

Logic, Law and Dreams*

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In considering what might be appropriate to discuss with a group of law librarians three words kept intruding into my thoughts—the words “logic,” “law” and “dreams.” For a good reason too, I think, the reason being that these words suggest ideas that are very relevant to one of the big problems faced by all librarians today.

To orient myself a little about what these words suggest to other people, I turned to a pair of standard desk books. Of the many comments listed there about these words, my attention focused on just three.

In Ambrose Bierce's *Devil's Dictionary*¹ “logic” is defined as:

The art of thinking and reasoning in strict accordance with the limitations and incapacities of the human misunderstanding.

“Law” fared no better in an excerpt from Plutarch included in Franklin Pierce Adams' *Book of Quotations*:²

Written laws are like spiders' webs; they hold the weak and delicate who might be caught in their meshes, but are torn in pieces by the rich and powerful.

* Remarks made to a joint conference of the Law Library Association of Greater New York and the Law Librarians of New England held in New York City, Feb. 14, 1959.

1. BIERCE, *DEVIL'S DICTIONARY* (1911).
2. ADAMS, *FPA'S BOOK OF QUOTATIONS* (1952).

But the word “dreams” moves men to express thoughts that are more optimistic and enthusiastic in tone. Among Adams' quotations we find Henry David Thoreau saying:

If one advances confidently in the direction of his dreams, and endeavors to live the life which he has imagined, he will meet with a success unexpected in common hours.

A dream that should intrigue librarians for some time is one that was recently described in detail publicly. This is “The Dream of a Library User” presented by Professor Robert M. Fano of the Massachusetts Institute of Technology at the International Conference on Scientific Information in Washington last Fall. It is a dream that is linked to the big problem faced by librarians that I mentioned.

I shall not repeat in detail Professor Fano's dream. A complete description of it will soon be available in the proceedings of the conference. In brief outline this dream was about a library user who had complete access to the total corpus of all written information from within the walls of his own office. By a device similar to a telephone this user could dial into any spot in a master repository of all written information and what was available at that spot would appear on a viewing screen in his office. If he wished to have a

permanent copy for his personal use of something that appeared on the screen, there was another button to push, and the copy would be produced and delivered to his desk almost instantly.

A real wild dream? Some of the conference participants did not think so. Of course, these participants were the theoreticians. This dream was presented at the session where the mathematicians, engineers, logicians, physicists and computer specialists were having their say. These are the very persons to whom we must look for a sound theoretical basis to expedite the rapid development of automatic processing of information. One after another, the members of the audience stood up to suggest some surprise that this story was presented as a dream. They indicated that in their organizations this "dream" was getting pretty close to being realized.

The dream that I would like to present for your consideration today is not Professor Fano's vision, but another one. This dream, too, is related to the librarian's big problem mentioned before.

This big problem has been mentioned enough. It is time to describe it. It is a problem that probably every librarian is aware of. It is the fundamental variable in the task of storing and retrieving information. It is so obvious that it is almost redundant to say it. But, it is worthwhile to explicitly describe, because there is an element to it that may surprise somewhat even those who are aware of the problem.

The problem is the rate of growth in the production of written literature.

In both this country and throughout the rest of the world the rate of increase in the amount of information that is published each year is simply staggering. The growth is so phenomenal that some sober observers are beginning to talk about the "monster of literacy that is . . . engulfing us."³

Some illustration of the proportions of this rate of growth in just one field is found in a report of G. Miles Conrad, Director of Biological Abstracts:⁴

The best estimates put the present number of biological-research journals published throughout the world at 3,500. If the creation of new journals continues at the same rate it has in the past, we can expect 7,000 journals by 1975; 14,000 by 1993; and about 21,000 by the year 2000. This growth of journal publication when translated into terms of individual articles suggests an annual volume of 490,000 research articles in 1975; 910,000 in 1993; and about 1,470,000 in A.D. 2000. If some new method isn't soon devised for the primary communication of research findings in biology, and if Biological Abstracts were able to provide complete coverage of this projected literature, its volume 74 (A.D. 2000) would require 120,000 pages of abstracts, 21,000 pages of subject index, and measure some 30 feet in thickness.

To report, analyze, and index such an annual volume of information is impossible of accomplishment by means of present-day methods and financial resources. Although it is undesirable to shut off the volume of research writing at its source by formal censorship, we are tempted to

3. Baker, W. O., Vice-President—research, Bell Telephone Laboratories. *Hearings Before a Subcommittee of the Senate Committee on Government Operations*, 85th Cong., 2d Sess., pt. 1, at 236 (1958).

4. Conrad, G. M., Director of Biological Abstracts. *Hearings supra* at 248.

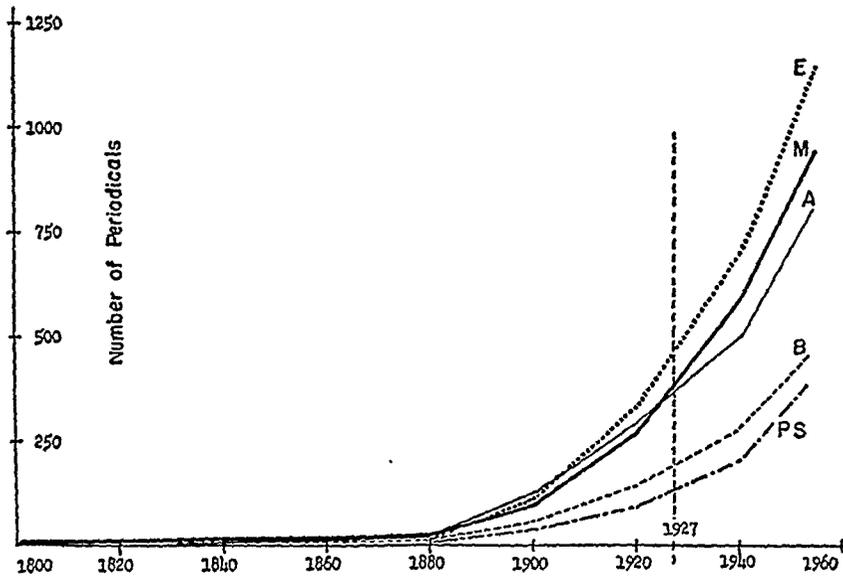


FIGURE 1. Growth of scientific and technical periodicals in the United States from 1800 to 1954. Data from (5). Key: E, engineering and technology; M, medicine; A, agriculture; B, biology; PS, physical sciences.

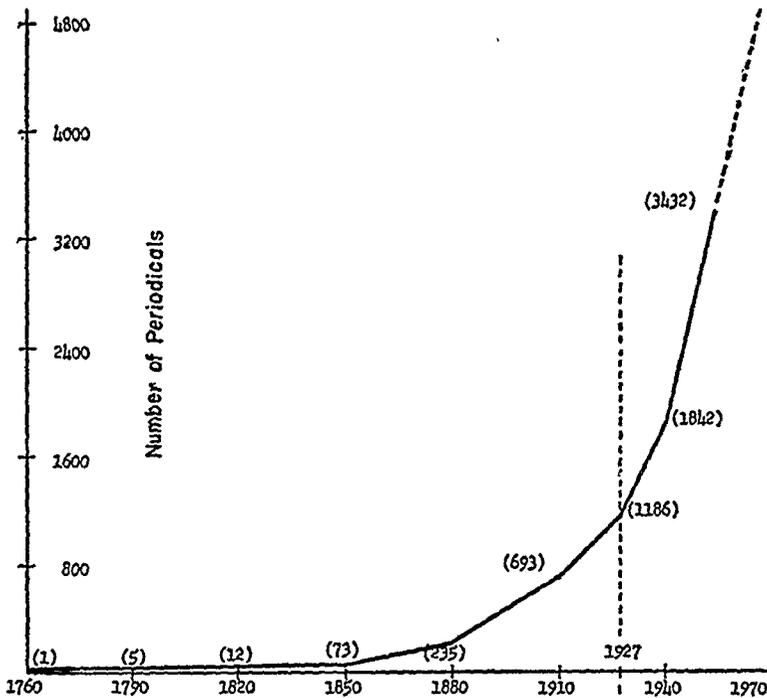


FIGURE 2. Growth of the world's biological research periodicals (exclusive of agriculture and medicine) from 1760 to 1954.

suggest that unless the present and potential future flow of writings is stemmed or diverted by the exercise of personal censorship and restraint in publication, biological literature may soon overwhelm us all in a chaotic flood.

This rate of growth of the literature in biology is indicated in Figure 1.⁵ The number of biological journals published throughout the world is shown for the two hundred-year span from the mid-Eighteenth Century to the present. The most significant fact is that the number of journals has doubled every eighteen years until by 1954 there were an estimated 3,500 journals being published.

A comparison of the literature growth in several other fields in the United States is shown in Figure 2. The increase in the number of periodicals during the past one hundred fifty years has been even more rapid in engineering, medicine and agriculture than in biology, and only slightly slower in the physical sciences. The growth curves in all of these technical and scientific fields are explosion curves.

What is the situation with respect to the legal literature? On this, your impressions are certainly better than mine. It will be interesting for me to hear in a few minutes what your impressions are on how fast the legal literature has been growing.

The basic problem for those who are concerned with the storage and retrieval of information is that the amount of information to be processed is growing so fast that it is getting out

5. Figures 1 and 2 from *Hearings supra* at 250-251 (originally published in 16 FEDERATION PROCEEDINGS 712 (1957)).

of hand. Traditional methods for processing information are becoming increasingly inadequate to handle the projected future flows of information. What is to be done about it? In this age of the electronic computer it requires no stroke of genius to wonder whether some of the tasks in the process of storage and retrieval can be done automatically. And this is exactly what has already begun to happen. Researchers from a wide variety of fields have turned a portion of their attention to the effort of (1) isolating those tasks that are sufficiently routine to be amenable to automatic processing from those that require some human intervention, and (2) transforming to the extent possible the non-routine tasks into ones that can be automatically handled. Already there are some systems that are operational. They are probably only the first rough approximations of what is to come, but even now a substantial proportion of the literature in metallurgy can be searched automatically at the Center for Documentation and Communication Research at Western Reserve University.⁶ Another example is in the U. S. Patent Office, where the patent searches for steroid compounds is being done mechanically and research is in progress to generalize the procedures for other types of patent searches.⁷

It is with this problem of automatically processing of information that the dream I wish to present to you is connected. The dream is about modern logic, sometimes called symbolic

6. PERRY & KENT, TOOLS FOR MACHINE LITERATURE SEARCHING (1958).

7. U. S. Patent Office, *A Punched Card System for Searching Steroid Compounds*, RESEARCH AND DEVELOPMENT REPORT Nos. 7 and 8 (1957).

logic or mathematical logic. The connection between this dream about logic and automatic processing of information and law is, perhaps, only dimly perceptible. That there is a significant connection, it is to be hoped, will be illuminated by the description of the dream.

The dream foresees a time when that peculiar form of intellectual paralysis, that so frequently follows any mention of mathematics or anything mathematical, will no longer be automatically induced among the majority of scholars, lawyers, librarians and other human beings by the sight of a message expressed in notation. And how will this astonishing state of affairs come to be? Most can agree that such a change would truly be astonishing because they would accept Hardy's observation⁸ that too many people "are so frightened of the name of mathematics that they are ready, quite unaffectedly, to exaggerate their own mathematical stupidity."

In the dream the seeds for this profound change were sown when man first began to devise machines to help improve the efficiency of the educational process. The optimum educational situation, it had long been recognized, was Mark Hopkins and a student at each end of a log. In that kind of situation the learning process was dynamic. The student had an active part. He was continually being called upon to make responses. Correct responses could be immediately reinforced; and mistakes, detected and rectified. Learning could, indeed, proceed at a rapid pace with a good pri-

vate tutor. But of course, a one-to-one teacher-pupil ratio was a luxury that could not be afforded in modern public education.

Then someone began to wonder about an interesting question? Could a machine-equivalent of Mark Hopkins be constructed for some purposes? If so, for what purposes? If the community could not afford a human private tutor, how about a machine private tutor? Since each student would work on his own machine, perhaps the machine could be rigged so that every student could go at his own pace. That would help take care of the problem of the gifted youngster, too.

The early machines that were built were pretty crude, but even so they produced some startling results. Seventh graders who had a course in symbolic logic from a mechanical tutor reported that they never before had learned so much, so fast, so easily. The results on their semester tests verified their impressions.

The first machines did little more than present some information, ask some questions about it, and indicate to the student quickly whether his responses were correct or wrong. Thus, the feedback from teacher-to-pupil was duplicated. But, it was only when pupil-to-machine feedback got systematized that the practice of machine-teaching began to snowball. Someone observed that the machine could more accurately than a human teacher keep a tally of just where in the presentation of the materials the students were having the most trouble. The tallies were made and used to detect the trouble spots in the presentation. The

8. Hardy, *A Mathematician's Apology*, 4 WORLD OF MATHEMATICS 2028 (1956).

materials were revised in these spots, and the revised materials tested in the same way. Every seventh-grade classroom (or perhaps we should say, every machine-room) became part of the great laboratory experiment to scientifically devise an optimum presentation of a course to develop skills in the manipulation of logical symbols. The data generated were used in a continuing process of refinement. Then, specialized optimum presentations were developed, some for students in the I.Q. range above 130, others for those with an I.Q. between 100 and 130, and still others for those below 100. From these, optimum presentations for even narrower I.Q. ranges evolved. This, in turn led to the investigation of other significant variables in the learning process. Optimum presentations were developed for students with different aptitude, motivational and socio-economic class profiles. From this there emerged in the learning process teaching-machines that were tailored, in effect, to cope most effectively with individual differences among students.

In the continual search for improved methods of presentation the wildest imaginable innovations were freely attempted. There was increasingly less dependence on armchair speculation about the probable effects of a suggested change. Arguments that produced much heat but little light were minimized. Now, there was available an effective and efficient means for testing any recommended changes in presentation. In less than a decade a revolution in the teaching of modern logic had occurred. In some ways this was a little disconcerting to some

parents. Upon graduation from junior high school they had become fairly skillful in manipulating the intricacies of arithmetic. Now their own children at the same stage had accomplished an even greater mastery of propositional calculus, class calculus, functional calculus, set theory and recursive function theory. Many parents had not even heard the names of these subjects before, much less, did they know anything about them. Of course, with this kind of training in the foundations of mathematics the students were equipped to make much faster progress in their studies of mathematics. Coupled with this, the use of machine tutors quickly spread to the teaching of related subjects—notably mathematics. You know the rest of the story. This is how the language called mathematics became commonplace.

Another real wild dream? I wonder what Professor B. F. Skinner of Harvard would think?⁹

Such a dispelling of the aura of mystery about symbolic logic by making it as much a part of our common culture as arithmetic is today would hasten the disappearance of the kind of suspicion of logic evidenced in comments like the one quoted from Bierce. Along with this, when modern logical tools are part of the intellectual work kits of the general citizenry, there will be a keener appreciation of the element of truth in Plutarch's cynical remark about law. The malleability of laws as currently written in English prose will be more clearly discerned. The sophistication about language that will accompany skill in the ma-

9. Skinner, *Teaching Machines*, 128 *SCIENCE* 969 (1958).

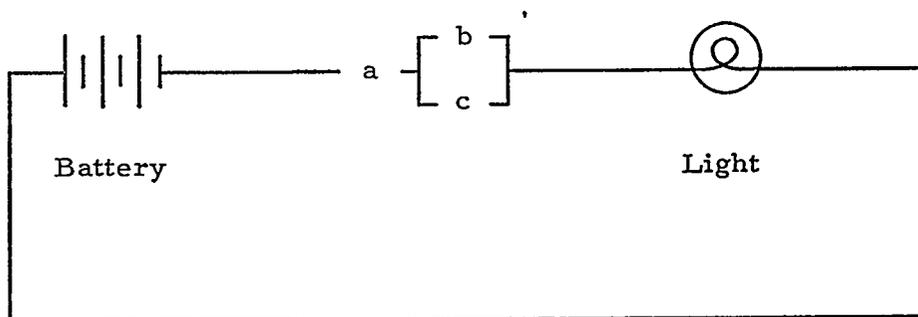


Figure 3

- (P1) law teacher
- (P2) law librarian
- (P3) engineering librarian
- (P4) one who is both a law teacher and an engineering librarian
- (P5) one who is both a law teacher and a law librarian.

Suppose that (S1) is modified by adding three words to the front.

(S2) Persons who are law teachers and librarians qualify.

Which of the five persons qualify by virtue of (S2)? Suppose that the logical form of the expression is changed so that it is expressed as an if-then statement.

(S3) If a person is a law teacher and librarian, then he qualifies.

Which of the five persons qualify by virtue of (S3)?

The answers to the questions of which persons qualify by which statements will depend upon how the statements are interpreted. Using the following abbreviations:

- wt=law teacher
- wn=law librarian
- n=librarian
- Q=qualifies

There are the following four possible alternative interpretations:

- (A1) 
- (A2) 
- (A3) 

(A4)

--wt-wn-----→ Q

The most inclusive interpretation is (A1); the most restrictive, (A4). Most people would either interpret (S1) as asserting (A1) or interpret it as asserting (A2). Also, most people would interpret (S3) as either asserting (A3) or asserting (A4). However, with respect to (S2) it is difficult to predict which of the four alternatives will be the most frequent interpretation. Some persons will insist that (S2) intends that both persons who are teachers and persons who are librarians qualify; thus, they will be interpreting the "and" in (S2) as indicating "conjunction" between prepositions. Others will insist that (S2) intends that only persons who are both teachers and librarians qualify. Thus, they will be interpreting the "and" as indicating "logical product" between classes. In analyzing an alternative interpretation by means of such a graphic representation the conclusion that the person qualifies will follow only if there is a continuous path through the "circuit." In a similar way in the graphic representation of Rule A, the events characterized by the lawyer will constitute a general averaging act if and only if there is a continuous path through the "circuit" representing the appropriate interpretation of Rule A.

All that needs to be done now is to determine what the "circuit" for Rule A looks like. This task of constructing a "circuit" for Rule A is in effect a job of partially interpreting what Rule A "means." It is a partial interpretation only because it is concerned merely with ascertaining the logical relationship *between* the constituent

elements of the entire rule and not concerned with ascertaining the range of meaning of the individual constituents. Another way of characterizing this, perhaps, is to describe it as being concerned with syntactical interpretation of the rule, but not concerned with semantic interpretation.

In doing this syntactical interpretation of Rule A one will quickly discover that the statement is much more ambiguous than it appears to be upon first blush. At least six questions must be decided before any conclusion can be reached about which one of thirty-two possible alternative interpretations is the one that Rule A "means." The questions are these:

- (Q1) Do f, p and c modify m? (Do the phrases "for the common safety," "for the purpose of preserving from peril the property involved" and "in a common maritime adventure" modify the word "made," or do they only modify the word "incurred?")
- (Q2) Do p and c modify m? (Do the phrases "for the purpose of preserving from peril the property involved" and "in a common maritime adventure" modify the word "made," or do they only modify the word "incurred?")
- (Q3) Does c modify m? (Does the phrase "in a common maritime adventure" modify the word "made," or does it only modify the word "incurred?")

- (Q4) Do i or r or both modify n? (Do either of the words "intentionally" and "reasonably" or both of them modify the word "incurred?")
- (Q5) Does e modify x? (Does the word "extraordinary" modify the word "expenditure," or does it only modify the word "sacrifice?")
- (Q6) Which logical relationship does the word "and" between i and r indicate, *conjunction*, or *logical product*? (Does the word "and" between the words "intentionally" and "reasonably" indicate the relationship that the "and" in (S2) indicates when (S2) is interpreted as asserting "persons who are law teachers qualify and persons who are librarians qualify;" or does the "and" between "intentionally" and "reasonably" indicate the relationship that the "and" in (S2)

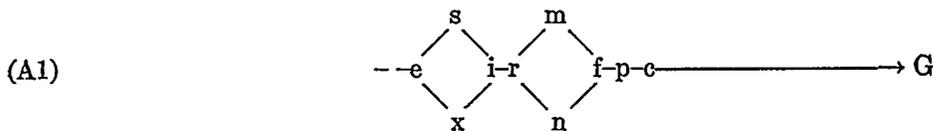
indicates when (S2) is interpreted as asserting "persons who are both law teachers and librarians qualify?")

Notice that the first five questions call for "yes" or "no" answers; and the sixth question, an answer of either "logical product" or "conjunction." Let us suppose that the first alternative interpretation of Rule A is the interpretation in which the first five questions are answered "yes" and the sixth question answered "logical product." If the following abbreviations are used:

- I for yes
- O for no
- C for conjunction
- LP for logical product

Then this first alternative interpretation can be indicated as LP-11-111.

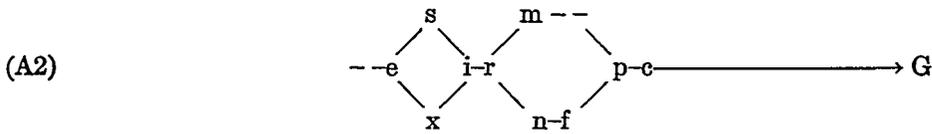
What would be the graphic representation of this first alternative interpretation? It would be:



- in which:
1. Yes, f, p and c do modify m. (Any path through the circuit that goes by way of m must also pass through f, p and c.
 2. Yes, p and c do modify m.
 3. Yes, c does modify m.
 4. Yes, both i and r modify n.
 5. Yes, e does modify x.
 6. The connection between i and r is logical prod-

uct because any path through the circuit that goes by way of i must go by way of r, and any path that goes by way of r must go by way of i.

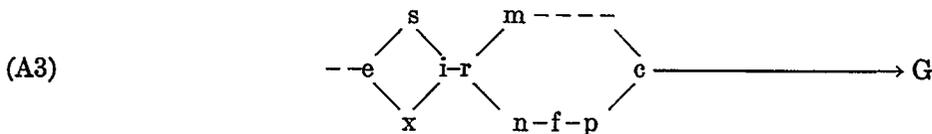
A second interpretation might be where the first question is answered "no" and all the other answers are the same as (A1). This second alternative interpretation would be indicated as LP-11-110. Its circuit would be:



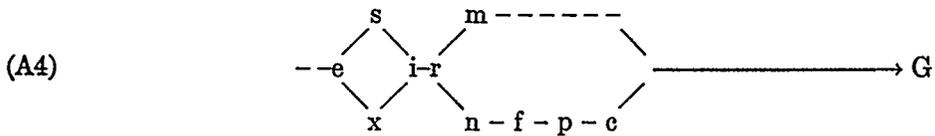
There are thirty additional alternative interpretations, making a total of thirty-two in all. They are as follows:

- | | | | |
|-------|-----------|-------|----------|
| (A1) | LP-11-111 | (A17) | C-11-111 |
| (A2) | LP-11-110 | (A18) | C-11-110 |
| (A3) | LP-11-100 | (A19) | C-11-100 |
| (A4) | LP-11-000 | (A20) | C-11-000 |
| (A5) | LP-10-111 | (A21) | C-10-111 |
| (A6) | LP-10-110 | (A22) | C-10-110 |
| (A7) | LP-10-100 | (A23) | C-10-100 |
| (A8) | LP-10-000 | (A24) | C-10-000 |
| (A9) | LP-01-111 | (A25) | C-01-111 |
| (A10) | LP-01-100 | (A26) | C-01-110 |
| (A11) | LP-01-100 | (A27) | C-01-100 |
| (A12) | LP-01-000 | (A28) | C-01-000 |
| (A13) | LP-00-111 | (A29) | C-00-111 |
| (A14) | LP-00-110 | (A30) | C-00-110 |
| (A15) | LP-00-100 | (A31) | C-00-100 |
| (A16) | LP-00-000 | (A32) | C-00-000 |

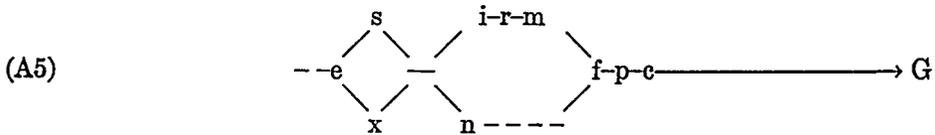
Of course, each of these thirty-two different interpretations of Rule A will have its own distinctive circuit. An examination of a few of the circuits shows how the circuits vary in pattern with the variations in interpretation. For the third alternative, which is just like (A2) except that the second question has been answered "no," i.e., LP-11-100, the circuit is:



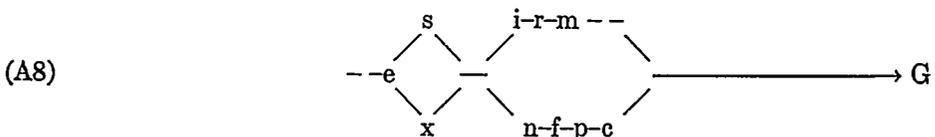
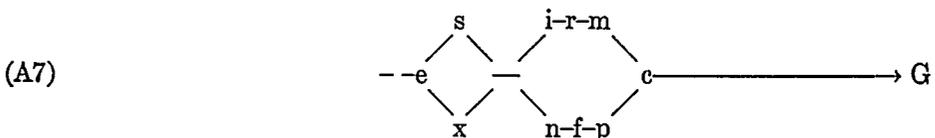
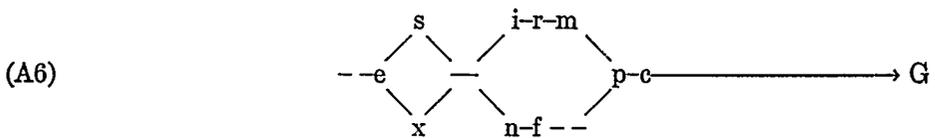
The "no" answer to (Q2) indicates that the combination of p and c does not modify m, while the "yes" answer to (Q3) indicates that c does modify m. The fourth alternative is just like (A3) except that (Q3) is answered "no," i.e., LP-11-000, and its circuit is:



The fifth alternative is just like (A1) except that (Q4) is answered “no,” i.e., LP-10-111. The circuit is just like the

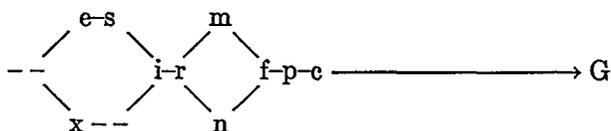


If this same change that was made in (A1) to get (A5) is also made in (A2), (A3) and (A4) the resulting circuits are the circuits for (A6), (A7) and (A8):



The ninth alternative is just like (A1) except that (Q5) has been answered “no,” which indicates that e does not modify x. The circuit for (A9) is modified to provide a path through x without going through e, and the resulting circuit is the one for (A9):

(A9)

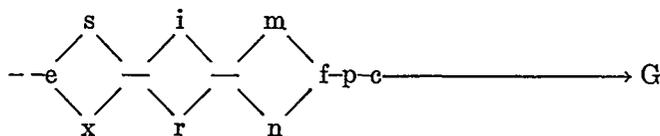


A similar change in circuits (A2) through (A8) will result in circuits that indicate alternatives (A10) through (A16).

The final change involves (Q6). The seventeenth alternative is the same as (A1) except that the “and” between

“intentionally” and “reasonably” is interpreted as indicating “conjunction” rather than “logical product.” To indicate this change from LP-11-111 to C-11-111 the i and r are connected in parallel in the circuits, rather than in series as in (A1):

(A17)



This same change in circuits (A2) through (A16) produces circuits that represent interpretations (A18) through (A32). The most inclusive of these thirty-two alternative interpretations is (A32), and the most restrictive is (A1).

Returning to the attorney’s problem of determining whether the situation his client was involved in was a “general average act” under Rule A, it is evident that this

extraordinary expenditure reasonably made for the purpose of preserving from peril the property involved in a common maritime venture,

in an —e-x-r-m-p-c— path. The only interpretations of Rule A for which there is a continuous path for this set of constituents are (A32), (A31), (A30), (A28), (A27), (A26), (A24), (A23), (A22), (A20), (A19) and (A18). Thus,

the situation the attorney is handling for his client will be a “general average act” if and only if it is decided that Rule A “means” one of these 12 interpretations.

Before the attorney can ascertain whether this —e-x-r-m-p-c— situation constitutes a “general average act” under Rule A, he must make some decisions about the syntactical structure of Rule A. The bare prose of the rule is not enough for him. Similarly, it is not enough for a computer. In order for the computer to be able to answer all questions about situations involving constituents of Rule A, it must be “told” which of the alternative interpretations Rule A “means.” The high degree of syntactical imprecision of a great deal of the discourse in natural languages is one of the problems that must be dealt with in automatically retrieving and analyzing this kind of discourse. This is exactly where the

precisely and carefully constructed artificial language systems of the modern logician are relevant. In addition to its usefulness in connection with the automatic processing of information, it should be evident that modern logic has great value for the practicing lawyer in sharpening two of his basic skills—drafting and interpreting.

In conclusion I would like to return for a moment to the world of dreams and to a comment by T. E. Lawrence¹¹:

11. ADAMS, *op. cit. supra*.

Those who dream by night in the dusty recesses of their minds, wake in the day to find that it was vanity; but the dreamers of the day are dangerous men, for they may act their dream with open eyes, to make it possible.

I must ask whether it is a night dream or a dream of the day to envision that among such a band of dangerous men there will be found representatives from the small group of professionals known as law librarians?