware that attempts at meaningful design and evaluation of the performance of engineering systems were futile unless the knowledge of the physical properties of materials and substances concerned in the study of systems were known within acceptable accuracy levels. When the knowledge on the properties of materials in the open literature often turned out to be severalfold divergent from each other, it was clear that a need existed for better data on the properties of materials. With this realization, I was convinced that perhaps one of the most rewarding areas of scientific and engineering contributions was an attempt to improve the state of knowledge on the physical properties of matter in general and thermophysical properties in particular.

Plans were drawn with a view of establishing a center on thermophysical properties research at Purdue University. Twenty-two industrial organizations and two governmental research agencies made commitments of nearly $300,000 to try out an idea not necessarily new in itself, but rather novel in structure and conception. Hence, on January 1, 1957, the Thermophysical Properties Research Center (TPRC) was established at Purdue University. It was perhaps a gamble by those twenty-four Founder Sponsors whose names are listed on the inside cover of our Annual Report each year. On the other hand, the potential returns were high enough that in the event of possible success, the benefits would definitely justify the gamble, and science and technology would stand to benefit.

From such modest beginnings, TPRC progressed because of its convictions, dedication, and excellence. In 1962, Purdue University found it appropriate to designate TPRC an administratively separate nonteaching entity within the Schools of Engineering, and in the fall of 1963, TPRC moved to its present quarters, a 17,500 ft^2 new building. In 1974, when the activities of TPRC were extended beyond thermophysics, the name of the center was changed from the Thermophysical Properties Research Center (TPRC) to its present name of Center for Information and Numerical Data Analysis and Synthesis (CINDAS).

3. THE TOPOGRAPHY OF DATA GENERATION IN RESEARCH

The generation of physical data on material properties continues at an accelerated pace, as illustrated in Table II. However impressive these statistics may be, they do not justify the contention that during the last couple of decades there has been an "information explosion." This contention is not only factually incorrect, but it is also erroneous in terminology since the term "information" is indeed a misnomer for what is usually meant to be the "printed page." It is recognized, of course, that documents may contain information, and at times, they may even contain correct information.

Referring to statistics on documents and their dubious information content, I wish to suggest that these statistics only represent the visible part of the iceberg. What is even more startling is the fact that aside from sheer physical volume, today's literature is more complex in character, and papers in 1981 contain at least one order of magnitude more numerical data than

Table II. Growth of the world literature on thermophysical properties

Years	Number of publications in CINDAS's bibliographic data bank													
	Thermal conductivity		Electrical conductivity		Specific heat		Viscosity		Reflectance		Thermal linear expansion		Transmittance	
	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total
1780–1899	147	0.6	18	0.1	22	0.1	15	0.1	11	0.1	11	0.1	5	0.1
1900–1909	75	0.3	35	0.1	21	0.1	19	0.1	22	0.2	14	0.1	16	0.1
1910–1919	110	0.5	58	0.2	80	0.4	43	0.3	52	0.5	30	0.3	33	0.5
1920–1929	232	1.0	114	0.5	336	1.5	318	2.4	43	0.4	163	1.6	29	0.5
1930–1939	571	2.4	261	1.1	873	4.0	939	6.9	79	0.8	343	3.4	58	0.9
1940–1949	675	2.8	130	0.6	865	3.9	991	7.3	94	0.9	269	2.6	73	1.1
1950–1959	3,066	12.7	672	2.9	2,944	13.4	2,360	17.5	451	4.4	687	6.8	370	5.8
1960–1969	9,435	39.0	2,164	9.2	7,070	32.1	4,251	31.4	3,062	29.9	3,499	34.4	2,302	36.0
1970–1979	9,905	40.9	20,061	85.3	9,801	44.5	4,584	33.9	6,443	62.8	5,155	50.7	3,514	54.9
Grand total	24,216	100	23,513	100	22,012	100	13,520	100	10,257	100	10,171	100	6,400	100
% of grand total among properties	20.0		19.4		18.2		11.2		8.5		8.4		5.3	

Years	Number of publications in CINDAS's bibliographic data bank											
	Emittance		Absorptance		Thermal diffusivity		Thermal contact resistance		Accommodation coefficient		Grand total for 12 properties	
	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total	Total number	% of total	Grand total number	% of grand total
1780–1899	4	0.1	3	0.1	14	0.5	0	0	0	0	250	0.2
1900–1909	8	0.2	3	0.1	2	0.1	1	0.1	0	0	216	0.2
1910–1919	21	0.6	9	0.3	3	0.1	1	0.1	3	0.6	443	0.4
1920–1929	21	0.6	7	0.2	10	0.3	0	0	1	0.2	1,274	1.1
1930–1939	33	1.0	11	0.4	21	0.7	2	0.2	26	5.1	3,217	2.7
1940–1949	35	1.0	16	0.5	26	0.9	9	1.1	10	2.0	3,193	2.6
1950–1959	194	5.6	103	3.4	261	8.8	51	6.2	29	5.7	11,188	9.3
1960–1969	1,565	45.3	757	24.9	1,181	39.6	345	42.1	171	33.7	35,802	29.6
1970–1979	1,577	45.6	2,132	70.1	1,462	49.1	411	50.1	267	52.7	65,312	54.0
Grand total	3,458	100	3,041	100	2,980	100	820	100	507	100	120,895	100
% of grand total among properties	2.9		2.5		2.5		0.7		0.4		100	

those in 1951, due to laboratory electronic instrumentation operating in the automated mode. Furthermore, the accessibility of the literature is much more diffused, its cost constantly increases, and the language barrier remains a formidable one in spite of massive national programs at cover-to-cover translations. As a result of these factors and several others having to do with the presentation of numerical data in the primary literature, I wish to suggest that the numerical data of science and technology is effectively increasing at a rate of nearly one order of magnitude every decade, and not simply doubling, as bibliographical statistics would seem to indicate.

The fact that the rate of generation of physical data continues unabated is a clear indication of the urgent need for such data. The observation to be made at this point concerns the quality of the data, which has not significantly improved over the last couple of decades. One must conclude that our increasingly sophisticated electronic research instrumentation has enabled us to generate a larger body of numerical data more precisely, but not necessarily more accurately.

4. THE QUALITY OF DATA IN THE OPEN LITERATURE

Owing to the difficulties encountered in the accurate measurement of the properties of materials and in the adequate characterization of test specimens, especially in the case of solids, the property data recorded in the scientific and technical literature are often conflicting, widely divergent, and subject to large uncertainty. Noncritical use of literature data (both from primary and secondary sources) for important engineering and design calculations, without knowing their reliability, is often dangerous and may lead to failure or, at best, poor product design. Therefore, it is very important for engineers to seek out and use critically evaluated data and information whenever these are available.

The validity of physical data depends on a number of parameters. For purposes of illustration, let us consider the factors that would influence the validity and reliability of a particular set of experimental data on the thermal conductivity of a solid. Assuming the author has provided adequate information in his paper, the temperature dependence of the data is examined and any unusual anomaly is carefully investigated. Furthermore, the reduction of the data is examined to see whether all the necessary corrections were appropriately applied, and the estimation of uncertainties is checked to ensure that all the possible sources of error, particularly systematic errors, were considered by the author. Since the primary factor contributing to unreliable and erroneous experimental results is the systematic error in the measurement, experimental data can be judged to be reliable only if all sources of systematic error have been eliminated or minimized and accounted for. Perhaps the most important contribution to systematic error results from the mismatch

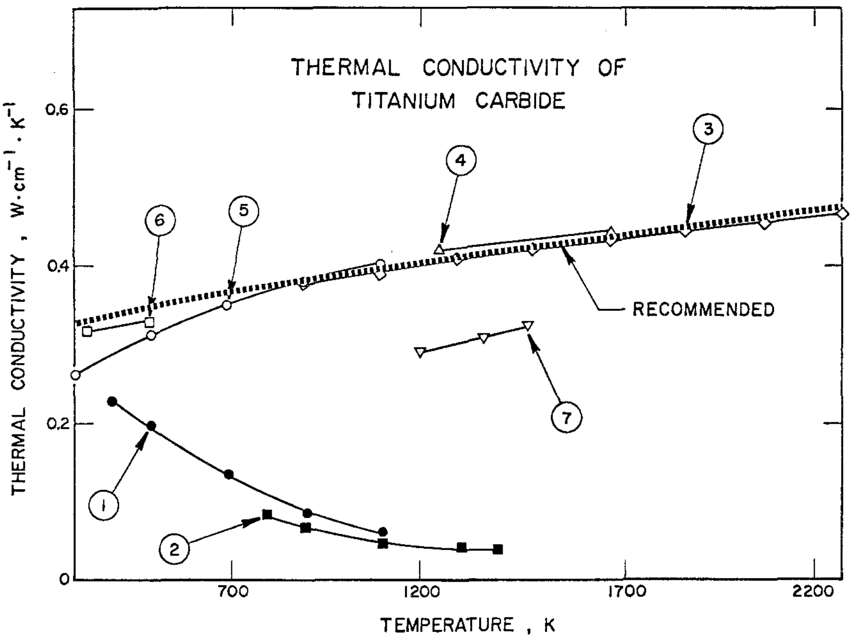

Fig. 1. Temperature dependence of the thermal conductivity of TiC [1].

between actual experimental boundary conditions and those assumed in the theoretical model used to derive the value of thermal conductivity. Other sources of systematic error may include unsuitable experimental method, improper experimental technique, low sensitivity of measuring devices, specimen and/or thermocouple contamination, unaccounted for stray heat flows, incorrect form factor, etc. These and other possible sources of errors are carefully considered in the critical evaluation of experimental data. The uncertainty of a set of data depends, however, not only on the estimated error in the data, but also on the degree of inadequacy of characterization of the material for which the data are reported. A few typical examples of confusing or erroneous information found in the literature are discussed in the following paragraphs.

One typical example of available data from the literature showing lack of agreement is the thermal conductivity data on titanium carbide shown in Fig. 1. In this figure, the upper data are about five times higher than the lower data at 800 K and are about 10 times higher at 1350 K. The lower data were published in 1954, and the two sets were obtained by using two completely different experimental methods, which seem to confirm each other. Since 1961, newer measurements show that the thermal conductivity of TiC actually increases with temperature instead of decreasing as indicated by the lower data.

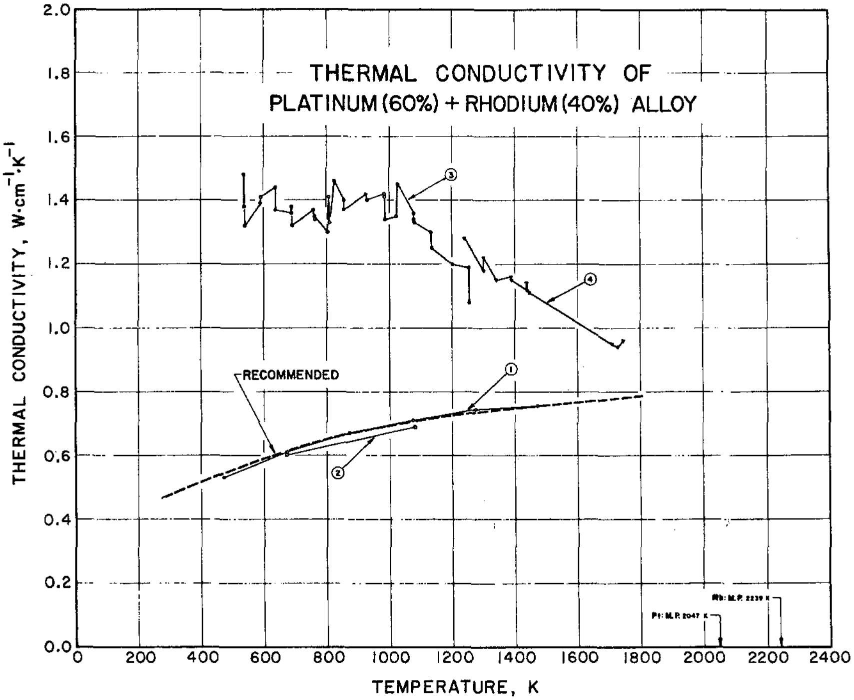

Fig. 2. Temperature dependence of the thermal conductivity of Pt + Rh Alloy [2].

Another example of discordant data from the literature is shown in Fig. 2. This is for the thermal conductivity of platinum (60%) + rhodium (40%) alloy. At the lower temperature end, the upper data are higher than the lower data by about 140%. In this case, the lower data are correct and the upper data are wrong. To prove that the upper data are wrong is simple. These data are much higher than that for pure platinum and are as high as that for pure rhodium, which is impossible for a high alloy of solid solution of Pt and Rh based on our present state of knowledge. Furthermore, the rapid decrease of thermal conductivity with increasing temperature is also unlikely for a high alloy; in other words, the slope of this curve is wrong. However, to prove that the lower data are accurate is not simple, and this involves the whole subject of critical data evaluation.

Figure 3 shows another type of disagreement of experimental data from the literature. Here the two sets of thermal conductivity data on gadolinium are for the same sample measured in the same laboratory and published two years apart in 1967 and 1969. The accuracy of curve 1 was stated as within 1% and that of curve 2 as 0.5%, though the two curves differ from each other by up to 500% at the higher temperature end.

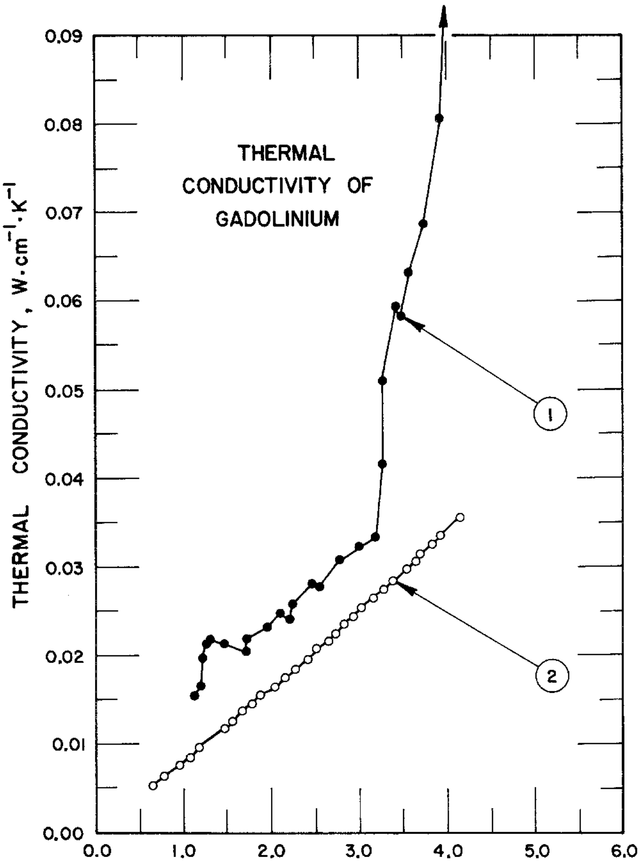

Fig. 3. Temperature dependence of the thermal conductivity of gadolinium [3].

5. THE CONCEPT OF CRITICAL DATA EVALUATION

The procedure of data evaluation involves the critical assessment of the validity of data and related information, resolution and reconciliation of disagreements in conflicting data, correlation of data in terms of various controlling parameters or using theoretical or empirical equations, comparison of experimental results with theoretical predictions or with results from generalized empirical correlations, etc. Besides critical evaluation and analysis of existing data, theoretical methods and semiempirical techniques are employed to fill gaps in data and to synthesize fragmentary data so that the resulting recommended values are internally consistent and cover as wide a range of each of the controlling parameters as possible.

Correlation of data in terms of various parameters is a valuable technique frequently used in data analysis. These parameters may include composition, residual electrical resistivity, density, porosity, hardness, surface conditions, homogeneity, crystal axis orientation, degree of cold working, degree of heat treatment, etc. Applying the principle of corresponding states, reduced property values may be correlated with reduced temperature, pressure, and other reduced parameters. Several properties of a given material can also be intercorrelated. For instance, thermal conductivity, specific heat, and density may be correlated with thermal diffusivity to check for internal consistency. It is important to note that irrespective of how much experimental data are available, reliable information is attainable only after the experimental data have been critically evaluated and recommended values generated.

Before progressing much further, I wish to define the key term "critical analysis" in the sense it is used in this discussion. For purposes of this presentation, the term "critical analysis" implies that a body of data has been critically reviewed and evaluated by experts having a significant degree of sophistication in the field. As a result of such close scrutiny of the raw data, one arrives at a set of recommended values of the property, which are, of course, subject to revision at a future date based on newer and more conclusive data and/or improved state of knowledge. While "critical analysis" always sets a "level of confidence" for the recommended values, there is *no* implication whatsoever of high accuracy or precision in these values.

Data that have undergone such critical analysis may be referred to as "reference values," "most probable values," "recommended values," or "best values." One should refrain at all times from using such terms as "critical data" or "standard reference data," since there is nothing "critical" or "standard" about such data. On the other hand, critically selected values of the precise universal fundamental constants and the mathematical constants known with a high degree of accuracy should be referred to as "standard reference constants," and *not* as "standard reference data." The general acceptance and usage of the terminology presented above will go a long way in creating a better understanding concerning the nature of evaluated data.

At this point, the finger points directly to each and every author, reminding him that he is not only a direct contributor to the overwhelming mass of the literature under the weight of which he is threatened to be crushed, but is also a potential "polluter" of scientific and technical knowledge if he has faltered in closely scrutinizing his laboratory observations and in the assessment of his systematic errors. Based on available documented evidence, chances are he is guilty. The term "pollution" as used in this context is, indeed, uniquely descriptive of the state we find ourselves in when we examine most numerical data, and perhaps more so in the case of data on transport properties.

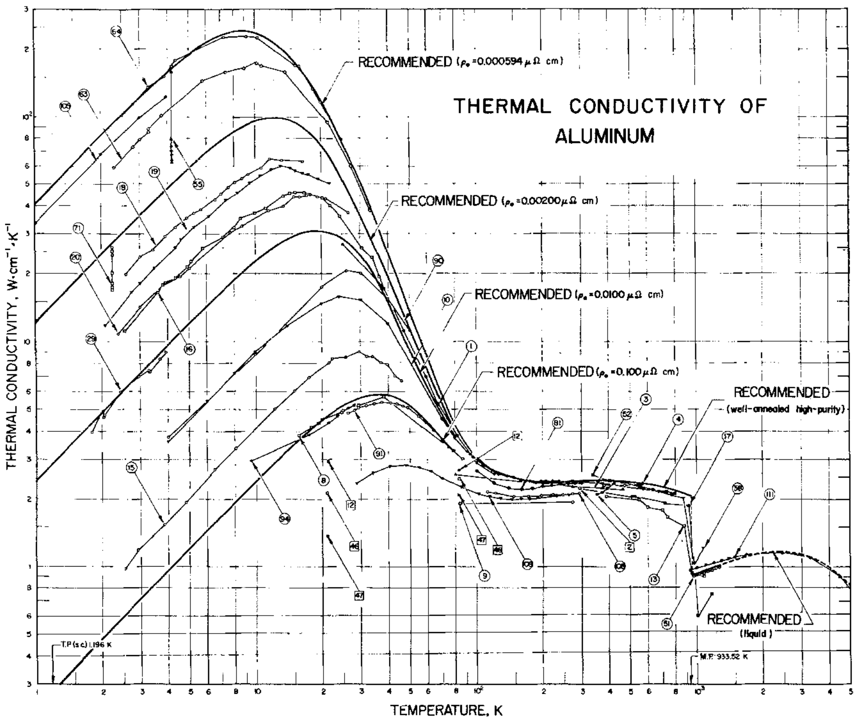

Fig. 4. Temperature dependence of the thermal conductivity of aluminum [4].

To illustrate the point, let us look at the data on the properties of materials, as represented by the information content of Figs. 4 and 5. These figures further illustrate the prime function of an information analysis center (IAC) through the curves labeled as "recommended," which are arrived at after painstaking study of the papers cited, their objective critique (within the limits possible based on the information available in the papers), the guidelines provided by theoretical considerations, etc. In the final analysis, by necessity, the final decision is often tinged by the personal judgment and subjective considerations of the analyst, which some term "bias." Therefore, as characterized by Weinberg [6], the specialized IAC is a technical institute staffed with competent and experienced scientists and engineers and not a mechanized technical library. I wish to conceive, therefore, that at its best, the specialized IAC interposes itself as a filter between the flood of diffused information of high noise level and the ultimate user of this information, the engineer and scientist. The effectiveness of such a center is measured, therefore, by its ability to increase the signal-to-noise ratio in the published information as well as the range of the bandwidth of the spectrum it covers.

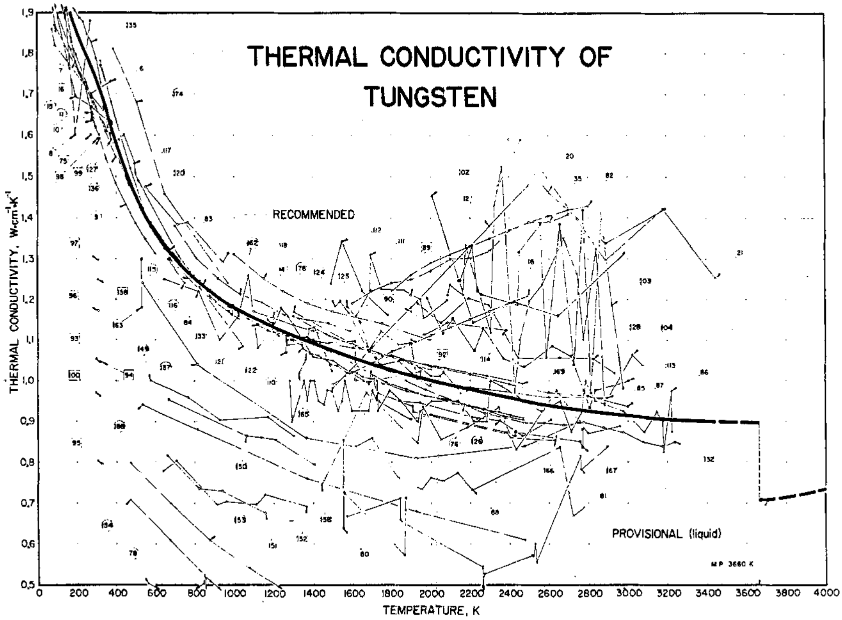

Fig. 5. Temperature dependence of the thermal conductivity of tungsten [5].

Going one step further, data synthesis, as exemplified by Figs. 6 and 7, truly creates new knowledge, feeding itself on the fragments of often conflicting information and other related data, thus making contributions of original information of lower levels of entropy than is commonly reported to be the results of *original research*. The thermodynamic explanation, of course, is found in the *information negative entropy* (negentropy) provided by the synthesizer or analyst who is external to the system.

6. CONTRIBUTIONS BY CINDAS TO TECHNOLOGY AND SCIENCE

As a national data analysis center, CINDAS's primary mission is to evaluate the available data on physical properties of materials within its area of cognizance and to come forth with sets of data which the engineer and scientist can use with confidence. In carrying out its mission over the past 25 years, certain unanticipated patterns and benefits have emerged, which go far beyond the simple dissemination of evaluated data. These represent distinct contributions to science and technology in which CINDAS takes proper pride. Some of the more directly observable contributions of CINDAS over the past 25 years are as follows:

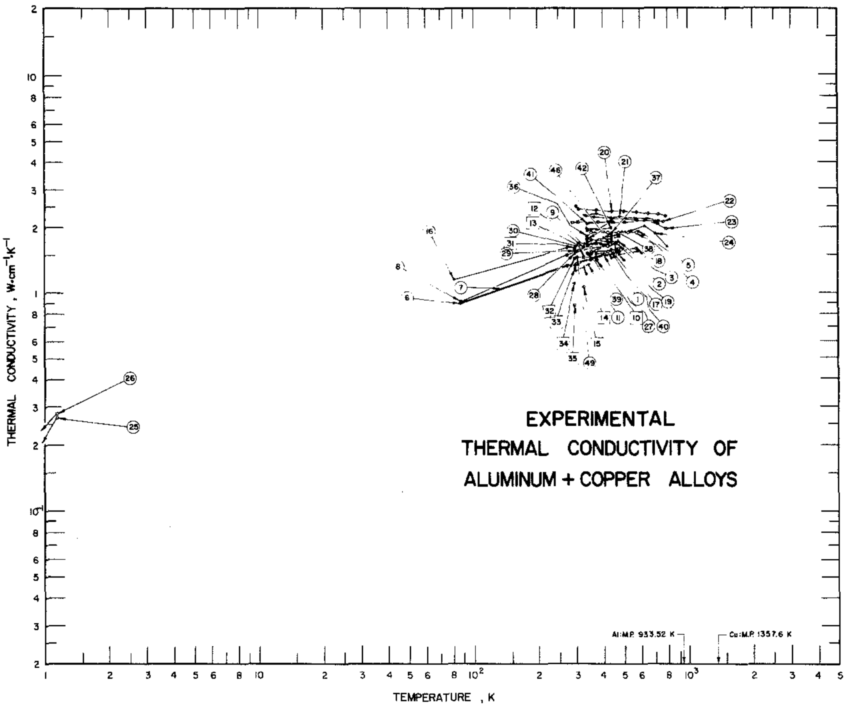

Fig. 6. Experimental data on the thermal conductivity of Al + Cu alloys [7].

1. Development of national capability to respond for reliable data needs of industry and government.
2. Development of a broad-base, in-depth, data bank for bibliographic information on the thermophysical, electronic, electrical, magnetic, and optical properties information on over 57,000 materials of scientific and technical interest. An additional 9000 synonyms and trade names are indexed. The bibliographic data base covers over 240,000 reference citations, dating back to 1800, which come from over 8600 different sources worldwide. Over 10,000 new reference citations are added each year.
3. CINDAS interacts with its worldwide constituency through two primary channels; namely, by providing an inquiry service whereby responses are given to technical questions for a nominal fee and by dissemination (free of charge) of a bimonthly Newsletter to some 12,000 engineers, scientists, librarians, and administrators both in this country and abroad. This unique communication media is in its tenth year of publication.
4. Development over the years of extensive and authoritative reference

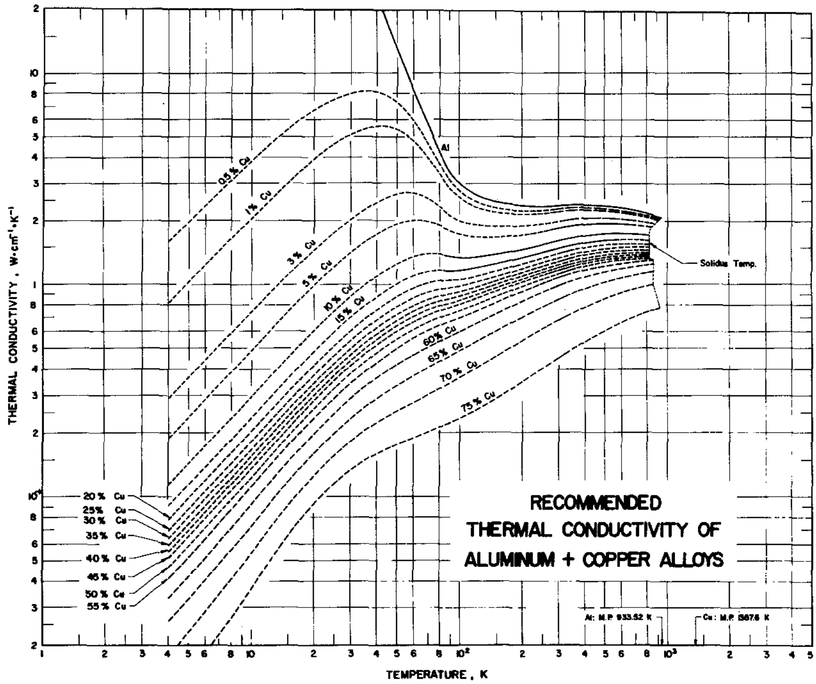

Fig. 7. Recommended values of the thermal conductivity of Al + Cu alloys obtained through data synthesis [7].

works on the physical properties of materials used on a worldwide basis:

a. *Thermophysical Properties Research Center Data Book,* 3 vols., Purdue University (1960–1966).

b. *Thermophysical Properties of High Temperature Properties of Solid Materials,* 9 vols. (MacMillan, New York, 1967).

c. *Thermophysical Properties of Matter—The TPRC Data Series,* 14 vols. (Plenum Press, New York, 1970–1978).

d. *McGraw-Hill/CINDAS Data Series on Material Properties,* 42 vols. (McGraw-Hill, New York, 1980-continuing).

e. *Thermophysical Properties Research Literature Retrieval Guide: 1900–1980,* Plenum consolidated, expanded, and revised edition, 7 vols. (Plenum Press, New York, 1981).

f. *Electronic Properties Research Literature Retrieval Guide,* 4 vols. (Plenum Press, New York, 1979).

g. *Masters Theses in the Pure and Applied Sciences,* annual publ., (Plenum Press, New York, 1957-continuing).

5. Contribution of numerous research papers by CINDAS staff members to national and international scientific and technical journals.
6. Completion and dissemination of over 60 CINDAS technical reports.

The contributions of CINDAS go far beyond its own comprehensive publications listed above. Authors of many textbooks with large reader audiences have requested permission to use CINDAS's evaluated data almost exclusively in chapters and appendices of their works. In the case of major handbooks, which are prepared by multiple contributors, a somewhat different situation exists. Contributors to such works as the *ASM Metals Handbook*[2] and the *Handbook of Chemistry and Physics*,[3] have used generous amounts of evaluated data generated by CINDAS. It is indeed gratifying to find that contributions by CINDAS extend far beyond its own publications and are accepted by internationally used major reference works.

CINDAS has been also instrumental in the sponsorship and promotion of continuing international conferences and journals such as the International Thermal Conductivity Conference, the International Thermal Expansion Symposium, and the *International Journal of Thermophysics.* We believe these multifaceted contributions by CINDAS have left a lasting imprint on the improved state of the data of a major segment of knowledge on the physical properties of materials.

7. CONCLUDING OBSERVATIONS

The expression "need to know" has become almost a euphemistic phrase for denoting the requirements for operating in our potentially information-rich environment. Although luck, intuition, and hunches are likely to retain a place in many endeavors, the individual, organization, or the nation having the *right information* at the *right time* in the *right place* has at least an initial advantage over those without this information. Thus efforts to upgrade the quality of information and to improve access to and control of information resources must parallel the production of raw information. There is, currently, a serious imbalance between these two activities. Production has been the hare and information synthesis the tortoise. In this race, the hare can win only if the tortoise is close behind him.

The big problem we still face involves putting together these innumera-

[2] Volume 2, 9th ed. (1979).

[3] The last six editions starting from the 54th edition (1973–1974) to the most recent 60th edition (1979–1980).

ble bits of intelligence into larger, more meaningful and useful patterns. So we must make commensurate efforts to bring our understanding and activities from the level of simply generating and compiling data to organizing them into an internally consistent set of an ensemble, which process I wish to refer to as the "synthesis of knowledge."

While the nation's scientific and technical community starves from a lack of critically *evaluated* information, it is being smothered by an overwhelming document birth rate with the associated emission of polluted information referred to as "original data." The nation spends large sums of money on its research and development only to waste it by ignoring its results. *Information discovery* is indeed futile in the absence of an adequate means of *information recovery.* Should there be continued research, then the evaluation and proper dissemination of the results of this research to the end-user can hardly be questioned.

The expenditure of public funds on basic and applied research is justified to a major extent for maintaining the nation's scientific and technological leadership and, thus this research makes a significant impact on our economy, commerce, and national defense. In recent years, there have been negative attitudes toward the support of research in the physical sciences in general, particularly at a time when such research should have been accelerated to assist in the solutions of the manyfold problems we face as a nation. As researchers, where did we go wrong?

I suggest that a major part of the answer to the above question lies in the fact that the results of our research often do not reach the end-user for whom they are intended. This implies a broken link or perhaps an unfilled gap in policies for funding research. Because federal planners of research have not recognized the importance of closing the gap between the generation of information and translating it into a form useful to the end-user, the status quo remains. We should see to it that research results are properly channeled to nourish our national anatomy. I suggest that this function is the full and unshirkable responsibility of the research supporting federal agencies and may not be relegated to some other agency. Evaluation, analysis, and synthesis of research results are part and parcel of research itself and not a separate function in the form of an afterthought.

Turning to the management side, unfortunately, there has been a lack of realization that when properly used, good information conserves other resources, such as material, time, money, etc. Management should monitor and establish the cost of not knowing to ascertain internal disruptions, missed opportunities, or whether objectives are set high enough.

In order to instill in future engineers and scientists an awareness for the need of reliable data, it is paramount that universities take a double pronged action in their academic programs: first, in the design of the undergraduate curriculum, requiring the effective use of accumulated engineering and scientific information; second, the incorporation of critical analysis of the data as an integral part of the research projects they undertake. Both of these activities are well within the charter of a university; namely, the responsibility of translating the often confused state of the results of research into a coherent information base readily usable by the nation's industry for improved production and advanced technology.

To further substantiate some of the points made earlier, I believe it would be worthwhile to touch upon certain elements from the recommendations set forth in an in-depth study prepared under the auspices of OECD [8]. Concerning the level of research support, the study concludes that the major obstacles to fundamental research are *structural* rather than financial. Another point that is immediately salient is the *deemphasis* in the design and definition of information systems, where the recent emphasis has been primarily on accessibility to great masses of raw information and on the machines manipulating such masses, with little or no thought given to the quality of the input or its evaluation and interpretation.

The report distinguishes the needs for various user communities such as the specialist scientist, the engineer, and the technical administrator. Briefly, the recommendations relevant to the subject of our discussion are as follows:

1. Policies and strategies for information should be developed as an integral part of the design of policy as a whole and, more specifically, cannot be considered apart from R&D strategy.
2. Governments should give greater support to mechanisms for ensuring effective interchange of information among scientists, paying special attention to analysis, consolidation, evaluation, and repackaging.
3. Systematic information requirements of industrial technology, in comparison with the requirements of basic science, have been neglected by governments.
4. Greater emphasis on quality control is needed to ensure that information is not misleading without extensive interpretation.

As CINDAS reaches its quarter century mark, it is personally gratifying to me to see that the need for a sound, integrated policy regarding scientific and technical information, which I have been persistently advocating for so many years, is drawing increasing national and international attention. Unfortunately, the progress toward the implementation of such a policy has been extremely slow, and its acceleration requires a greater awakening on the part of the scientific and technical community to the importance, value, and power of correct information. I am still very optimistic regarding the future developments and evolution.

NOTE ADDED IN PROOF BY THE EDITOR

Professor Yeram S. Touloukian died about a month after submitting this paper. It is very unfortunate that he could not see the publication of his paper summarizing the accomplishments of CINDAS, the center that he had established and directed over the past quarter of a century. An In Memoriam appears at the beginning of this issue on page 201.

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