12. R. Ceppellini, *Proc. Intern. Congr. Blood Transfusion, 5th, Paris* (1955), p. 207; W. M. Watkins, *Proc. Intern. Congr. Blood Transfusion 7th, Rome* (1958), p. 206; W. M. Watkins, in *The Red Blood Cell*, C. Bishop and D. M. Surgenor, Eds. (Academic Press, New York, 1964), p. 359.
13. W. M. Watkins and W. T. J. Morgan, *Vox Sang.* **4**, 97 (1959).
14. R. Ceppellini, in *Symposium on the Biochemistry of Human Genetics*, G. E. W. Wolstenholme and C. M. O'Connor, Eds. (Churchill, London, 1959), p. 242.
15. F. Bernstein, *Klin. Wochschr.* **3**, 1495 (1924).
16. There are a few very rare exceptions to this rule, described by Race and Sanger (*1*).
17. F. Schiff and H. Sasaki, *Klin. Wochschr.* **34**, 1426 (1932).
18. F. Schiff, *ibid.* **6**, 303 (1927).
19. W. T. J. Morgan and W. M. Watkins, *Brit. J. Exp. Pathol.* **29**, 159 (1948).
20. The *Hh* genes correspond to the *Xx* genes described by P. Levine, E. Robinson, M. Celano, O. Briggs, L. Falkinburg, *Blood* **10**, 1100 (1955).
21. R. Grubb, *Nature* **162**, 933 (1948).
22. W. T. J. Morgan and R. van Heyningen, *Brit. J. Exp. Pathol.* **25**, 5 (1944).
23. D. Aminoff, W. T. J. Morgan, W. M. Watkins, *Biochem. J.* **46**, 426 (1950); E. F. Annison and W. T. J. Morgan, *ibid.* **50**, 460 (1952); and **52**, 247 (1952); R. A. Gibbons and W. T. J. Morgan, *ibid.* **57**, 283 (1954).
24. Details of isolation and purification of blood-group specific substances from ovarian cyst fluids are given by W. T. J. Morgan, *Methods Carbohydrate Chem.* **5**, 95 (1965).
25. A. Pusztai and W. T. J. Morgan, *Biochem. J.* **78**, 135 (1961); H. M. Tyler and W. M. Watkins, unpublished observations.
26. Z. Dische, *Ann. N.Y. Acad. Sci.* **106**, 259 (1963).
27. A. Pusztai and W. T. J. Morgan, *Biochem. J.* **88**, 546 (1963).
28. K. Landsteiner, *Biochem. Z.* **104**, 280 (1920); *The Specificity of Serological Reactions* (Harvard Univ. Press, Cambridge, 1947), pp. 182–196.
29. W. M. Watkins and W. T. J. Morgan, *Nature* **169**, 852 (1952); W. T. J. Morgan and W. M. Watkins, *Brit. J. Exp. Pathol.* **34**, 94 (1953); E. A. Kabat and S. Leskowitz, *J. Amer. Chem. Soc.* **77**, 5159 (1955).
30. W. M. Watkins and W. T. J. Morgan, *Nature* **175**, 676 (1955).
31. ———, *ibid.* **178**, 1289 (1956); P. Z. Allen and E. A. Kabat, *J. Immunol.* **82**, 340 (1959).
32. R. Kuhn, *Angew. Chem.* **60**, 23 (1957).
33. W. M. Watkins and W. T. J. Morgan, *Nature* **180**, 1038 (1957); *Vox Sang.* **7**, 129 (1962).
34. W. T. J. Morgan and W. M. Watkins, *Nature* **177**, 521 (1956); W. M. Watkins and W. T. J. Morgan, *Acta Genet. Statist. Med.* **6**, 521 (1957); P. C. Brown, L. E. Glynn, E. J. Holborow, *Vox Sang.* **4**, 1 (1959).
35. S. Iseki and S. Masaki, *Proc. Japan Acad.* **29**, 460 (1953); W. M. Watkins, *Biochem. J.* **64**, 21P (1956); S. Iseki, K. Furukawa, S. Yamamoto, *Proc. Japan Acad.* **35**, 513 (1959); W. M. Watkins, M. L. Zarnitz, E. A. Kabat, *Nature* **195**, 1204 (1962); G. J. Harrap and W. M. Watkins, *Biochem. J.* **93**, 9P (1964).
36. W. M. Watkins, *Bull. Soc. Chim. Biol.* **42**, 1599 (1960); ———, *Immunology* **5**, 245 (1962); K. Furukawa, K. Fujisawa, S. Iseki, *Proc. Japan Acad.* **39**, 540 (1963).
37. R. Côté and W. T. J. Morgan, *Nature* **178**, 1171 (1956); G. Schiffman, E. A. Kabat, S. Leskowitz, *J. Amer. Chem. Soc.* **84**, 73 (1962); T. J. Painter, W. M. Watkins, W. T. J. Morgan, *Nature* **193**, 1042 (1962).
38. G. Schiffman, E. A. Kabat, W. Thompson, *Biochemistry* **3**, 113, 587 (1964); V. P. Rege, T. J. Painter, W. M. Watkins, W. T. J. Morgan, *Nature* **203**, 360 (1964); ———, *ibid.* **204**, 740 (1964).
39. V. P. Rege, T. J. Painter, W. M. Watkins, W. T. J. Morgan, *Nature* **200**, 4906 (1963).
40. I. A. F. L. Cheese and W. T. J. Morgan, *ibid.* **191**, 149 (1961); T. J. Painter, W. M. Watkins, W. T. J. Morgan, *ibid.* **199**, 282 (1963).
41. V. P. Rege, T. J. Painter, W. M. Watkins, W. T. J. Morgan, *ibid.* **204**, 740 (1964).
42. ———, *ibid.* **203**, 360 (1964).
43. K. Lloyd and E. A. Kabat, *Biochem. Biophys. Res. Commun.* **16**, 5 (1964).
44. T. J. Painter, W. M. Watkins, W. T. J. Morgan, *Nature* **206**, 594 (1965).
45. J. Koscielak and K. Zakrewski, in *International Symposium on Biologically Active Mucoids* (Polish Acad. of Sciences, Warsaw, 1959), p. 21; J. Koscielak, *Nature* **194**, 751 (1962).
46. W. M. Watkins, J. Koscielak, W. T. J. Morgan, *Proc. Intern. Congr. Blood Transfusion, 1962, 9th, Mexico City* (1964), p. 213.
47. T. Baranowski, E. Lisowska, A. Morawiecki, E. Romanowska, K. Strozecka, *Arch. Immunol. Terapii Doswiadczalnej* **7**, 15 (1959); K. Stalder and G. F. Springer, *Fed. Proc.* **19**, 70 (1960); R. H. Kathan, R. J. Winzler, C. A. Johnson, *J. Exp. Med.* **113**, 37 (1961); G. M. W. Cook and E. H. Eylar, *Biochim. Biophys. Acta* **101**, 57 (1965).
48. E. Klenk and G. Uhlenbruck, *Z. Physiol. Chem.* **319**, 151 (1960).
49. G. F. Springer and N. J. Ansell, *Proc. Nat. Acad. Sci. U.S.* **44**, 182 (1958); O. Mäkelä and K. Cantell, *Ann. Med. Exp. Biol. Fenniae Helsinki* **36**, 366 (1958); E. Romanowska, *Arch. Immunol. Terapii Doswiadczalnej* **7**, 749 (1959).
50. G. Uhlenbruck, *Z. Immunitatsforsch.* **121**, 420 (1961).
51. ——— and M. Krüpe, *Vox Sang.* **10**, 326 (1965); E. Romanovska, *ibid.* **9**, 578 (1964).
52. G. L. Cameron and J. M. Staveley, *Nature* **179**, 147 (1957).
53. W. T. J. Morgan and W. M. Watkins, *Proc. Intern. Congr. Blood Transfusion, 9th Mexico, 1962* (1964) p. 225; W. M. Watkins and W. T. J. Morgan, *ibid.*, p. 230.
54. Two different systems of notation are in common usage to describe the antigens in the Rh system. In one system Rh_0 is equivalent to D in the other system. For a full description of Rh nomenclature see Race and Sanger (*1*, p. 135).
55. M. C. Dodd, M. J. Bigley, V. B. Geyer, *Science* **132**, 1398 (1960); W. C. Boyd and E. Reeves, *Nature* **190**, 1123 (1961).
56. M. C. Dodd, N. J. Bigley, G. A. Johnson, R. H. McCluer, *Nature* **204**, 549 (1964).
57. Personal communication.
58. R. R. Race, *Ann. N.Y. Acad. Sci.* **127**, 884 (1965).

Computers and Copyrights

Restrictions on computer use of copyrighted material would protect authors, publishers, and even users.

Curtis G. Benjamin

In the debate over the proposed new copyright law and its possible impact on the future of computer-based information systems, only two points have thus far emerged clearly and incontrovertibly: (i) new legislation is very badly needed; (ii) the new law, though it should adequately protect the owners of copyrights, must not be so stringent as to restrict the development of computerized information systems, particularly in science and applied science. Nevertheless, the Congress may soon deal decisively with this matter in acting upon the new copyright bill which is now before both houses.

To date there has not been enough debate, either public or private, on the problems and issues involved. It may be useful, therefore, to have an analysis of them by a book publisher, though an admittedly biased interest in the matter may be displayed here. But even a publisher can strive for objectivity in considering certain long-range involvements of the future welfare of science information and hence of science itself.

A basic requirement of the new law is to provide for copyright security in a work first produced by means of, or with the aid of, an automated mechanism such as a computer. This requirement has to be dealt with *de novo* because there is nothing in the present copyright law—enacted in 1909 and not overhauled since—that recognizes this kind of production. The pressing need to satisfy this requirement is suggested in a paragraph in the Annual Report (draft copy) of the Register of Copyrights for the Fiscal Year 1965:

> As computer technology develops and becomes more sophisticated, difficult questions of authorship are emerging. In past years the Copyright Office has received an application for registration of a musical composition created by computer. This year copyright was claimed for an abstract drawing, and for compilations of various kinds, which were at least partly the "work" of computers. It is certain that

The author is chairman of the board of the McGraw-Hill Book Company, 330 West 42 Street, New York, New York.

both the number of works proximately produced or "written" by computers, and the problems of the Copyright Office in this area, will increase. The crucial question appears to be whether the "work" is basically one of human authorship, with the computer merely being an assisting instrument, or whether the traditional elements of "authorship" in the work (literary, artistic, or musical expression or elements of selection, arrangement, etc.) were actually conceived and executed not by man but by a machine.

The crucial question is also a tough one. Though few people will allow that a machine can actually *create* an original literary or scientific work, it must be allowed that a computer when properly programmed can produce a compiled or derivative work that is copyrightable. In this tangled matter of human authorship versus machine performance, the Copyright Office has taken a liberal view. It has stated that where human direction has guided the computer in producing a work, either proximately or through one or more programs aimed at the result, or where the computer output was edited or arranged by human beings, the mere use of a computer would not of itself prevent copyright registration. (This is a reversal of an earlier decision on the point.) Further, the Copyright Office admits that it would be a rare case indeed where no elements of human authorship whatever can be identified in the preparation of a work.

The reasonable practicality of the Copyright Office's policy under the present law was to be expected because the Register of Copyrights, Abraham L. Kaminstein, made an eminently sensible approach to the general problem of computer storage and retrieval when the 1965 Copyright Bill was introduced last February. Let us go back and review what was then proposed for congressional action and what Kaminstein had to say in support of his draft of the bill.

Starting with a basic definition, Section 102 of the new bill describes subject matter of copyright simply as "original works of authorship" rather than "all the writings of an author," as the present law has it. The new definition is certainly much broader and more flexible. Still it seems not to deal adequately with the crucial question whether a machine or only a human being is capable of "authorship," and probably this question will eventually reach the courts for decision.

Following its new basic definition of subject matter, the bill does deal very effectively with the question of form. Whereas the 1909 Act has an implicit requirement that subject matter be fixed in some tangible form from which the work can be reproduced, the new bill more explicitly specified "fixed in any tangible medium of expression, now known or later developed, from which they [original works] can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device."

Again the new language is about as broad as one could ask, and certainly it is flexible and forward-looking. It leaves no doubt about the copyrightability of works *first produced* and fixed in a computer or any other kind of mechanized system.

So far, so good. The more debatable questions arise with the Register's proposals in Section 106(a) of the new bill, which covers the author's exclusive rights of "reproduction" and of the preparation of "derivative works" from a *previously copyrighted* work. The first two clauses of this section's so-called "bundle of rights" give the owner of a copyright exclusive rights (i) to reproduce the copyrighted work in copies or phonorecords, and (ii) to prepare derivative works based upon the copyrighted work.

Commenting in his Report of 1965 on the background to the wording of these two clauses with respect to information storage and retrieval systems, Kaminstein reviewed earlier thinking on the matter:

> An important question that has emerged since publication of the Report in 1961 involves computer uses of copyrighted materials. Mainly in an effort to stimulate a discussion of the issue, the preliminary draft of 1963 contained a provision granting an exclusive right "to reproduce [the work] in any form in the programming or operation of an information storage and retrieval system." We became convinced, however, that it would be a mistake for the statute, in trying to deal with such a new and evolving field as that of computer technology, to include an explicit provision that could later turn out to be too broad or too narrow. A much better approach, we feel, is to state the general concepts of copyright in language, such as that in Section 106(a), which would be general in terms and broad enough to allow for adjustment to future changes in patterns of reproduction and other uses of authors' works.

After making this background statement, Kaminstein came directly to grips with the basic issues:

> At the same time, we should emphasize here that, unless the doctrine of "fair use" is applicable in a particular case, the bill contemplates that certain computer uses would come within the copyright owner's exclusive rights. It seems clear, for example, that the actual copying of entire works (or substantial portions of them) for "input" or storage in a computer would constitute a "reproduction" under clause (1), whatever form the "copies" take: punchcards, punched or magnetic tape, electronic storage units, etc. Similarly, at the "output" end of the process, the "retrieval" or "print-out" of an entire work (or a substantial part of it) in tangible copies would also come under copyright control.
>
> More difficult questions arise with respect to the detailed indexing or abstracting of a work for use in a computer program, and the reference use of the work in the course of the computer's operations. An index or abstract so complete and detailed that it could replace the work on which it is based should probably be regarded as an "abridgment" or "condensation," and hence a "derivative work" covered by Section 106(a)(2). On the other hand we do not believe that the mere use of a work by the computer as a reference source in solving problems or compiling data should be regarded as within the scope of copyright, any more than the use of books in a library is now.

Kaminstein's forthright opinion that the mere input of a copyrighted work into a computerized system would clearly be an infringement under the new law came as a surprise, not to say a shock, to many people. They could not agree that storage could be considered as copying, or even as the making of a "derivative" work. Nor did they understand that the possession of a copy of a work does not give the owner any property rights whatever in the work itself—that the purchaser of a book has indeed bought no more than the right of access to a certain literary or scientific work through the physical form of the particular copy purchased. Such people, confronted by the facts of the law on literary property, usually declare stoutly, "But if I have bought a book, it is mine and I can do what I want with it!"

In actual fact, however, the owner of a store-bought book—or of a free copy, for that matter—cannot do as he wants with it. He cannot copy such portions of it as may be considered "unfair use" by the courts; he cannot translate it into another language; he cannot make from it an abridgment or an adaptation or a derivative version of any kind. And now the proposed new law would keep him from storing its content in a computer without permission of the copyright owner.

It is not surprising that Kaminstein's statement of the intent of the language of the new bill has caused some consternation among computer manufacturers and users, nor that it has served to reassure authors, editors, and publishers of scientific and educational books. Both camps have been on edge, and each has tried, of course, to place its cause in the best possible light. The "hardware" camp has contended that the public interest demands that progress in information-retrieval methods and systems must not be impeded by copyright restrictions on the mere storage of materials in systems intended for scientific and educational use. The "software" camp has argued to the contrary, that the public interest will be ill served if copyrighted works are not protected at the point of input, because the lack of such protection will surely destroy incentives for the creation of scientific and educational publications for general public use. (Financial reward is only one of the incentives here involved; just as important are professional recognition, pride of authorship, and protection of the form in which a work has been created.) Nevertheless, both sides seem to agree —in principle at least—that the urge for progress in the development of "hardware" should not be allowed to kill off the "software" on which many information and educational systems must feed. Both agree, in short, that we should find a way to have our cake and eat it too.

The central question in this critical argument over input is really quite simple. Once a copyrighted work has been fully stored without permission in a retrieval system, just what concept of "fair use" would apply to its utilization from there on? It would be unreasonable to say that manipulation of materials within the system for analysis or problem solving, for example, would be unfair use. (Kaminstein already has suggested that it would not.) Also, in most cases one would be on rather unfirm ground in claiming that video displays of a page or two retrieved now and then would constitute unfair use. Nor could one usually argue that a computer print-out of a few figures or formulas or of small selections of data would contravene the "fair use" doctrine as it has been established by the courts.

Yet the foregoing are exactly the kinds of use that are customarily made of handbooks, data books, and other basic reference works in science and technology. Examples could be given also of similar kinds of seemingly fair use of copyrighted instructional or testing materials once they have been stored in a computerized teaching system established for citywide, statewide, or even nationwide classroom use. Thus it is understandable why authors and publishers of copyrighted educational materials that are subject to such use are also ready to support the concept of protection at the point of input.

The threat to the "software" camp can best be illustrated, perhaps by hypothesizing a situation which could well come into existence a few years hence. Let us suppose that a large corporation —say a Monsanto or a Du Pont—has established a company-wide (and hence a nationwide) computerized technical information system for use at the touch of dozens of consoles by its hundreds of scientists and engineers. Let us also suppose that the "hardware" camp has prevailed in the copyright argument and that the corporation is free to store the whole of Perry's *Chemical Engineers' Handbook* in its computerized system. Let us finally suppose that the corporation buys one copy of this handbook, stores its content, and then puts it to the seemingly "fair" uses described above. Obviously, in a situation such as this the one stored copy could take the place of as many as 500 or even 1000 copies of the handbook as it is now used. And if eight or ten other large corporations did likewise, there would be no remaining market sufficient to sustain publication. And soon no one would bother with compiling, editing, and printing a work of this sort. What then?

When this question has been put to members of the "hardware" camp, the answer usually has come quickly: "That's easy—the corporation itself will produce the data needed for its system." This is an easy answer, certainly, but it provides a rather difficult solution to the problem. To begin with it would be neither efficient nor economical, and hence would be more costly on the national scale. More important, it would more likely restrict than widen dissemination, because once a company had made a large investment in building up a mass of valuable research, design, and operating data, it would hardly be willing to share it with all comers. And, as usual, the little fellow would be the one most hurt. He could not afford to develop a comprehensive data system of his own, yet the springs of presently available copyrighted data would have been dried up.

In the face of these foreseeable difficulties and uncertainties, would it not be wise to proceed with the enactment of the proposed new copyright bill with its provision for the protection of copyrighted works from unauthorized storage? Both camps would have to be prepared to deal with permissions at the storage point, and also with fees in cases in which more than "fair" use is involved. Neither requirement should be onerous. Since storage is a one-time thing, fees could be fixed for annual payment. Further, as the dimensions of possible use could be estimated for each system, the question of setting proper fees or use-rates would not be difficult. (If it were worthwhile to do so, accounting subsystems could be built in to provide exact information on high-volume usage.) Moreover, since haste comes with retrieval rather than with storage, there would usually be ample time to negotiate permissions and fees. In short, there seems to be no practical problem that could not be met without undue effort, expense, or delay.

What else can be said and done?

Well, it can be said that both camps should make every effort to be flexible and originative in helping to meet the imperative national need for the development of large-scale computerized systems. The authors and publishers must frankly face the fact that their copyrighted materials must be made available to such systems, and on reasonable terms and conditions. "Hardware" manufacturers and systems developers must realize that neither their particular interest nor the general public interest is so important as to justify a demand for public expropriation of private literary property, either legally or otherwise.

Above all, authors and publishers must not be obstructionists in carrying out their obligations to protect their conventionally printed products. To the contrary, they should actively seek ways to promote the use of their materials in mechanized systems—making sure, of course, that they receive adequate fees to compensate for the consequent loss of sales of printed copies.

Why should publishers not vend many of their products in both magnetic-tape and printed form? Probably they should, but if they do, they must be careful not to accept licensing practices that might trap their authors and themselves in another "juke-box exemption" situation a few years hence—which is to say that they must not accept a licensing practice under which the copyright owner receives only a one-payment fee for the right to "record" a work on a computer tape which could be used over and over again in any number of informational systems without additional payments.

Above all, the "hardware" manufacturers and systems operators must be careful that their demands and practices do not hurt the generation and flow of copyrighted scientific and technical information. They must avoid demands that might cause a sacrifice of human creativity to the convenience of their machines. And they must realize that assaults on copyright protection of literary property in the name of overriding public interest can only invite similar assaults on patent protection of their machines and industrial processes.

When these accommodations in thinking and attitudes have been made on both sides, practical business solutions to the remaining problems must be sought and found. This may not be easy, but certainly it can be done, and done with fairness to all interests. "Be there a will, and wisdom finds a way."

NEWS AND COMMENT

Science Policy: When Congress Looks for a Leader NSF Is Usually Nominated

Since it was established 15 years ago, the National Science Foundation has maintained a measured rate of growth and an unobtrusive style. In Congress, however, a campaign to thrust a new "dynamism" on the NSF seems to be gathering momentum.

Hearings on a bill which would alter the scale and character of NSF operations are scheduled for 19 through 21 April, before the subcommittee on science, research, and development of the House Committee on Science and Astronautics. Chairman of the subcommittee is Hartford Democrat Emilio Q. Daddario, who is also author of the bill (H.R. 13696) which will be the subject of the hearings. Daddario's proposals were discussed in detail in an article by the congressman in last week's issue of *Science*.

In the Senate, early in March Senator Carl T. Curtis (R–Nebr.) introduced a resolution (S. Res. 231) which would also give NSF new marching orders. The resolution would request NSF to recommend changes in existing laws necessary "to provide for a more equitable distribution of [R & D] funds to all qualified institutions of higher learning to avoid the concentration of such activities in any geographical area and to insure a reservoir of scientific and teaching skills and capacities throughout the several States."

The attention being paid NSF is at least in part a symptom of dissatisfaction in Congress over national science planning. This dissatisfaction is not new. Since the war it has been a chronic condition which recently has been growing acute.

In the act founding NSF in 1950, the agency was directed "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." The young NSF, which had plenty of other problems to occupy it, did not perform this function to the satisfaction of Congress or the Executive. This was reflected in the establishment of the President's Science Advisory Committee (PSAC), made up of nongovernmental experts, and later of the Federal Council on Science and Technology, composed of policy-making officials of the science agencies. A further step was taken early in the Kennedy Administration with the expansion of the Office of the President's Science Adviser into the Office of Science and Technology. Under the reorganization plan which created OST, there was a transfer to OST from NSF of functions which were to "enable the Director of OST [i] to advise and assist the President in achieving coordinated Federal policies for the promotion of basic research in the sciences," and (ii) "to evaluate scientific research programs undertaken by agencies of the Federal Government."

OST's performance to date has been rated fairly high in advising and evaluating, but as less impressive in promoting coordination. The fugitive state of federal science planning is one of the factors which account for the creation in late years of several subcommittees, in both the House and the Senate, concerned with science policy as well as science programs.

While the reasons for the growing demand for effective planning for federal science are multiple, several seem particularly noteworthy. Perhaps the most obvious cause is the leveling off in the past 3 years of the government's annual R&D budget at around $16 billion. Since the R & D dough has lost its self-rising properties, problems have developed over finding funds to pay for new projects and also to defray the built-in escalation in costs of existing programs. Very expensive projects have come under closer scrutiny, and funds for young researchers just establishing themselves seem to be in particularly short supply.

In Congress, concern about geographical distribution of R & D funds is widespread and is producing such manifestations as the Curtis resolution. The experience of the postwar period has led Congress to believe that military R & D contracts and major research grants to universities are a sort of magic ingredient in regional development. Better science planning has come to be identified with broader geographic distribution of funds for scientific research and education.

In recent years the growing sophistication of the legislators has been evident in competition for such facilities as NASA's electronics research center and the PHS environmental health research facilities. The projected Midwestern Universities Research Association accelerator turned out to be a mirage, but the lessons learned in the MURA quest were not lost on the midwestern states. The biggest prize to date, the 200-Bev proton accelerator, has been the most earnestly sought after.

While parochial self-interest obviously