from the belief that I ignored the "temporal fixity" of imprinting, a characteristic which he regards (and rightly so) as unique. The following definition, contained in the article to which Klopfer refers, makes it evident that I did no such thing: "Thus, imprinting will be defined as the procedure of visually presenting to an animal a large moving object *during the first several hours of its life* under conditions that insure that the object is not associated with such conventional reinforcing agents as food and water" (italics added).

Klopfer also states that I ignored my "own dicta" and that I thereby compounded confusion. I must admit that I am unceratin as to what he intended to convey. To which dicta (or even dictum) is Klopfer referring? What is the nature of the confusion? To what extent have I compounded it?

In conclusion, may I say that it does not appear unreasonable to expect a scientist to be explicit when criticizing the work of another and to offer at least some evidence in substantiation of a sweeping dismissal.

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Handling Scientific Information

In a recent issue of *Science* [**132**, 1922 (1960)], Helen Brownson, in the article "Research on handling scientific information," makes the following statement: ". . . the essential problem of applying machines to the handling of scientific information on a large scale has yet to be solved. This unsolved problem has to do with means of analyzing the subject content, meaning, and relevance of documents for mechanized handling. Research directed toward this end is making progress but is still in its infancy."

What Helen Brownson calls *the* unsolved problem is really a pseudo-problem which cannot delineate or define a fruitful field for research. In *The Mathematical Theory of Communication*, by Shannon and Weaver, the following two statements appear: (i) "The semantic aspects of communication are irrelevant to the engineering aspects." (ii) "This does not mean that the engineering aspects are necessarily irrelevant to the semantic aspects."

If one properly understands these two statements, one can also understand why mechanized systems and coding can contribute to the semantic aspects of information storage and retrieval systems and why semantic considerations cannot contribute to the solution of problems of mechanization (engineering aspects). Suppose one wished to develop a high-fidelity system

for the reproduction or transmission of music. Such a high-fidelity system, properly engineered, might convey a good violin tone—that is, the engineering would contribute to the esthetics. On the other hand, whether or not violinists in general played sweet or sour notes would make no contribution to the development of high-fidelity systems—esthetics would not contribute to the engineering. We are only interested in storage and retrieval systems because individuals can index material, although some index poorly. Whether the indexing is good or bad does not contribute to the engineering aspects or the mechanization of storage and retrieval systems. On the other hand, good mechanized systems can convey the results of good indexing.

In brief, the type of research described by Helen Brownson can only be justified by denying Shannon's statement that the semantic aspects of communication are irrelevant to the engineering aspects. This is not usually understood, because this statement is confused with the converse statement—that engineering aspects are relevant to semantic aspects.

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I do not believe the quotations Taube gives from Shannon and Weaver are relevant to the broad problem discussed in my article, which is much more than an engineering problem. In his statement about "the semantic aspects of communication," Shannon was using *communication* in a very special sense—namely, the transmission of messages from one point to another. The paragraph containing that statement begins: "The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point" (p. 3). Weaver provides further clarification: "The mathematical theory of the engineering aspects of communication . . . admittedly applies in the first instance only to . . . the technical problem of accuracy of transference of various types of signals from sender to receiver" (p. 97). He emphasizes that the word *information*, in this theory, is used in a special sense that must not be confused with its ordinary usage; in particular, it must not be confused with meaning. At this point, Weaver states, "It is this, undoubtedly, that Shannon means when he says that 'the semantic aspects of communication are irrelevant to the engineering aspects' " (p. 99).

In discussing the interrelationship of the technical, semantic, and effectiveness problems of communication, Weaver points out that the mathematical theory "contributes to the problem of translation from one language to another, al-

though the complete story here clearly requires consideration of meaning, as well as of information" (p. 115). Translation is only a part of the broader problem of dealing effectively with the content of scientific literature.

Arguing by analogy is confusing if the analogy is not a close one. With respect to mechanization of the handling of scientific information, the problem is not that of designing something equivalent to a high-fidelity system for the reproduction or transmission of music. We are not merely trying to develop means for undistorted reproduction or transmission of scientific writings. A closer analogy might be the mechanization of some or all procedures involved in handling written music so as to facilitate searches for, say, compositions of a particular period in a particular style, rhythm, and tempo, in which a certain combination of notes is used. The essential problem then would be how best to obtain and to store coded representations of the compositions' characteristics and contents, in machine-searchable form, so that compositions with the desired characteristics could be readily identified—after, of course, first determining what musicologists are likely to want to search for.

I don't know for whom Taube speaks when he says, "We are only interested in storage and retrieval systems because individuals can index material. . . ." It is clear that many persons doing research or administering funds for research in this field believe it worth while to explore the possibility of mechanizing the indexing process or its equivalent. It is important, of course, to work on the engineering problem of efficient manipulation of index data. Such work, however, will contribute little toward the broad problem of mechanizing the retrieval of scientific information if the indexing, whether human or mechanized, is poor. Mechanized information-handling systems will serve us well only if human analysis and indexing of the "input," or whatever mechanized procedures may substitute for them, are sufficiently reliable for scientists to have confidence in the systems.

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Doomsday

The article "Doomsday" by von Foerster, Mora, and Amiot [*Science* **132**, 1291 (1960)], although perhaps written and published with an obvious tongue-in-cheek attitude, has received some publicity in the newspapers, and there is danger that it may be taken too