S. Hrg. 98-493

THE SEMICONDUCTOR CHIP PROTECTION ACT OF 1983

HEARING

BEFORE THE

SUBCOMMITTEE ON
PATENTS, COPYRIGHTS AND TRADEMARKS

OF THE

COMMITTEE ON THE JUDICIARY
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

S. 1201

A BILL TO AMEND TITLE 17 OF THE UNITED STATES CODE TO PROTECT SEMICONDUCTOR CHIPS AND MASKS AGAINST UNAUTHORIZED DUPLICATION, AND FOR OTHER PURPOSES

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THE SEMICONDUCTOR CHIP PROTECTION ACT OF 1983

THURSDAY, MAY 19, 1983

U.S. SENATE,
COMMITTEE ON THE JUDICIARY,
SUBCOMMITTEE ON PATENTS, COPYRIGHTS AND TRADEMARKS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:43 a.m., in room SD-562, Dirksen Senate Office Building, Senator Charles McC. Mathias, Jr. (chairman of the subcommittee) presiding.

OPENING STATEMENT OF SENATOR CHARLES McC. MATHIAS, JR.

Senator MATHIAS. The Subcommittee on Patents, Copyrights and Trademarks today begins hearings on S. 1201, the Semiconductor Chip Protection Act of 1983, which would provide the semiconductor chip industry with copyright protection against chip piracy.

When we marvel at the wonders of modern technology, it is usually the work of the semiconductor chip that is being admired. The microprocessor, the computer on a chip, has made many of our modern-day conveniences possible.

The chip is in the home, making dinner in the microwave oven, setting the thermostat, and tuning the radio. It is in the supermarket, adding up the purchases. It is in the car, controlling fuel consumption. It is in the hospital, helping doctors to diagnose disease. The microprocessor is the brain of the consumer product that may do the most to revolutionize the way we live today, which is, of course, the personal computer.

If chip technology continues on the fast track that it is on today, this catalog may soon include technological innovations that have yet to be imagined. But our progress toward such wonders may be delayed or frustrated if something is not done to protect the products of the innovative chip designers from piracy and from theft.

High-tech firms spend huge amounts of time and money on producing semiconductor chips. Engineers design intricate layouts of circuitry analagous to the architect's blueprint. Like the architect, the chip designer must find the most elegant solution to a specified set of needs and problems.

Concentrating hundreds of thousands of transistors into such a tiny space is in itself no easy task. The real challenge is finding ways to maximize and diversify the electronic possibilities of the components.

So, chip production is a fine art, and like most fine art, it is costly. It can take an innovative firm years and consume millions of dollars and thousands of hours of engineers' and technicians' time.

Yet, these innovators are being ripped off by both onshore and offshore chip pirates who, at minimal expense, can now legally appropriate and use the chip designs as their own. All they need do is buy a computer or a similar device on the open market, remove the chips, scrape off the protective plastic coating, photograph the circuitry, enlarge the photographs and study the designs in order to produce their own masks, and thus their own chips.

Then the pirate firm can flood the market with cheap products. They can sell the products cheaply because they are made cheaply, because the innovative firm has already paid for the R&D costs.

Current law gives very limited protection to semiconductor chips. Patent law can protect the basic electronic circuitry used in the chip, but not the carefully developed design. By giving chip engineers and manufacturers copyright protection for a 10-year period, S. 1201 would protect the research and development investment.

It would also protect the innocent purchasers of pirated chips by including a compulsory licensing provision allowing them to use that chip after paying a royalty to the innovating firm, and by eliminating any liability for innocent infringement.

Providing the right kind of protection for chip designs will not be easy. The aim is to deter chip piracy and, where possible to punish it without, at the same time, discouraging legitimate reverse engineering.

We have to recognize that by bringing chip design under the protection of the copyright system, we are asking the system to do something that it has never been called upon to do before. The copyright law seems to be the best tool at hand to get the job done, but I think we have to make sure that it is not stretched out of shape in order to accommodate this new need.

[A copy of S. 1201, introduced by Senator Mathias, follows:]

II

98TH CONGRESS
1ST SESSION

S. 1201

To amend title 17 of the United States Code to protect semiconductor chips and masks against unauthorized duplication, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 4 (legislative day, MAY 2), 1983

Mr. MATHIAS (for himself and Mr. HART) introduced the following bill; which was read twice and referred to the Committee on the Judiciary

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A BILL

To amend title 17 of the United States Code to protect semiconductor chips and masks against unauthorized duplication, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Semiconductor Chip Protection Act of 1983".

DEFINITIONS

SEC. 2. Section 101 of title 17 of the United States Code is amended by adding at the end thereof the following:

"A 'semiconductor chip product' is the final or intermediate form of a product—

"(1) having two or more layers of metallic, insulating, or semiconductor material, deposited on or etched away from a piece of semiconductor material in accordance with a predetermined pattern;

"(2) intended to perform electronic circuitry functions; and

"(3) that is a writing or a discovery, or the manufacture, use, or distribution of which is in or affects commerce.

"A 'mask work' is a series of related images—

"(1) having the predetermined, three-dimensional pattern of metallic, insulating, or semiconductor material present or removed from the layers of a semiconductor chip product; and

"(2) in which series the relation of the images to one another is that each image has the pattern of the surface of one form of the semiconductor chip product.

"A 'mask' is a substantially two-dimensional, partially transparent and partially opaque sheet. A mask embodies a mask work if the pattern of transparent and opaque portions of the mask is substantially similar to the pattern of one of the images of the mask work. Masks and mask works shall not be deemed pictorial, graphic, or sculptural works. The copyright in a mask or mask work shall not extend to any other work of authorship embodied therein.

"As used in sections 109(a), 401, 405, 406, 501(A), 503, 506, 509, and 602 of this title, 'copy' includes a semiconductor chip product that is subject to the exclusive rights described in section 106.".

SUBJECT MATTER OF COPYRIGHT

SEC. 3. Section 102(a) of title 17 of the United States Code is amended—

(1) by adding after paragraph (5) the following:

"(6) mask works;"; and

(2) by redesignating paragraphs (6) and (7) as paragraphs (7) and (8), respectively.

EXCLUSIVE RIGHTS

SEC. 4. Section 106 of title 17 of the United States Code is amended—

(1) by striking out "and" at the end of paragraph (4);

(2) by striking out the period at the end of paragraph (5) and inserting "; and" in lieu thereof; and

(3) adding at the end thereof the following:

"(6) in the case of mask works—

"(A) to embody the mask work in a mask;

"(B) to distribute a mask embodying the mask work;

"(C) to use a mask embodying the mask work to make a semiconductor chip product;

"(D) in the manufacture of a semiconductor chip product, substantially to reproduce, by optical, electronic, or other means, images of the mask work on material intended to be part of the semiconductor chip product; and

"(E) to distribute or use a semiconductor chip product made as described in subparagraph (C) or (D) of this paragraph.".

LIMITATION ON EXCLUSIVE RIGHTS AS TO MASKS

SEC. 5. (a) Chapter 1 of title 17 of the United States Code is amended by adding at the end the following:

"§ 119. Scope of exclusive rights: Compulsory licensing with respect to mask works

"(a) In the case of mask works, the exclusive rights provided by section 106 are subject to compulsory licensing under the conditions specified by this section.

"(b) The owner of a copyright on a mask work shall be required to grant a compulsory license under the copyright, to any applicant therefor, subject to all of the following terms and conditions, and all of the following circumstances:

"(1) The applicant has purchased a semiconductor chip product made or distributed in violation of the owner's exclusive rights under section 106.

"(2) When the applicant first purchased such semiconductor chip product (hereinafter in this section referred to as the 'infringing product'), the applicant did not have actual knowledge that or reasonable grounds to believe that the infringing product was an infringing product (hereinafter in this section referred to as 'having notice of infringement').

"(3) The applicant, before having notice of infringement, committed substantial funds to the use of the infringing product; the applicant would suffer substantial out-of-pocket losses (other than the difference in price between the infringing product and a noninfringing product) if denied the use of the infringing product; and it would be inequitable in the circumstances not to permit the applicant to continue the use or proposed use of the infringing product.

"(4) The applicant offers, subject to the applicant's rights, if any, under section 501(e) of this title, to pay the copyright owner a reasonable royalty for infringing products.

"(5) The royalty shall be for each unit of the infringing product distributed or used by the applicant after having notice of infringement.

"(6) The license shall be one to make and have made (but only if the copyright owner and the owner's licensees, if any, are unable to supply the applicant at a reasonable price), use, and distribute the infringing product, for substantially the same purposes that gave rise to the applicant's right to a compulsory license, throughout the United States, for the life of the copyright, revocable only for failure to make timely payments of royalties.".

(b) The chapter analysis for chapter 1 of title 17 is amended by adding at the end thereof the following:

"119. Scope of exclusive rights: Compulsory licensing with respect to mask works.".

DURATION OF COPYRIGHT

SEC. 6. Section 302 of title 17 of the United States Code is amended by adding at the end thereof the following:

"(f) MASKS.—Copyright in mask works endures for a term of ten years from the first authorized—

"(1) distribution;

"(2) use in a commercial product; or

"(3) manufacture in commercial quantities

of semiconductor chip products made as described in subparagraph (C) or (D) of paragraph (6) of section 106.".

INNOCENT INFRINGEMENT

SEC. 7. Section 501 of title 17 of the United States Code is amended by adding at the end thereof the following:

"(e) Notwithstanding any other provision of this chapter, a purchaser of a semiconductor chip product who purchased it in good faith, without having notice of infringement (as that term is used in section 119 of this title), shall not be liable as an infringer or otherwise be liable or subject to remedies under this chapter with respect to the use or distribution of units of such semiconductor chip product that occurred before such purchaser had notice of infringement.".

IMPOUNDING AND SEIZURE

SEC. 8. Sections 503(a), 503(b), and 509(a) of title 17 of the United States Code are each amended by inserting "masks," after "film negatives," each place it appears.

EFFECTIVE DATE

SEC. 9. The amendments made by this Act shall take effect ninety days after the date of enactment of this Act, but shall not apply to—

(1) semiconductor chip products manufactured in the United States or imported into the United States before the effective date;

(2) masks made in the United States or imported into the United States before the effective date; or

(3) semiconductor chip products manufactured in the United States by means of masks described in paragraph (2) of this section.

○

Senator MATHIAS. Today, we have with us representatives of high-tech firms, professional associations, and the academic world, who will, I hope, help us come to grips with the complex technical, legal, and economic issues that surround chip piracy. Consumers as well as producers will air their views.

In addition, the general counsel of the Copyright Office will be here to offer guidance. First, however, I would like to extend a very special welcome to our colleague and friend of many years from the other body, the distinguished Representative from California, Don Edwards, who will appear this morning as the first witness.

STATEMENT OF HON. DON EDWARDS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. EDWARDS. Thank you very much, Mr. Chairman. Your excellent opening statement framed the issue very well. I do think Mr. Chairman, that this legislation's time has come.

Norman Mineta and I started to worry about this issue back in 1978, and in 1979 we had hearings in Bob Kastenmeier's Judiciary Subcommittee on Courts, Civil Liberties, and the Administration of Justice. At that time, the semiconductor industry people could not get together on a bill that they felt would be acceptable and workable.

In the years since 1979, industry negotiations have been going on, and I hope that your witnesses will testify that the industry is behind your good piece of legislation. It is really a very critical issue, and critical to our continued leadership in semiconductors.

Our bill in the House is very similar to your bill here. So rather than read my entire statement, I would like my full statement to be made a part of the record.

Senator MATHIAS. Your statement will, of course, be made part of the record.

Mr. EDWARDS. I thank you for acting so promptly in scheduling these hearings, and I certainly hope that you can move ahead and enact the bill.

Senator MATHIAS. I am wondering, since you have been thinking about this problem for several years, if you have come to any conclusions about how widespread chip piracy may be and what the economic drain is on the American economy.

Mr. EDWARDS. I understand that as the technology of manufacturing and developing semiconductor chips has progressed to where there are 30,000 or 40,000 transistors on one chip, the technology for copying has done the same, using semiconductor chips in the process of making a copy.

The economic harm is significant, but I would defer to more expert witnesses to outline the seriousness of the loss to our industries.

Senator MATHIAS. Of course, the economic profile of this problem is interesting. As I understand it, about 80 percent of the chips are used in the United States and 20 percent are exported.

To the extent it can be determined, although the great majority of the piracy is offshore piracy, not all of it is.

Mr. EDWARDS. That is correct.

Senator MATHIAS. So, it is both a domestic and an international problem, which gives it a certain degree of complexity.

Mr. EDWARDS. Mr. Chairman, we worry about some of our friendly trading partners on this issue.

Senator MATHIAS. And, of course, we have to worry about some of ourselves.

Well, we appreciate very much the leadership you have taken in the House, and I hope that by forging a partnership, we can get this bill passed during this Congress.

Mr. EDWARDS. Thank you. We have done it in the past and I hope we can do it on this issue, too. Thank you.

Senator MATHIAS. Thank you.

Mr. EDWARDS. We miss you on the Judiciary Committee in the House of Representatives.

Senator MATHIAS. Thank you very much.

[The prepared statements of Representatives Edwards and Mineta follow:]

PREPARED STATEMENT OF REPRESENTATIVE DON EDWARDS

I thank the Chairman and the distinguished members of the Subcommittee for inviting me to present my views on "The Semiconductor Chip Protection Act of 1983".

Along with Congressman Mineta and other members of the House of Representatives, I have sponsored legislation similar to the bill before this Committee today. I believe that passage of such legislation is critical to our country's continued leadership in the semiconductor field.

Because of the rapid change inherent in new technologies, protecting rights to those technologies can be very difficult. Current law fails to provide that protection to semiconductor chip innovations. As Congressman Kastenmeier, Chair of the House Judiciary Subcommittee on Courts, Civil Liberties, and the Administration of Justice, noted in 1979:

> "There are many designs which are original but do not meet the standard of novelty required for patent protection and are also not eligible for copyright protection because they are not purely ornamental. The designs of circuits used in small computer devices fall within this unprotectable category."

As current laws do not give protection to semiconductor chip designs, chip innovations by one firm are subject to piracy by other firms.

Making innovative semiconductor chip designs is not merely drafting, but also requires considerable creativity. Many thousands of transistors and their intricate, rabbit-warren interconnections must be fitted into an absolutely minimum area in order to minimize the chip size and placed so that the device operates efficiently and economically. This is a fine art and also a costly one. The layout and design process, and the preparation of the photographic "masks" used to etch, deposit layers on, and otherwise process the chips often take the innovating firms years, consume thousands of hours of their engineers' and technicians' time, and cost millions of dollars.

Yet, a pirate firm can photograph the chip and its layers, and in a few months, for a cost of less than $50,000, duplicate the mask work of the innovator. Because the pirate firm does not have the enormous development costs borne by the innovator, the pirate firm can undersell the innovator and flood the market with cheap copies of the chip. Such piracy is a clear threat to the economic health of our semiconductor industry.

Continuation of this piracy eventually will make it impossible for innovator firms to continue their investment in the development of new chip designs. Unless the piracy is stopped, the industrial leadership enjoyed in the past by our semiconductor firms may vanish. This, of course, will have a ripple effect throughout our economy, with the impact becoming ever more critical as we continue an accelerated transition to a high-tech society.

To provide the innovating semiconductor firms with legal protection, the current copyright law must be changed. The proposed bill will amend Section 101 of the Copyright Act of 1976 to grant copyright protection for the imprinted design patterns on semiconductor chips. This will protect the substantial investments of innovating firms from misappropriation by pirating firms. The bill grants 10 years of copyright protection to those who develop new integrated circuit mask designs and grants copyright owners exclusive rights to make, distribute, and reproduce images of the mask design and the chips embodying that design. In addition, the bill protects semiconductor chip users from liability for innocent conduct. It also makes compulsory, reasonable royalty licenses available to them when necessary to protect their reasonable interests in their ongoing business activities as users of chips.

This bill will not interfere with the legitimate "reverse engineering" prevalent in the semiconductor industry. "Reverse engineering" requires only one or a very few photographs of the layers of the chip. The taking of these photographs for study and analysis, but <u>not</u> for duplicating, is clearly permitted within the "Fair Use" doctrine set forth in Section 107 of the Copyright Act. The "Fair Use" doctrine is not changed by this bill and "reverse engineering" for the purpose of teaching, analysis, or evaluation, would still not be an infringement of the Act.

In summary, this proposed legislation will close a gap in our current copyright law. I believe it is a balanced, reasonable proposal, with due concern for the legitimate interests of chip designers and of chip users. I commend this Subcommittee for holding this hearing on this important measure. I look forward to the testimony of your expert witnesses and I look forward to your work on the bill. It has been my pleasure to have the opportunity to share my views on this measure with you.

PREPARED STATEMENT OF REPRESENTATIVE NORMAN Y. MINETA

Mr. Chairman and the distinguished members of the Subcommittee, I would like to thank you for allowing me to present my views on this important bill, the Semiconductor Chip Protection Act of 1983. Representative Don Edwards and I have introduced similar legislation, H.R. 1028, in the House. Passage of this legislation is vitally important to the continued strength and viability of our electronics industry.

S. 1201 and H.R. 1028 would amend the Copyright law to provide ten-year protection for the mask work of a computer chip.

Integrated circuits or semiconductor chips contain hundreds of thousands of transistors, the basic building blocks of chips, photographically etched onto a silicon wafer. Each chip is typically a quarter-inch square. It is extremely important that the transistors be fit on to the chip in the most efficient and economic manner possible. Designing the best layout or mask for these transistors is a time consuming and costly process. Often a company will spend millions of dollars to develop the mask work for a particular chip. It is this design or mask which the bill before us today seeks to protect.

Copyright protection is necessary because although it may take years and millions of dollars to develop a particular mask design, a foreign or domestic pirate company can copy this design in a short time, and at virtually no cost, through the process of microphotography. The pirate company can then flood the market with cheap copies of the chip because it does not have the development costs of the original innovative company.

If this type of mask theft is allowed to continue, companies will have no incentive to develop new mask designs and the quality of our electronics industry will fall. The United States lead in this vital industry will diminish.

Copyright protection for the mask is an expansion of the use of the Copyright law. However, it is not an illogical expansion and it is clearly the best possible solution to this immediate and serious problem.

Patent protection for the mask, a solution that has been suggested, is not possible. The Patent Act makes patents available for plants, ornamental designs, or novel items of utility. The mask design does not fall under any of these categories. It is not a plant. It is clearly not just ornamental. And the layout of transistors on a chip does not meet the standard of a unique invention.

However, the mask work can logically be defined as a "writing" under the Copyright Act. Examples of "works" similar to the mask design to which copyright protection has been extended include maps, blueprints, and film images. A mask work is similar to a motion picture in that it is a series of related images. In the case of a mask work, these are the images or masks that embody the pattern of the various layers of a semiconductor chip.

It is argued that the Copyright law does not cover items of utility and therefore the mask work should not be given copyright protection. However, the Copyright law has often been extended to many items of utility including belt buckles, telephone books, ashtrays, doorknockers, and advertisements.

When the Copyright Act was first enacted no one could even envision such a product as the mask work or a computer chip. Our laws must be adapted to fit the realities of our times. The extension of Copyright protection to the mask work may be somewhat unique, but it does not conflict philosophically with the purpose of the Copyright law, which is to protect the author of a work while providing wide dissemination and use of the product.

Furthermore the bill recognizes the unique properties of the mask work. First of all the bill recognizes the commercial realities of the computer market by providing for only a ten-year copyright for the mask work.

Secondly the bill contains a compulsory licensing provision that requires the owner of a copyright of a mask work to grant a compulsory license to any applicant who innocently purchases an illegally copied chip. This provision protects the innocent company who spends millions of dollars developing a computer around an illegally copied chip. Compulsory licensing is a just market solution to this potential problem.

In summary, I would just like to stress once again the importance of this legislation to the electronics industry. Copyright protection for the mask design is necessary immediately to prevent erosion of our leadership in this expanding and highly competitive industry.

Thank you. It has been a pleasure sharing my views with you.

Senator MATHIAS. Our next witness is the General Counsel of the Copyright Office, Dorothy Schrader.

STATEMENT OF DOROTHY SCHRADER, ASSOCIATE REGISTER OF COPYRIGHTS FOR LEGAL AFFAIRS, U.S. COPYRIGHT OFFICE, ACCOMPANIED BY MICHAEL KEPLINGER, CHIEF, INFORMATION AND REFERENCE DIVISION; RICHARD GLASGOW, ASSISTANT GENERAL COUNSEL; MARY BETH PETERS, CHIEF, EXAMINING DIVISION; AND PATRICE LYONS AND CHRISTOPHER MEYER, SENIOR ATTORNEY ADVISERS, STAFF OF THE GENERAL COUNSEL

Ms. SCHRADER. I am accompanied by several colleagues, whom I will introduce.

Thank you, Mr. Chairman. We appreciate the opportunity to appear before you. I present the views of the Copyright Office on S. 1201. Let me first introduce my colleagues. On my left is Michael Keplinger, the Chief of the Information and Reference Division of the Copyright Office.

Next to Mr. Keplinger is Mr. Glasgow, the Assistant General Counsel; on the far left, Mary Beth Peters, Chief of the Examining Division. On my right is Patrice Lyons, and next to her, Chris Meyer, senior attorney advisers on the staff of the General Counsel.

I assume that the full statement of the Copyright Office will be made part of the record, and I will just discuss some of the highlights of the statement.

Senator MATHIAS. The full statement will, of course, be included.

Ms. SCHRADER. The Copyright Office supports the principle of protection for original semiconductor chips and masks, and we will generally refer to these as chips. Some form of protection is just and necessary. The office is however, not certain that the Copyright Act is the best answer to this need, and we have doubts in any case about some of the features of the bill.

We do note that other features of the bill seem to represent an improvement in comparison with the approach considered in 1979. Under your bill, a new category of copyrightable subject matter would be created, called mask works. Under the 1979 bill, protection would have been achieved by adding imprinted patterns to the category of pictorial, graphic, and sculptural works, and no other changes would have been made in the statute.

We do think that the limitations on term, the provisions concerning innocent infringer, and to some extent the compulsory license represent an improvement over the 1979 bill.

In your opening remarks today, Mr. Chairman, you have clearly made the case for the protection for semiconductor chips. The question now is what form should this protection take. Should it be traditional copyright, with a few modifications, which is basically the approach of your bill?

Or would it be better to develop a special law based on design copyright principles, for example, or based on the misappropriation doctrine, neither of which should be that difficult to achieve if Congress agrees that protection is necessary?

In the time that I have, I would like to briefly review the present legal situation and note some of our concerns about the bill.

PRESENT LEGAL SITUATION

Semiconductor chip technology involves several related elements, some of which are presently registerable under the Copyright Act, but the scope of protection is inadequate or uncertain.

Arguments in favor of protection for chips or chip design under the current act must confront the barriers of at least four fundamental principles of traditional copyright law. Copyright does not protect useful articles themselves. Copyright protects the design of a useful article only to the extent that it can be identified separately from, and is capable of existing independently of, the utilitarian aspects of the article.

Copyright in a drawing or other representation of a useful article does not protect against duplication of the useful article. This is section 113(b) of the act. And copyright protects only expression, not ideas, plans, or processes—section 102(b) of the act.

Certain schematic diagrams that constitute technical drawings under the current act are registered by the Copyright Office, but it would appear that protection would not extend to the product portrayed by the drawing or the technical data.

With respect to chips themselves, the office does not register claims to copyright in chips, in their design or layout or in printed-circuit boards. At least under the current act, it would seem that the topology or topography of a microelectronic circuit formed in semiconductor material is intrinsically a useful part of a useful article, and the courts have consistently refused to extend copyright protection to useful articles, as such.

Computer programs are copyrightable, and computer programs may be fixed in chips; they may be employed as tools in the designing of chips. But, apparently, the semiconductor chip industry does not believe that any copyright in the program would be sufficient to protect their designs.

This may be because the part of the chip that contains the program may not be copied, or there may be a difference in ownership. The owner of the copyright in the computer program may be different than the owner of the copyright in the chip.

CONCERNS ABOUT S. 1201

Now, as to our concerns about the bill, we have three major concerns. One is the subject matter classification. The proposed definitions of semiconductor chip product, mask work, and mask would dramatically alter the fabric of copyright by extending copyright to products intended to perform electronic circuitry functions and products that are discoveries, or the manufacture, use or distribution of which are in or affect commerce.

This explicit extension of copyright to electornic devices, which are characterized as writings, discoveries, or articles in or affecting commerce, clearly represents a dramatic departure, as you have noted in your opening remarks. Morevoer, Congress has not enacted a copyright law previously based on the interstate commerce clause, and there is a present statutory bar, which is not changed by the bill, against affording copyright to discoveries. This reference is in 102(b) of the Copyright Act.

A second major concern is the clarity of the bill with respect to the relationship between the proposed copyright in masks and chips on the one hand, and works of authorship, such as programs, which may be embodied in the chip. There clearly was an attempt to separate these categories of works, but the Copyright Office, at least, has some doubt that the purpose has been achieved, and we recommed further thought on this.

A third major point is that, above all, we are concerned about the new use right. This is a right that, as far as we are aware, has absolutely no equivalent in copyright law either in the past history of the U.S. copyright law or in any copyright law abroad. It may be a patent concept, but it has not heretofore been part of the copyright law.

The provisions concerning the compulsory license and innocent infringers to some extent place limits on this new use right. But, again, the Copyright Office is not at all certain that this unprecedented right is justified, and we recommend further thought about that.

The Copyright Office is not taking a position with respect to the preferred mode of protection for semiconductor chips. We have elected to explore several alternatives, and we have set them out at the end of our statement.

It is possible that special design copyright protection for chips, for example, could be sustained under the copyright—patent power—a combination of the two, perhaps—even if chips are not original works of authorship under the Copyright Act.

Of course, the bill, while creating a new subject matter category, does not change the basic standard of copyrightability which is found in section 102(a, which is that all works that are subject to copyright must be original works of authorship. We are concerned as to whether chips can meet that standard, or if they were forced into that standard, whether this would not affect other works.

So, in sum, we definitely believe that some protection is warranted. We tend to believe that modified copyrightlike protection is more suitable than any other mode of protection, but we question at this point the wisdom of granting chip protection under chapters 1 to 8 of title 17 of the United States Code.

Thank you, Mr. Chairman. That concludes my remarks. If you have any questions, I would be pleased to try to respond.

Senator MATHIAS. Well, of course, you are right in saying that the bill does represent a dramatic departure from previous copyright legislation. But, we are facing rather dramatic departures in industry and technology that may require some changes in the law that are more drastic than we have been accustomed to.

Ms. SCHRADER. Your point is well taken. We have simply set certain alternatives before you for consideration.

Senator MATHIAS. That is right, and I think we need to at least think in those terms. However, when we are facing what we know is going to be not only innovative, but really drastically innovative change, I think we have a greater responsibility to scrutinize what we are doing.

The Constitution authorizes copyright protection for writings. Now, writings over the years has been construed to encompass photographs, sound recordings, the grooves on a record, computer programs, and a variety of other works. And I suppose that the critical question to ask of you is whether the Congress would be exceeding its constitutional powers if it granted copyright protection to the design of masks.

Ms. SCHRADER. We have concerns about that. You are quite right that copyright has been extended over the years to protect new manifestations of authorship. I would respectfully mention that I think not so much the grooves of the record, but the creativity that is put into the recording and the performance—the creativity of the record producers in arranging and mixing the sound. This was, of course, the last subject matter category added.

Senator MATHIAS. I accept that amendment.

Ms. SCHRADER. Thank you. Copyright has not to date protected utilitarian articles, and that is the point that, to us, seems to require the greatest reflection.

Senator MATHIAS. Is this an intellectual creation, really?

Ms. SCHRADER. If one were talking about the mask works alone, perhaps that would clearly be the case, or it would be certainly more likely the case. But the combination of the definitions of the bill, plus the use right, makes it clear that the protection will be with respect to the chip.

Senator MATHIAS. Well, obviously, the chip is the object of the protection.

Ms. SCHRADER. And the chip, I think, without any disagreement, is a utilitarian object.

Senator MATHIAS. Ultimately, the chip is what we are trying to protect by copyrighting the mask. Is that the way you see it?

Ms. SCHRADER. That is quite clear, and that is where a precedent——

Senator MATHIAS. And we cannot blink at that.

Ms. SCHRADER. No; I think, clearly, that is the protection the industry works.

Senator MATHIAS. Of course, this bill is predicated, in part, as you have already noted, on the commerce clause. Let me test your thinking a little bit on the broad philosophy of constitutional interpretation.

Is it wrong for Congress to rely on other parts of the Constitution besides the copyright clause in enacting legislation to deal with copyright matters? Can we take a comprehensive view of the Constitution and touch upon several points at once?

Ms. SCHRADER. I do not really have an answer to that question, except to suggest that if one did craft a special-design law that was predicated on the general intellectual property clause of the Constitution, taking into account both the patent concepts and the copyright concepts, it might be easier to sustain the constitutionality of the bill by putting it in a separate chapter, with all the necessary features of the system of protection in that one chapter, rather than relying on traditional copyright principles.

But I do not mean to press this because the Office does not really take a position that traditional copyright as proposed in the bill is not a possible mode of protection.

Senator MATHIAS. Well, now, as you pointed out, there is a distinction between chips and the contents of chips. This bill, unlike the House version, contains a provision which states that copyright in the chip does not extend to any work of authorship embodied in the chip.

As you point out, there is a possibility that this could be interpreted several ways. I appreciate your noting that, because it seems to me that one of the duties of the Congress, which we have not discharged very faithfully as the press of legislation has gotten heavier, is the careful sculpting of laws so that they are susceptible of only one single, clear interpretation. So, this is the time to point out ambiguities.

The intent was to convey the first possibility which you suggested—that the chip copyright shall not affect the copyright, if any, of the work stored in the chip. And I think that ought to be made clear because we do not want to complicate further an issue that is already complex by making any change in the copyright law beyond the protection of chip design.

Now, if the bill were rewritten to clarify that understanding, would that put to rest your concerns?

Ms. SCHRADER. I think that would take care of the one point, Senator.

Senator MATHIAS. Well, we will just have to take one point at a time.

Ms. SCHRADER. Fine.

Senator MATHIAS. S. 1201 would provide the owner of the copyright of a chip—we have to be very precise here—the right to control the use of the chip. Conversely, it would make unauthorized use of an infringing chip, unlike the use of an infringing book, a violation of the copyright.

Now, you describe this use right as the ability "to control in every respect how a bona fide purchaser of a chip product uses that copy," and that this "appears to permit chip-copyright owners to define any use of which they disapprove as infringing." I think that raises a serious question that we have to address.

If that was what the bill really said, I would be as alarmed as you, if not more so. But what about the first-sale doctrine? Is it not true that the bona fide purchaser of a chip would have the right to use it for any lawful purpose, the same way that the purchaser of a book, or a phonograph, or a poster, or a work of graphic art has the right to use that in any way he sees fit?

Ms. SCHRADER. Perhaps that is the intent. We are not at all sure that that is what is carried out in the bill. It seems to us that with respect to the first-sale doctrine, you are dealing with the public distribution right and a limitation on that.

The problem with this use right is that it is not otherwise defined. I think it would be very difficult to define what you mean by "use," but it presumably would apply to what would be considered private uses—the actual use of the product as part of another machine or device; the use of it in a word processing machine; the use of it in any machine into which the chip is added.

The right could extend to private use in the home. It could clearly extend to use in business. Ordinarily, the copyright statute has protected against distribution, reproduction, and performance adaptation. The "use right" is something entirely different. I am not sure what it is, but it is clearly very different.

Senator MATHIAS. Well, we would appreciate it if you would reflect on that language.

Ms. SCHRADER. We will certainly do that, Senator, and we will try to provide assistance.

Senator MATHIAS. Now, you express some concern over what you term the "mini-term," the 10-year term. Of course, that was reflecting the limited anticipated life of the chip.

Ms. SCHRADER. Yes.

Senator MATHIAS. I am not sure that even William Shakespeare could have anticipated that he would be still literarily viable after 400 years, so, you cannot always anticipate exactly what your worth is.

Ms. SCHRADER. No; we certainly cannot. As we note in a footnote, we do not oppose the short term itself. It is simply that at least until the relationship between the copyright in the chip and the copyright in other works embodied in the chip is clarified, there would be a concern about what is the length of protection for those other works, which, by and large, would have 75 years from publication.

Senator MATHIAS. Well, let us assume that the language is susceptible of giving us the ability to express clearly that we are protecting the chip design and not the contents of the chip. Then does that reduce your concerns over the mini-term?

Ms. SCHRADER. It does, yes. There may be some slight question which we have not advanced in our statement about our obligations under the Universal Copyright Convention. The Universal Copyright Convention does generally require a minimum term of 25 years from publication for works that are protected under copyright.

There is an exception for works of applied design—the artistic features of works of applied design. For those, the term may be 10 years. We have been giving some thought to this and do not really have a position about it. I would just note it for reflection. It is likely that one could analogize semiconductor chips to works of applied design for purposes of interpreting the Convention's obligation concerning minimum term.

Senator MATHIAS. Of course, you mention the universal convention. A number of countries do have differing terms for different subjects of copyright, do they not?

Ms. SCHRADER. Yes; they do, although there is a fairly close uniformity on the life plus 50 term.

Senator MATHIAS. Does the fact that there are differing terms create enormous administrative problems, where such differing terms exist?

Ms. SCHRADER. No; I cannot say that it has to date. Clearly, it does mean that certain works are susceptible of copying earlier. To the extent that there are differences from country to country, then there are a few difficulties in that lack of uniformity. But, as you point out, that exists to some extent now.

Senator MATHIAS. Well, perhaps we should look more closely at the 10-year term that is provided for some artistic designs under the universal convention, because that might provide us with some basis for applying the 10-year term we contemplate in this bill.

There is a general agreement, I think, that chip design needs more protection than it now has. There may not be a general agreement as to how to provide that protection, but I think it is such an important element in the American economy and in our future that we need to do what we can to provide some protection for this new industry.

Ms. SCHRADER. The Copyright Office agrees entirely with that.

Senator MATHIAS. Well, you have really anticipated my question because I was going to say, given the importance of the issue, can this committee depend on the Copyright Office for the expert advice of which you are capable, and the counsel and the information about foreign applications that I think we need to know and on which you are the primary source of information?

Ms. SCHRADER. Most certainly. We are grateful for the request and we would be pleased to help in any way that we can.

Senator MATHIAS. One final question. Is there any interpretive bearing or any kind of coloration that is derived from the location of the protection statute within title 17 as far as constitutionality goes?

Ms. SCHRADER. We think there may be because if you fashioned a sui generis form of protection, you would have a new statutory standard of protection. It would have to qualify either under the writings or the discovery provision of the Constitution.

But at least I personally do not believe that the Constitution necessarily sets the same standard now as the statute does either for patents or copyrights. I realize some statements have been filed to the contrary at this hearing in the case of patents, but I think the same point applies to patents and copyrights—neither the patent power nor the copyright power has clearly been exhausted by present statutes.

And it would seem that by looking to the general intellectual property power—a combination of the patent and copyright power—you could create a new system of protection for designs.

Certainly, that seems to be the constitutional basis underlying the proposed design bill.

As we have noted, Mr. Moorhead in the House has just recently reintroduced the basic design protection bill, and this would add a chapter 9, I believe, to title 17. But it would be its own self-contained form of protection, having a new standard of originality and having new standards regarding infringement.

I think that the tendency would be, then, that it might be easier for the court to find that this new basis of protection is constitutional. After all, they would not have a track record against which to compare the design, under copyright or patent protection, per se, the design would have to be tested against a body of past precedents.

Senator MATHIAS. Well, I pursue this constitutional question because it does seem to me we have to be as right as it is possible to be. There is a tendency at times in the Congress to assume constitutionality and say, "well, the courts are going to decide it anyway."

I think that is wrong, in principle. We, after all, have taken oaths here to support and defend the Constitution, and we should try to do that. But beyond that, of course, it is clear that whatever we decide will inevitably be reviewed by the courts and I would like our batting average to be as high as possible.

Thank you very much.

Ms. SCHRADER. Thank you, Senator.

[The prepared statement of Ms. Schrader follows:]

PREPARED STATEMENT OF DOROTHY SCHRADER

ASSOCIATE REGISTER OF COPYRIGHTS FOR LEGAL AFFAIRS
COPYRIGHT OFFICE

Mr. Chairman and members of the Subcommittee, I am Dorothy Schrader, Associate Register of Copyrights for Legal Affairs and General Counsel of the Copyright Office. I thank you and the Subcommittee staff for giving me the opportunity to appear before you and present the views of the Copyright Office on S. 1201, a bill to protect semiconductor chips and masks against unauthorized duplication. The Copyright Office supports the principle of protection for original semiconductor chips and masks (hereafter generally referred to as "chips"). Some form of protection is just and necessary. The Office is, however, not certain that the Copyright Act is the best answer to this need for protection, and we have doubts in any event about some features of the proposed bill. Other features of the bill do represent an improvement in comparison with the approach considered by Congress in 1979,1/ which I will discuss later.

I. INTRODUCTION

Mr. Chairman, in your remarks in connection with the introduction of S. 1201, you described the importance of the semiconductor chip technology to our country, the investment, skill, and effort, required to develop chips, and the ease with which "chip pirates" rip off these products and catch "a free ride on the creativity, financial investment, and hard work of others."2/ You also remarked that "creative scientists and engineers must be protected from theft and exploitation" and that the "ingenuity of an age that has produced a tool as remarkable as the computer chip should be able to devise laws adequate to protect it."3/

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1. H.R. 1007, 96th Congress, First Session (1979) would have simply provided that the "photographic masks" and "imprinted patterns" on integrated circuit chips were copyrightable as "pictorial, graphic, and sculptural works."

2. 129 Cong. Rec. Daily S 5991, S 5992 (May 4, 1983).

3. Id. at S 5992.

The Copyright Office fully agrees with these remarks and joins in your view that those who create must be rewarded and protected by our laws. If the Congress accepts this point in principle, it should be possible to fashion a law that will protect the creators and innovators of semiconductor chip products against piracy.

The question then is: what scheme or mode of protection should be devised to protect against chip piracy -- traditional copyright with a few modifications, a new sui generis law based on design copyright principles, or perhaps a new sui generis law based on misappropriation doctrine?

The questions which we are raising about the mode of protection and particular features of the bill are offered to assist in the public debate on this major public policy issue. With this purpose in mind, the Copyright Office in this statement first reviews the present law and Office practices, previous consideration of the chip piracy issue, chip technology, and the need for protection. Next, we analyze the major features of S. 1201, discuss some concerns about the bill, and discuss alternative modes of protecting chips.

II. BACKGROUND

A. Present Legal Situation

Semiconductor chip technology involves several related elements, some of which are presently registrable[4] under the Copyright Act,[5] but the scope of the protection is inadequate or uncertain.

Arguments in favor of protection for chips or chip design under the current Act must confront the barriers of at least four fundamental principles of traditional copyright law: copyright does not protect useful

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4. Registration of a claim to copyright is made by the Copyright Office following examination if the Office determines that the material deposited constitutes copyrightable subject matter and the other legal and formal requirements of the Act are satisfied. 17 U.S.C. 410(a). If registration is refused, action for infringement may nevertheless be instituted pursuant to 17 U.S.C. 411(a), provided the Register of Copyrights is duly served a notice of the action. The Copyright Office has special expertise regarding registrability. What is protectible under the Act, and the scope of protection, are ultimately for the courts to decide.

5. Title 17 of the United States Code, §§101 et seq. (hereafter generally the "Copyright Act" or the "Act").

articles[6] per se; copyright protects the design of a useful article only to the extent that it can be identified separately from, and is capable of existing independently of, the utilitarian aspects of the article; copyright in a drawing or other representation of a useful article does not protect against unauthorized duplication of the useful article; and copyright protects only expression, not ideas, plans, or processes.

Section 102(b) of the Copyright Act of 1976 clearly provides that: "In no case does copyright protection for an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, or embodied in such work." 17 U.S.C. §102(b) (Supp. IV 1980). See Baker v. Selden, 101 U.S. 99 (1879). Moreover, where there are only a limited number of ways to express an idea, there may be no protection for the particular expression. See Morrissey v. Procter & Gamble Co., 379 F.2d 675, 678 (1st Cir. 1967) (particular form of expression found to come from subject matter).

1. Technical drawings. Schematic diagrams or similar works containing technical data and drawings of electrical circuits which constitute "original works of authorship" [17 U.S.C. 102(a)] are registrable as "pictorial, graphic, or sculptural works." 17 U.S.C. 101. However, under section 113 of the Copyright Act, protection apparently would not extend to the semiconductor chip product portrayed by the drawing or technical data.

Generally, under section 113(b), the extent of protection afforded a technical drawing that portrays a useful article as such is to be construed in accordance with the law in effect on December 31, 1977. The 1976 House Report[7] refers back to the 1961 Report of the Register of Copyrights where it was stated that, on the basis of judicial precedent, "copyright in a pictorial, graphic, or sculptural work, portraying a useful article as such, does not extend to the manufacture of the useful article

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6. Section 101 of the Act defines a useful article as "an article having an intrinsic utilitarian function that is not merely to portray the appearance of the article or to convey information."

7. H.R. Rep. No. 94-1476, 94th Cong., 2d Sess. 105 (1976) (hereafter, the 1976 House Report.

itself," and recommended specifically that "the distinctions drawn in this area by existing court decisions" not be altered by the statute. The House Report also noted the discussion of this subject in the Register's 1965 Supplementary Report.8/ The 1965 Supplementary Report contains, in a note, a list of court decisions illustrating what is meant by a work portraying a useful article as such.9/

Technical drawings, prepared as part of the intermediary stages of chip manufacture, are sometimes alleged to be embodied in mylar sheets, photolithographic masks, and related products. The Copyright Office is not aware of any court decision specifically upholding the validity of copyright in such "technical drawings." Sometimes registration has been made on the basis of the "drawing" authorship and the technical data conveyed. As one moves from traditional blueprint-type drawings to mylar sheets and masks, questions arise about registrability because of uncertainty as to whether the sheets and masks convey information.

2. Chips and imprinted patterns therein. The Copyright Office historically has refused, and presently does refuse, to register claims to copyright in the design or layout of printed circuit boards, the design or "topology" of, or imprinted patterns in, semiconductor chips, and the

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8. Supplementary Report of the Register of Copyrights on the General Revision of the U.S. Copyright Law: 1965 Revision Bill, Copyright Law Revision Part 6, 47-48 (1965).

9. Id. at 48. The following cases are of particular relevance: Muller v. Triborough Bridge Authority, 43 F. Supp. 298, 300 (S.D.N.Y. 1942) (court found that "plaintiff's copyright of a drawing, showing a novel bridge approach to unsnarl traffic congestion, does not prevent any one from using and applying the system of traffic separation therein set forth"); Jack Adelman, Inc. v. Sonners & Gordon, Inc., 112 F. Supp. 187, 190 (S.D.N.Y. 1934) ("To give an author or designer an exclusive right to manufacture the art described in the certificate of copyright registration, when no official examination of its novelty has ever been made, would unjustly create a monopoly and moreover would unsurp the functions of letters-patent"); and Fulmer v. United States, 103 F. Supp. 1021 (Ct. Cl. 1952) (case involved copyrighted design showing a top view and a side view of a parachute with irregular curved lines painted or dyed upon the cloth of the parachute. The court concluded that plaintiff's petition did not state a cause of action for infringement of copyright).

printed circuit boards and chips themselves.[10] The topology of a microelectronic circuit or other device formed in semiconductor material is arguably an intrinsically useful part of a useful article. The patterns formed in and on semiconductor material, usually a silicon wafer, are used primarily to open "windows" in the material in order to permit the introduction of certain chemical substances, which in turn result in the formation of transistors, interconnections, etc.

Useful Articles. Courts have consistently refused to extend copyright protection to useful articles as such. A District Court in a case involving the design of a radio cabinet found that: "Copyright infringement, however, can only be based upon appropriation of subject matter. It is conceded that the idea, as distinguished from the expression of it, has utility and that the arrangement has a functional value. These things are not copyrightable attributes of a design. The fact that the defendant's radio cabinets answer the foregoing description establishes nothing more than it has made use of certain structural features there indicated having functional utility." Clair v. Philadelphia Storage Battery Co., 43 F. Supp. 286, 287 (E.D. Pa. 1941). The Court of Appeals for the Seventh Circuit reached an analogous decision in the case of Taylor Instrument Companies v. Fawley-Brost Co., 129 F.2d 98 (7th Cir. 1943), cert. denied, 321 U.S. 785 (1943). In the Taylor Instrument case, the court held that:

> The proof, as well as an examination of plaintiff's recording thermometer, including its chart, leaves no room for doubt but that the latter is a mechanical element of the instrument of which it is an integral part. The chart is as indispensable to the operation

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10. In addition, the Copyright Office will refuse to register a claim to copyright in a chip product or design based on the contention that the chip represents the published version or embodiment of a copyrightable (and, perhaps, registered) technical drawing. An action was filed against the Office in 1977 to compel such registration, but the case was withdrawn without prejudice on the understanding that the Office would file the chip in its correspondence records, while not accepting it as a deposit copy. Intel Corp v. Ringer, C 77-2848 (N.D. Cal., October 10, 1978). Recently, a suit has been filed to establish the validity of a claimed copyright in the Zilog, Inc Z80 microprocessor chip. Zilog, Inc. v. Nippon Electric Co. Ltd. (NEC) of Tokyo, (N.D. Cal., March 1983) (complete citation unavailable). Copyright registration has been made as a technical drawing based on a paper blueprint-type deposit. A patent has apparently issued for the microprocessor apparatus and method of the Z80.

> of a recording thermometer as are any of the other elements. They are interdependent ... the chart neither teaches nor explains the use of the art. It is an essential element of the machine; it is the art itself. It is our judgment that plaintiff's charts are not the proper subject of copyright and that the recognition of an exclusive property right therein would be, in the words of the Supreme Court in the Baker case, "a surprise and fraud on the public."

Id. at 100; see also Brown Instrument Co. v. Warner, 161 F.2d 910 (D.C. Cir. 1947), cert. denied, 332 U.S. 801 (1947).

Artistic work-separability test. Although in the years following the landmark decision in Mazer v. Stein, 347 U.S. 201 (1954), there was arguably a certain widening of the scope of copyright protection for artistic works incorporated in useful articles, the courts continued to deny copyright to useful articles per se. The decision in SCOA Industries, Inc. v. Famolare, Inc., 192 U.S.P.Q. 216 (S.D.N.Y. 1976), may help to illustrate this point.

The controversy in the Famolare case centered on "a design for a thick rubber shoe sole which features several pronounced corrugations (or 'waves') on the bottom, a pattern of raised wavy lines on the side, and another pattern of raised lines on the bottom with a bicycle design, the words 'Get There', 'Patent Pending' and 'Made in Italy' also on the bottom." Id. at 217. Although a certificate of registration was issued by the Copyright Office, the court found that the certificate could not be accepted "as prima facie evidence of a valid copyright to anything except the bicycle design." Id. at 218. It went on to state that:

> There can be no valid copyright in troughs in the sole or wavy lines on the sides. These have no existence as works of art and if they did have, lack even the minimum originality needed for copyright. ... A shoe sole is an object whose intrinsic function is utilitarian. ... It is concluded, in agreement with the Copyright Office, that the troughs, waves and lines which appear on the shoe sole cannot be identified and do not exist independently as works of art.

Id.; see also Esquire v. Ringer, 591 F.2d 796 cert. denied, 440 U.S. 908 (1979).

The separable artistic features doctrine enunciated by the Copyright Office in applying the Mazer decision has now been specifically incorporated in the copyright law. As defined in section 101 of the Copyright Act of 1976, "pictorial, graphic, and sculptural works" include "works of artistic craftsmanship insofar as their form but not their mechanical or utilitarian aspects are concerned; the design of a useful article ... shall be considered a pictorial, graphic, or sculptural work only if, and only to the extent that, such design incorporates pictorial, graphic, or sculptural features that can be identified separately from, and are capable of existing independently of, the utilitarian aspects of the article." 17 U.S.C. §101 (Supp. IV 1980). In commenting on this definition, however, the House Committee on the Judiciary made clear that it had no intention of extending copyright to useful articles as such. With respect to works of industrial design, the Committee clearly stated:

> Unless the shape of an automobile, airplane, ladies' dress, food processor, television set, or any other industrial product contains some element that, physically or conceptually, can be identified as separable from the utilitarian aspects of that article, the design would not be copyrighted under the bill. The test of separability and independence from "the utilitarian aspects of the article" does not depend upon the nature of the design — that is, even if the appearance of an article is determined by esthetic (as opposed to functional) considerations, only elements, if any, which can be identified separately from the useful article as such are copyrightable. And even if the three-dimensional design contains some such element (for example, a carving on the back of a chair or a floral relief design on silver flatware), copyright protection would extend only to that element, and would not cover the over-all configuration of the utilitarian article as such.

Report of House Committee on the Judiciary to accompany S. 22, H.R. Rep. No. 94-1476, 94th Cong., 2d Sess. 51 (1976).

The boundaries of the new definition of "pictorial, graphic, and sculptural works "have been tested in a number of cases since the 1976 Act entered into force on January 1, 1978, and the courts have consistently refused to extend copyright protection to shapes of useful articles as such. The outside limits of copyrightable subject matter were explored in a recent case which the court described as being on "a razor's edge of copyright law." Kieselstein-Cord v. Accessories by Pearl, Inc., 632 F.2d 989, 990 (2d Cir. 1980). Discussing the scope of the useful articles definition in the 1976 Act, the court was able to identify in the belt buckles (registered as jewelry by the Copyright Office) certain elements that were conceptually separable from their subsidiary utilitarian function. See 632 F.2d at 993. No such separable elements were found in a case involving the design of wire-spoked automobile wheel covers. Norris Industries v. International Tel. & Tel. Corp., and Ladd, 696 F.2d 918 (11th Cir. 1983). The court found that the useful article did "not contain a superfluous sculptural design, serving no function, that can be identified apart from the wheel covers themselves." 696 F.2d at 924.

The proposed extension of copyright to the topology of semiconductor chip products in S. 1201 would grant protection to useful aspects of useful articles, which apparently have no separable artistic features. Moreover, notwithstanding section 113(b) of the Act, rights would be granted to control the making and distribution of a useful article. The bill therefore represents a marked departure from the current law's treatment of utilitarian articles as such. Whether such a step should be taken may be questioned.

3. Computer programs. Computer programs constitute copyrightable subject matter. The Copyright Act classifies these works as a specie of literary works and defines them as "a set of statements or instructions to be used directly or indirectly in a computer in order to bring about a certain result." 17 U.S.C. 101. The Copyright Office registers computer programs that constitute original works of authorship.

Although computer programs may be fixed in chips and may be employed as "tools" in the designing of chips (CAD or computer-aided design), the semiconductor chip industry apparently does not believe that copyright for the computer program is sufficient to protect their designs. As we discuss more fully in a later section of this statement,11/ this inadequacy of protection arises either because: 1) some chips may not embody programs at the time they are exposed to duplication; 2) the part of a chip containing the program may not be duplicated; 3) the owner of the program copyright may not own rights in the design of the chip; or 4) the scope of protection for designs developed with the assistance of a computer program is uncertain (i.e., to what extent, if any, would duplication of the CAD-developed "work" infringe the copyright in the program?).

11. Section IV, "Need for Protection."

B. Previous Consideration of Semiconductor Chip Protection

Whether, and to what extent, the design or layout of semiconductor chips should be afforded copyright protection was raised in the closing days of the National Commission on New Technological Uses of Copyrighted Works; however, there was not sufficient time remaining for the Commission to deal adequately with the matter.

Further consideration was given to what was termed the "imprinted design patterns on semiconductor chips" during a hearing on April 16, 1979 before the House Subcommittee on Courts, Civil Liberties, and the Administration of Justice. The legislation then pending before the Subcommittee was a bill, H.R. 1007, to amend section 101 of title 17 U.S.C. to add the following new sentence at the end of the definition of "Pictorial, graphic, and sculptural works": "Such pictorial, graphic, and sculptural works shall also include the photographic masks used to imprint patterns on integrated circuit chips and include the imprinted patterns themselves even though they are used in connection with the manufacture of, or incorporated in a useful article."

The Copyright Office testified at the hearing in support of the principle of protection for the imprinted design patterns on semiconductor chips covered by H.R. 1007. However, similar to our present testimony, the Office raised several major questions for further Congressional consideration:

1. Within the constraints of chip purpose and size, are the layouts, masks, and patterns dictated by the chip's function, or do they represent a creative choice from among different possibilities?[12/] If the former, the elements would be uncopyrightable concepts, principles or ideas rather than copyrightable works of authorship.
2. What are the limits of protection presently available for the various elements — schematic

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12. To date, the Copyright Office has concluded that designs of semiconductor chips are not "original works of authorship" under the current Act. Later in this statement we consider whether Congress could constitutionally protect chips under the Copyright-Patent Clause.

drawings, mylar sheets, photographic masks, imprinted patterns, and programs — stored in the chips, and programs used in generating the chip?

3. In light of existing and anticipated industry structure and technology, should copyright protection of masks and imprinted patterns be subject to specific limitations regarding term of protection, scope of rights, or nature of infringement remedies?13/

Many witnesses appeared from the semiconductor chip industry either for or against the pending bill, H.R. 1007. Supporting witnesses argued that protection was essential to combat the rising threat of unfair competition from chip pirates. They argued that the ability of firms to invest in development and research would be adversely affected by unchecked piracy, and they pointed to the threatening competition from Japan. Patent protection was available for only a few processes in creating chips. Supporters of H.R. 1007 saw it as a simple, constitutionally sound remedy against duplication of creative products.

Opponents of H.R. 1007 argued that protection would reduce the ability of U.S. firms to compete in the world market and would increase costs to U.S. consumers.14/ They argued that

> chips, as utilitarian articles, cannot appropriately be protected by copyright;15/
>
> existing copyright protection for computer programs and patent protection for certain processes was adequate;16/
>
> industry practices of "second sourcing" or "reverse engineering" would be inhibited if not illegal;17/

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13. Statement of Jon Baumgarten, Copyright Protection for Imprinted Design Patterns on Semiconductor Chips, Hearing Before the Subcommittee on Courts, Civil Liberties, and the Administration of Justice, House Committee on the Judiciary, 96th Cong., 1st Sess. on H.R. 1007, 14-15 (1979). (Hereafter, the 1979 Hearing).

14. 1979 Hearing at 51 (statement of John Finch, Vice-President, National Semiconductor Corp.)

15. Id. at 52-53.

16. Id. at 54.

17. Id.

existing copyright remedies (especially the remedy allowing destruction of infringing articles) would work an undue hardship;[18]

protection was being sought for ideas;[19] and

copyright gives more protection than is necessary to encourage innovation in this field.[20]

One person argued that protection is needed, but not under copyright; he suggested legislation affording protection against misappropriation of proprietary information by illicit means.[21]

Apparently because of the force of the opposition to H.R. 1007, there was no further action on the bill.

Senator Mathias and Congressman Edwards introduced S. 3117 and H.R. 7207 respectively near the end of the 97th Congress, for discussion purposes. These bills were virtually the same as S. 1201 and would have made mask works a new copyrightable subject matter category as a means of protecting the design or layout of semiconductor chips.

III. CHIP TECHNOLOGY

As we informed the Congress in 1979, the Copyright Office does not consider itself expert in the field of semiconductor chip technology. You will hear from experts in the field today. However, in order to analyze the issues affecting copyright for the design of chips, the Office has reviewed the technical literature and has prepared the followi.. lay explanation of the technology.

A. Overview of Chip Design and Manufacture

There are several distinct steps in the development of a microelectronic circuit to be formed in semiconductor material. The process usually starts with an abstract description of the electrical function to be performed by a particular circuit chip. In successive steps in the

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18. Id. at 54-55.

19. 1979 Hearing at 56 (statement of James M. Early, Division Vice-President, Fairchild Camera & Instrument Corp.).

20. 1979 Hearing at 74 (letter of Quincy Rodgers, Director-Governmental Affairs, General Instrument Corp.).

21. Id. at 76.

design process, the electrical specifications of the device are then set forth with increasing precision. At the risk of oversimplification, the process may be compared to the work of a city planner who drafts a plan to build a town in a given location that will have houses, a school and a shopping center. The planner then hires an architect to design the town. Blueprints are drawn that specify where the streets are to be situated, how large the shopping center will be, what types of houses will be built and other specifics. Eventually, consideration is given to such minor details as the plumbing to be installed in the individual houses.

Once a detailed schematic or logic diagram of the device has been made, or the schematic data has been set forth in a higher level representation (e.g., described symbolically), a decision is made on the geometrical placement and interconnection of the components. Today, this layout is commonly done with the aid of complex computer programs.[22] Although there is much research under way to automate completely the design effort, a layout designer using a computer-aided design system is still required to make choices concerning particular layout and interconnection patterns.

During the layout process, the design may be displayed on a CRT screen or reproduced using a plotter for verification purposes. After the layout of the microelectronic circuit is finalized, it is usually fixed in a pattern generation tape that is sent for use in the production of the particular device. Although the layout and interconnection patterns encoded in the tape may be "written" directly on a silicon wafer using electron-beam technology, the transfer of the patterns by a photolithographic process using a series of masks is now industry standard.

B. Chip Design and Manufacture - A More Detailed Account

Although the steps in developing microelectronic circuits or other devices in semiconductor material may vary widely, it is possible to group them in four general stages for discussion purposes.

1. Electrical behavior. The process of producing a semiconduc-

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22. For a concise summary of advances in computer-aided design, see M. Feuer, VLSI Design Automation: An Introduction, 71 Proceedings of the IEEE 5, (1983), attached as Appendix A. (Duplicated with the permission of the copyright owner.)

tor chip product usually starts with a general description of the electrical function to be performed by a particular device. An outline or "floor plan" of the device is sometimes made.

2. Description of circuits. On the basis of the abstract description of the behavior of the device to be formed, an engineer sets forth the electrical specifications of the device in increasing detail. The schematic data may be set forth in a logic diagram, or the data may be described in a higher level représentation.

3. Layout. Just as there are many different circuits that may be selected to perform a particular electrical function, there are also different ways to arrange the components in semiconductor material. The focus of the semiconductor chip protection legislation appears to be the determinations of the layout designer, either alone or with the assistance of a logic designer or process expert, with respect to the structural placement of the components of a device and the routing paths to interconnect these components. The layout and interconnection patterns generated by the layout designer would be deemed "mask works" under the proposals in S. 1201.

The eventual commercial success of a semiconductor chip product often depends on the ability of the layout designer to achieve an optimized layout configuration. In attempting to provide the highest functional component density in order to reduce the chip area per circuit function, the layout designer is subject to certain layout constraints. As noted in patent 3,987,418:

> Minimum geometry spacings between metallization lines, diffused regions and polycrystalline silicon conductors must be maintained, yet the length of such lines and the associated capacitances must be minimized as complex interconnection patterns are implemented. Parasitic electrical leakage paths in the circuit must be minimized or compensated for in the chip topology. A very high degree of creativity is required of the chip architect in order to choose a particular layout and interconnection pattern for an LSI circuit from the large number of possibilities that exist for arranging such a layout.

Today, the layout designer has powerful tools to help in producing the geometrical layout patterns for each layer of a microelectronic circuit or other device. In recent years, computer-aided design systems have become commercially available that, once a layout designer inputs specific schematic data from a logic diagram or a higher-level symbolic description, are capable of making most of the placement and routing determinations. Although it appears likely that the layout process may eventually be completely automated, skill is still required of a chip architect in the layout design.

A layout design is usually based upon a preexisting technical drawing or other representation of schematic data. Where a designer uses an interactive computer system to determine the placement of the electrical elements on the surface of a semiconductor wafer and the routing of the "wires", and today this is standard industry practice, the first step in the layout process is the inputting of the schematic data into the computer. The layout designer then manipulates the schematic database, with the assistance of computer programs, to produce the layout and interconnection patterns to be used in the fabrication of a microelectronic circuit or other devices.

4. Fabrication of devices in semiconductor material. Once a layout design is finalized, the encoded layout patterns are used in the patterning and fabrication processes to implement the desired integrated system. While the patterns are usually transferred to a silicon wafer by a photolithographic process using a series of masks, it is now possible to "write" the patterns directly on a wafer using electron-beam technology. Apparently, this new method of imprinting patterns on semiconductor material is intended to be covered by S. 1201. In a detailed analysis of similar legislation published by Congressman Edwards[23] in the Congressional Record of February 24, 1983, it is stated that: "The fourth of these exclusive rights is inclusive of all means of embodying the images of a mask onto a chip. This includes not only the use of masks to do so, but also the new technological process of impressing the image directly onto the chip with the aid of a computer-driven light beam."

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23. H.R. 1028, 98th Cong., 1st Sess. (1983).

IV. NEED FOR PROTECTION

The need for protection against chip piracy has been concisely and forcefully set out by Senator Mathias in remarks accompanying the introduction of S. 1201.

> High tech firms spend huge amounts of time and money producing semiconductor chips....
> Yet, these innovators are being ripped off by onshore and offshore 'chip pirates', who, for less than $50,000 can now legally appropriate and use these chip designs as their own...
>
> Chip piracy reduces the incentive for our innovative semiconductor industry to invest in the development of new chips .... I advocate protections that will 'promote the Progress of Science and Useful Arts'; the very 'protectionism' that is incorporated in our Constitution, and on which all our copyright and patent laws are based.[24]

The Copyright Office is in accord with these views, and we agree that the present law is inadequate to stem chip piracy. Since the last Congressional hearings on chip piracy, we believe the need for protection has become even clearer. This seems true notwithstanding increased reliance on computer programs to design and create layouts of chips and the judicial developments in the field of computer programs.[25]

A. Programs Distinguished from Chips.

Providing protection for computer programs is not equivalent to providing protection for semiconductor chips *per se*. As Senator Mathias has pointed out[26] the semiconductor or integrated circuit chip is a marvel of modern solid state electronics. To a large measure, the chip has the capacity to combine, in a few square millimeters, the major elements of a conventional computer system — the central information processor and large quantities of information storage capacity. In many cases processor and

24. 129 Cong. Rec. at S 5992.

25. Recent cases upholding copyright in computer programs include: Tandy Corp. v. Personal Micro Computers, Inc., 524 F. Supp. 171 (N.D. Cal., 1981); GCA MAP Corp. v. Chance, Civ. No. C-82-1063 (N.D. Cal. Aug. 31, 1982); Williams Electronics, Inc. v. Artic Intern. Inc., 685 F.2d 870 (3d Cir. 1982); Hubco Data Products Corp. v. Management Assistance, Inc., Civ. No. 81-1295 (D. Idaho, Feb. 3, 1983); Apple Computer, Inc. v. Formula Intern., Inc., Civ. No. 82-5015-IH (C.D. Cal., April 11, 1983); and Midway Mfg. Co. v. Artic Intern., Inc., Civ. No. 82-1607 (7th Cir., April 11, 1983).

26. 129 Cong. Rec. at S 5992.

storage capacity may equal the typical computer system of only 10 years ago.

Thus, the chip, at once, may carry out two fundamental functions of a computer system: 1) computing or processing information; and 2) storing either permanently or temporarily significant quantities of data. As well, some chips may have only one of those functions. The primary function of a whole family of chips is to store programs or data. These are the so-called ROM (read-only-memory) chip, the PROM (programmable-read-only-memory) chip, and the EPROM (erasable PROM) chip. Functionally, these chips can substitute for magnetic tape, disk, or core memory in a conventional computer system. Other chips have as their primary function to be a computer itself; to process and manipulate information by the execution of a computer program stored in a memory chip or in a portion of the processor chip designed to serve as a memory.

The copyright law presently provides protection for computer programs independently from their medium of fixation. It protects a program whether it is stored in a chip, a disk, a tape, or printed out on paper. Protection for the program does not protect the chip in which it is stored any more than protection for a novel protects the book format in which it is stored.

Providing protection for that portion of a chip or the entire chip that is the functional equivalent of the processor hardware in a conventional computer system is a complex matter. As discussed earlier, copyright protection is presently available for the technical drawings that are prepared at various stages in the manufacture of a chip. Protection apparently does not extend to the chip form in which those works may ultimately be embodied. That lack of protection, of course, is the reason for this inquiry.

B. Proprietary Interests Distinguished.

Just as it is possible to distinguish among types of chips, it is possible and, perhaps, even necessary to distinguish among the various proprietary interests that are interrelated and brought together in chip technology. The owner of the proprietary interest, if any, in the layout or design of the chip may or may not be the owner of the proprietary interest in a program embodied in that chip.

For example, the producer of an electronic video game may own the copyright in the audio-visual work that is the game (but there can be no copyright in the idea for the game). Such works are typically embodied in memory chips of the ROM or PROM types. The typical arrangement is for the game proprietor to develop the game and the computer program or programs necessary to create the sights and sounds presented on the cathode ray tube display in the game. When the programs are fully developed — tested, debugged and determined to be reliable — the proprietor will have them embodied in a chip. If a small production run is contemplated, the game manufacturer may load the program in a PROM purchased from the chip manufacturer. If a large production run is contemplated, such as is the case in a home video game, the game producer may have a ROM produced by a chip manufacturer that permanently and unalterably stores the program.

In both of these instances, the game producer is protected by the copyright in the audio-visual work and the underlying program.27/ In neither instance is the proprietary interest of the chip manufacturer protected. It is true that in either case, the audio-visual work or the game play program may be copied by copying the chip. The game proprietor could use copyright to prevent that copying, but only to the extent it involved the program or the audio-visual work.

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27. As noted in Apple Computer, Inc. v. Franklin Computer, Corp., 545 F. Supp., at 818, n. 8, "[i]n the last year, a number of courts have held that a ROM-based object program used to create visual displays in arcade games is properly copyright protected," citing: Midway Mfg. Co. v. Artic Intern., Inc., 547 F. Supp. 999 (N.D. Ill. 1982) [now aff'd, Civ. No. 82-1607 (7th Cir., April 11, 1983); Atari, Inc. v. North American Philips Consumer Electronics Corp., 672 F.2d 607 (7th Cir. 1982); Stern Electronics, Inc. v. Kaufman, 669 F.2d 852 (2d Cir. 1982); Atari, Inc. v. Amusement World, Inc., 547 F. Supp. 222 (D. Md. 1981); Midway Mfg. Co. v. Dirkschneider, 543 F. Supp. 466 (D. Neb. 1981); Williams Electronics, Inc. v. Artic Intern., Inc., 685 F.2d 870 (3d Cir. 1982); and Cinematronics, Inc. v. K. Noma Enterprise Co., Civ. No. 81-489 PHX-EHC (D. Ariz., May 22, 1981).

To date, the courts have generally found that separate copyrights may exist in an audio-visual work fixed in chips and in the computer program which operates the video game, but losing counsel have sometimes argued that the audio-visual work is not fixed and that copyright exists only in the computer program.

V. ANALYSIS OF S. 1201

As indicated, the Copyright Office shares the belief of the Chairman and his co-sponsor that semiconductor chips are products which are vitally important to the American economy and should be protected against piracy. We believe, however, that there are substantial questions about certain features of S. 1201 which should be reflected upon before positive action is taken on any bill which would afford semiconductor chips, and the masks from which they are made, copyright protection. The Office also believes that several features of S. 1201 represent a positive attempt to meet many of the objections lodged against the approach of the 1979 bill.

A. Basic Features.

S. 1201 would create a new subject matter category of copyrightable work known as "mask works." This new category is specially defined in a way that appears intended to encompass the skills and creativity, if any, employed in the intermediate stages of producing semiconductor chips (that is, between the first technical drawing, if any, and the finished chip product). The ultimate objective is to protect the finished chip against unauthorized duplication. As a mark of this bill's completely different approach compared with the 1979 bill, mask works are specifically declared not to be deemed pictorial, graphic, or sculptural works. But the objective is the same: protection of the finished chip.

Other major and distinguishing features of this bill include:

1. limited term of protection — ten years from first authorized distribution, use in a commercial product, or manufacture in commercial quantities;

2. new or modified exclusive rights — to embody the work in a mask; to distribute the work; to use a mask embodying the work to manufacture chips; in the manufacturing process, substantially to reproduce the work on material intended to be part of a chip product; and to distribute or use a chip product made as described in the last two rights;

3. compulsory license — the purchaser of an infringing chip

product, having no notice of infringement, who commits substantial funds to the use of a chip and would suffer substantial financial detriment if enjoined, is entitled to a compulsory license based on an offer to pay the copyright owner a reasonable royalty;

4. "innocent infringer" provision — a bona fide good faith purchaser of an infringing chip product is not liable as an infringer with respect to the use or distribution of the chip products before the purchaser has notice of the infringement; and

5. no retroactive effect — the bill would not protect chips manufactured or imported into the U.S. before the effective date, which is 90 days after enactment.

While the Office is not prepared to endorse the specific copyright solution advanced by S. 1201, we note that the limitation on term, the compulsory license, and the innocent infringer provisions in principle respond to concerns raised in 1979 by the Copyright Office and segments of the semiconductor chip industry about the length of protection and about the perhaps unduly broad scope of traditional copyright infringement protection when applied to semiconductor chips.

For example, the innocent infringer provision would insulate unconscious infringers from copyright liability (traditional copyright law protects against both conscious and unconscious infringement).[28] The compulsory license, although it should perhaps be given further thought, does provide a modest encouragement of voluntary agreements while avoiding the

28. In a copyright infringement case, the plaintiff has the burden of proving unlawful copying, which ordinarily is established by proof of defendant's access to the copyrighted work, and substantial similarity between the alleged infringing work and the copyrighted work. However, once the plaintiff offers evidence of access and substantial similarity, the burden shifts to the defendant to prove independent creation rather than copying, to account for the substantial similarity between the works. M. Nimmer, NIMMER ON COPYRIGHT, §13.01[B], page 13-8 (1982 ed.) Both intentional and nonintentional copying are proscribed. Fisher v. Dillingham, 298 Fed. 145 (S.D.N.Y. 1924) (Jerome Kern found to have infringed by unconscious copying).

otherwise draconian impact of injunctive relief against a bona fide purchaser of chip products.

B. Concerns about S. 1201.

a. Summary of concerns. Before going into more detail, I would like to advise you briefly of the provisions of the bill which cause the Copyright Office the most concern.

First, the proposed definitions of "semiconductor chip product," "mask work," and "mask" would arguably dramatically alter the fabric of copyright by extending copyright to "product[s]... intended to perform electronic circuitry functions" and "product[s] that [are]... discover[ies], or the manufacture, use, or distribution of which [are] in or affect commerce." Section 102(b) of the Copyright Act (which is not, and should not be, amended in the present bill) expressly prohibits any claim of copyright in, *inter alia*, "any process, system, method of operation... or discovery." The constitutional basis for every portion of every Copyright Act in American history has been Article I, section 8, clause 8 of the Constitution, which speaks in terms of "Writings."

Next, the provision concerning the relationship between the proposed copyright in masks and chips, on the one hand, and the works of authorship which may be embodied therein is unclear. The selective inclusion of semiconductor chips as "copies" under certain sections of the Copyright Act, but not under others, may lead to confusion about where chips fit within the copyright law and, at root, what the rights of chip-copyright owners29/ are.

Some of the proposed new exclusive rights for chip-copyright owners appear to track traditional rights.30/ The right to embody the mask work in a mask looks rather similar to the classic "copy right"31/ now codified in section 106(1), *i.e.*, the right to reproduce, in copies, the copy-

29. By "chip-copyright owners" we mean the owner of the new rights in the new subject matter category "mask works," as established in S. 1201.

30. The structure of the bill, which deliberately attempts to confine the term "copy" in relation to semiconductor chips, to only a few sections of the statute, necessitates this tracking of certain rights.

31. However, the bill, for the first time, would grant a right to make a useful article.

righted work. The right to distribute mask and chip works looks almost exactly like the right provided already in section 106(3). On the other hand, the "use" right proposed here seems unrelated to anything known to any copyright system, past or present, here or abroad. Such a right appears, by its terms, to give a copyright owner the right to control the manufacture of a useful article and to control in every respect how a bona fide purchaser of a chip product uses that copy (subject to the compulsory license and innocent infringer provisions). While copyright has long forbidden "uses" that amounted to specific restricted acts (reproduction, distribution, performance, and adaptation), this provision appears to permit chip-copyright owners to define any use of which they disapprove as infringing.

The license contained in the bill is by its terms less compulsory than any of the present statutory licenses which bear that name. The license here may be invoked only by those who purchase infringing chips without "having notice of infringement" and who meet several factual standards, although little guidance is provided about what those standards are.

Finally, the introduction of a "mini-term" of ten years into an otherwise uniform law, although not uncommon in foreign copyright statutes, may cause some problems, especially if the relationship between "mask works" and other works embodied in chips is not entirely clear. Copyright now arises in every type of work upon its creation, while this proposal would have chip-copyrights last for ten years from the first (query: the earliest of?) distribution, use, or manufacture.

B. Detailed Analysis of the Bill

1. Subject matter/constitutional issue. The explicit extension of copyright to electronic devices which are characterized in the bill as "writings," "discoveries," or "articles in or affecting commerce" represents a dramatic departure from 200 years of copyright legislation. Congress has never enacted a copyright law based on the Interstate Commerce clause. Moreover, there is presently a statutory bar, not repealed by the

bill as drafted, against affording copyright to "discoveries."[32] In addition, there is substantial precedential weight for the proposition that utilitarian devices are ineligible for copyright on the ground that they are not "writings." While that term has been construed ever more broadly as such media as photography, motion pictures, sound recordings, and television have developed, it has never been held to apply to purely utilitarian devices.

Industrial design legislation in the nature of copyright, but intended to occupy a separate chapter of title 17 U.S.C. and to cover a broad array of articles, was passed by the Senate in 1975,[33] but ultimately failed of enactment. The Copyright Office suggests that an examination of that legislation, together with the recent effort of former Rep. Railsback with respect to design protection,[34] may provide useful models for the drafting of provisions to provide copyright-like protection for works of various kinds which simply do not "fit" into the broad, but not limitless, expanse of the statutory term, "original works of authorship."

2. Distinction between mask works and other works. One of the most difficult tasks in considering how best to afford intellectual property rights with respect to semiconductor chips is separating the notion of protecting the design or layout of the chip from protecting the work of authorship which may (but need not be) contained therein. It is possible to store conventional copyrighted material, such as written text, on chips, in which case copyright would clearly apply to the copying of such works. Unconventional materials (at least in copyright terms), such as video games and computer programs may also be stored therein. The jurisprudence of the last three years permits the observation that courts have ordinarily been

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32. Section 102(b) of the Copyright Act specifically prohibits copyright in a "discovery" — "regardless of the form in which it is described, explained, illustrated or embodied in ... [an original work of authorship]."

33. Title II of S.22, 94th Cong., 1st Sess. (1975).

34. The "Design Protection Act," H.R. 20, 97th Cong., 1st Sess. (1981). On May 11, 1983, Congressman Moorhead introduced a design bill, H.R. 2985, which reportedly is nearly identical to H.R. 20. In this statement, the Office has referred to H.R. 20 as the design bill, since we have not had an opportunity to review H.R. 2985.

willing to grant relief to copyright proprietors whose works, distributed in chip form, were the subjects of unauthorized reproduction.[35]

The statement in the bill that "the copyright in a mask or mask work shall not extend to any other work of authorship embodied therein" appears to admit of two possible meanings, either that the proposed chip copyright shall not affect the copyright, if any, in works stored in chips, or that works in chips shall be unprotected apart from the chip copyright. These are obviously two very different rules, and the language should be clarified.

By providing that the term "copy" includes chips with respect to only nine of the 36 sections in the copyright law where the term is used, the bill would create a distinction as between those sections of the law in which chips are treated as "copies" and those in which they are not. It seems likely that this distinction may have the purpose of differentiating between copyrignt in mask works and chips on the one hand, and copyright in other works (computer programs, audiovisual works, etc.) fixed in chip products. The Copyright Office has doubts that this purpose has been achieved, and recommends further reflection on this point.

3. New exclusive rights. The proposed "use" right granted in the bill far exceeds any copyright right heretofore created. Control over copying, adaptation, distribution, public performance, and public display are the rights which presently comprise American copyright. The law is rather clear about the meaning of those rights, and certain limitations on them, but the ability of a chip-copyright owner to control the use of a semiconductor chip product would make him or her far more powerful, and customers (and, for that matter, customers' cutomers) far less free in their businesses, than any other class of copyright users.[36]

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35. Supra, note 25.

36. In the case of a new subject matter category, the exclusive rights perhaps should be somewhat limited rather than expanded, in comparison with the rights granted traditional subject matter. Sound recordings, for example, were accorded rights only against exact, unauthorized duplication and distribution initially, in 1972. The 1976 Copyright Act later extended a modified adaptation right, but the public performance right has still not been granted to sound recordings.

The compulsory license and innocent infringer provisions establish some limits to the broad reach of the proposed "use" right, but those chip purchasers who cannot meet the terms of those provisions would apparently be prohibited from using a lawfully acquired chip. It is not at all clear that such an unprecedented right is justified.

4. Compulsory license. The "compulsory license" provisions in the bill are markedly different than existing compulsory licenses in the Copyright Act. It appears that the chip license could only be invoked by a bona fide purchaser of infringing products who bought without having notice of infringement, who committed substantial funds to the use of the infringing product, who offered to pay the copyright owner a "reasonable" royalty and who could not receive the product directly from the copyright owner or licensee at a "reasonable price." Whether the purchaser has actually received notice of infringement, what amounts to "substantial funds," and the meaning of "reasonable royalty" and of "reasonable price," are left undefined by the bill. Perhaps, clarification and explication in the Committee report would satisfy our concerns about this new "compulsory license."37/ Without further clarification in the bill or the report, most of these terms may be an invitation to litigation, thus virtually guaranteeing that the licensing procedure will be both slow and unpredictable. It might be more desirable to require the services of a non-judicial arbitrator in determining the eligibility and price issues associated with this somewhat complex licensing scheme, if "voluntary" negotiations fail.

5. Concluding thoughts. In some repects, the problems seen in trying to create one class of works subject to a set of special rules, including a very different period of protection, demonstrate how difficult it may be to fit semiconductor chips into copyright. The very brevity of the proposed term,38/ when compared with life-plus-fifty years or seventy-five years for other works, suggests that traditional copyright protection

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37. It might be useful to substitute the term "statutory license" to differentiate this new, quasi-voluntary license from existing compulsory licenses.

38. The Copyright Office does not oppose a short term of protection for chips; indeed, overprotection was one of the major objections to the 1979 bill (H.R. 1007).

may not be appropriate for these works. Likewise, the bill's statements that chip products are devices (i.e., they perform electronic circuitry functions), or discoveries, or products distributed in interstate commerce, suggest that they do not fit easily, if at all, into the constitutional class of works for which Congress may authorize copyright: "writings." The phrase "manufacture, use, or distribution of which is in or affects commerce"[39] was presumably included in an attempt to preserve the constitutionality of the bill, should the courts find that chips are not constitutional writings (or discoveries?).

Rather than take a position on the question now, the Copyright Office has elected to explore in the next section possible alternative modes of chip protection. For example, it is possible that sui generis design-copyright protection for chips could be sustained under the Copyright-Patent power, even if chips are not "original works of authorship" — the current statutory standard for all works now subject to copyright protection.

VI. ALTERNATE MODES OF PROTECTION

In this section we briefly examine alternate modes of protection for designs of semiconductor chips, both under existing law (patent and copyright) and under sui generis approaches (design copyright and misappropriation).

A. Patent Protection

We understand that patent protection is presently available for certain aspects of semiconductor chips (i.e., the processes used in the manufacture of the chips, the electrical circuits implemented in the chips, and certain elements of the design and layout itself) but that the semiconductor chip industry believes this protection is inadequate to deal with chip piracy. Relatively few patents are granted: relatively few processes or designs satisfy the patent standards of novelty and invention; the patenting process may take several years (which presents particularly acute

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39. SEC. 2, Clause (3) of the definition of "semiconductor chip product," in S. 1201.

problems in an innovative, rapidly changing technological field); and, if ever involved in litigation, the patent may not be upheld by the courts.

The Copyright Office is not aware of any specific proposal to modify the standard of patentability to permit patenting of a larger proportion of semiconductor chip designs.

B. Copyright Protection

Elsewhere in the statement, we have examined the specific proposals to include designs of semiconductor chips in the framework of traditional copyright law, and noted the completely different approaches of the 1979 bill and S. 1201. Both bills, however, raise concerns about the statutory standard of copyrightability (original works of authorship, now), about the relationship between a chip-copyright and copyright in other works fixed in chips, and about the desirability of protecting essentially useful articles under copyright.

The Copyright Office tends to believe that modified, copyright-like protection is more suitable for chips than any other mode of protection; but we are not prepared to support S. 1201, and we have questions about the wisdom of granting chip protection under Chapters 1-8 of title 17 of the U.S. Code.

C. Design-Copyright Protection

At the San Jose hearing on H.R. 1007, the then General Counsel of the Copyright Office, Jon Baumgarten, suggested that the hearing could be considered the first step toward a reconsideration of protection for industrial designs.[40] John Craig Oxman in his interesting review of the law in this area made a similar observation. Expressing reservations about relaxing the "useful articles" doctrine in the case of integrated circuits, he noted that:

> Printed circuit boards are manufactured by a photoprocess similar to that used in the manufacture of ICs and also require an enormous development effort. In fact, one could view the aluminum metallization pattern on ICs, which connects the various components, as a miniature printed circuit. Should printed circuits be included too? Would this turn the copyright laws into industrial design protection laws? If so, then should

40. 1979 Hearing at 9.

> the problem be reconsidered in toto from a global perspective rather than on a point-by-point basis.41/

The ABA Section of Patent, Trademark and Copyright Law at its Annual Meeting in 1982 also had certain misgivings about protecting the topology of semiconductor chips under copyright.42/

In view of the difficulties that may be experienced in trying to uphold a copyright in the configuration of a semiconductor chip product if the proposals in S. 1201 were enacted, it might be more advisable to craft sui generis design protection patterned on modified copyright principles.

1. Brief review of H.R. 20

A useful starting point in considering design-copyright protection for semiconductor chips would be the bill [H.R. 20] introduced in the last session of Congress to add a new chapter to title 17 U.S.C., to protect ornamental designs of useful articles. With few exceptions, section 1 of H.R. 20 is identical to the text of Title II of S. 22 as reported by the Senate Committee on the Judiciary in November 1975.43/

Generally, to be protected under the proposed legislation, a design of a useful article would have to be "ornamental" and "original." Protection would not be available for a design that was:

(a) not original;

(b) staple or commonplace, such as a standard geometric figure, familiar symbol, emblem, or motif, or other shape, pattern, or configuration which has become common, prevalent, or ordinary;

(c) different from a design excluded by subparagraph

(b) above only in insignificant details or in elements which are variants commonly used in the relevant trades;

(d) dictated solely by a utilitarian function of the article that embodies it; or

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41. J. C. Oxman, Intellectual Property Protection and Integrated Circuit Masks, 20 Jurimetrics Journal 405, 460 (1980).

42. Resolution 108-8, 1982 Summary of Proceedings, Section of Patent, Trademark and Copyright Law (1982) at 39; see also the 1983 Draft report of Committee No. 309: Kurt D. Steele, Chairman (3/28/83) (unpublished).

43. For text of Title II—Protection of Ornamental Designs of Useful Articles, see Report of Sen. Comm. on the Judiciary to accompany S.22, S. Rep. No. 94-473, 94th Cong., 1st Sess. 39 (1975).

(e) composed of three-dimensional features of shape and surface with respect to men's, women's, and children's apparel, including undergarments and outerwear.[44]

Pursuant to section 908(a), a person would infringe the design protection afforded by the bill if he or she makes, has made, imports, sells or distributes for sale or for use in trade any article, the design of which has been copied from a protected design, without the consent of the proprietor. Sellers and distributors of infringing articles who do not make or import any such articles would be exempt from liability under the bill where they do not induce or act in collusion with a manufacturer to make, or an importer to import infringing articles; or where, upon the request of the proprietor of the design, they disclose the source of the articles, and do not order or reorder such articles after receiving appropriate notice of the protection subsisting in the design.

The bill also provided that, under certain conditions, a person who incorporates into his own product of manufacture an infringing article acquired from others in the ordinary course of business or who, without knowledge of the protected design, makes or processes an infringing article for the account of another person in the ordinary course of business, is not deemed an infringer.[45]

With respect to protection of designs first filed in foreign countries, the bill provided that a person who files an application for registration of a design in a foreign country "which affords similar privileges in the case of application filed in the United States or to citizens of the United States," the applicant may benefit from the earlier filing date in the foreign country, provided an application is filed in the United States within six months from the earliest date on which the foreign application was filed.

Finally, with respect to the interaction between the Copyright Act of 1976 and the proposed design bill, where a pictorial, graphic, or sculptural work in which copyright subsists is used in an original ornamen-

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44. Chapter 9 — Protection of Ornamental Designs of Useful Articles, §902(a)-(e), H.R. 20, 97th Cong., 1st Sess., sec. 1 (1981).

45. Id., §908(c).

tal design of a useful article with the consent of the copyright owner, the design could be protected under the design law; however, once the copyright proprietor has obtained registration of the design, copyright protection would terminate.[46]

2. Adaptation of the design bill.

The requirements for design protection set forth in H.R. 20 may not be flexible enough to protect the topology of microelectronic circuits and other devices in semiconductor material, and, in any case, proponents of chip protection may prefer to separate any consideration of design-copyright for chips from design legislation for all useful articles. As a start in any revision of the design bill to accommodate chips, the Copyright Office has noted certain points.

Standard of ornamentality. Although the choices made by a layout designer in determining the placement of the electrical components on a wafer of semiconductor material and the routing paths to interconnect them are for the most part dictated by the function the generated patterns are to perform, there are certain aspects of a designer's work that are determined on other bases. A major objective for a designer is to achieve an optimized layout configuration that minimizes the surface used, while retaining the desired function. Efficiency of operation is also a concern. The resulting layout design embodied in layers of semiconductor material has features that may be conceptually distinguished from the basic electrical behavior of the particular device. Although the surface aspects of the device may not be viewed as aesthetically pleasing, they may be considered distinctive for reasons of economy and efficiency of operation. To the extent that these efforts are the result of substantial intellectual labor, they should be protected.

H.R. 20 tried to protect the shape and configuration of useful articles excluded under §113 of the Copyright Act of 1976; but protection was tied to a requirement of ornamentality.[47] A standard of ornamentality

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46. Id., H.R. 20, sec. 2.

47. For discussion of separable artistic features doctrine under the Copyright Act of 1976, see pp. 8-11, supra.

is also set in the current design patent law.[48] Although in recent years, the concept of what is ornamental has been stretched in certain cases, the concept is still viable for purposes of design patent protection. See, e.g., Blisscraft of Hollywood v. United Plastics Co., 294 F.2d 694 (2d Cir. 1961); and Bentley v. Sunset House Distributing Corp., 359 F.2d 140 (10th Circuit 1966); but see Contico International, Inc. v. Rubbermaid Commercial Products, Inc., 665 F.2d 820 (8th Cir. 1981). In the Contico case, the court considered whether a dolly for the transportation of trash cans can be "ornamental." Noting that "design patents are concerned with the industrial arts, not the fine arts," the court found that "[p]erhaps it is too much to expect that a trash-can dolly be beautiful. It is enough for present purposes that it is not ugly, especially when compared to prior designs." Id. 665 F.2d, at 825.

As defined in former H.R. 20, a design is considered "ornamental" "if it is intended to make the [useful] article attractive or distinct in appearance."[49] With respect to the topography of electronic devices fixed in semiconductor material, it may be suggested that this standard of "ornamentality" be recast clearly to protect distinctive layouts or designs for chips.

Concealed in use. Certain judicial decisions applying the ornamentality criteria in the current design patent law required that a design be visually perceptible. For example, the court in Electronic Molding Corp. v. Mupac Corp., 529 F. Supp. 300 (D. Mass. 1981), found that:

> The crux of Mupac's claim of patent invalidity is that the design is concealed in use. It is well settled that a design is not patentable if its elements are concealed in the normal use of the device to which the design is applied. ... In this case, only the top cap and tail of the [electronic] terminal are visible when the terminal is imbedded [sic.] in a panel board, and those then-visible portions do not constitute a new design. To the extent that the only "normal use" of the terminal is in the panel board, the design is not ornamental and the patent is not valid.

Id. 529 F.2d, at 302. Although former H.R. 20 did not specifically address

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48. See K. M. Mott, The Standard of Ornamentality in the United States Design Patent Law, 48 ABA Journal 548 (pt. 1), and 643 (pt. 2) (1962).

49. Chapter 9 — Protection of Ornamental Designs of Useful Articles, §901(b)(3).

this issue, it may be assumed that the proposed design legislation also required that a design be visible to the naked eye.

Since this requirement has now been eliminated from the Copyright Act of 1976, if a new sui generis design bill is drafted, perhaps the "concealed in use" restriction should be dropped expressly. This would seem necessary in the case of layout designs, since they are not visible in normal use, but may be perceived with the aid of complex equipment.

Constitutional underpinnings. H.R. 20 would have amended title 17 U.S.C. to provide protection for ornamental designs of useful articles. In fact, it would have added a new Chapter 9 to the current copyright law. Whether such a direct linkage between copyright and design protection was permitted under the Copyright-Patent power of the U.S. Constitution has been considered over the years.[50] The House Committee on the Judiciary when deciding to delete Title II from S.22 (the Senate version of the current Act) expressed certain reservations on this issue. As noted in the report accompanying the copyright revision bill "[t]he Committee chose to delete Title II in part because the new form of design protection provided by Title II could not truly be considered copyright protection and therefore appropriately within the scope of copyright revision."[51]

Nevertheless, there appears to be a solid basis for according design-copyright protection under the intellectual property clause in the U.S. Constitution.

D. Misappropriation.

One other mode of protection might accord remedies at the federal level against verbatim or near-verbatim copying of chips by a competitor.

Misappropriation and misbranding of the nonfunctional features of useful articles has been found to be "a false designation of origin" actionable under section 43(a) of the Lanham Act, 15 U.S.C. §§1125(a).[52]

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50. See, e.g., K.B. Lutz, Can Ornamental Designs for Useful Articles be Protected by Copyright?, 2 Patent, Trademark, and Copyright J. of Research and Education 289 (1958); see also Constitutional Limits on Copyright Protection, 68 Harv. L. Rev. 517 (1955).

51. 1976 House Report at 50.

52. See, for example, Truck Equipment Service Company v. Fruehauf Corp., 536 F.2d 1210 (8th Cir. 1976).

While some have denominated this section a "federal law of unfair competition," the distinction between functional and nonfunctional designs causes uncertainty, and there is no protection for so-called "functional" designs.

Attempts to enact a general federal unfair competition law have not been successful.53/ However, sui generis legislation predicated on misappropriation doctrine might be an appropriate method for protecting against exact duplication of chips.

This concludes my presentation of the views of the Copyright Office. I will be pleased to respond to your questions.

53. See, for example, S. 1416, 95th Cong., 1st Sess. 1977).

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APPENDIX A

VLSI Design Automation: An Introduction

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Invited Paper

Abstract—This paper is a brief introduction to the automation of the design of very-large-scale integrated circuits (VLSI). The field of design automation has grown so large in the last twenty years that a complete treatment would require an encyclopedia. What follows, therefore, is only a sketch of the history, state of the art, and current key problems of the automation of VLSI design.

History

THE HISTORY of anything to do with VLSI is almost a contradiction in terms. Until recently, VLSI had always been thought of in the future tense. Integrated circuits (IC's), medium-scale integration (MSI), and large-scale integration (LSI) are historical terms, but not VLSI. Only with the advent of microprocessors with some half-million transistors on a chip has there been a grudging acceptance that VLSI may indeed have arrived. These acronymic labels are always applied after the fact, but VLSI was resisted longer than most. Extrapolating from the fact that early IC's contained several logic gates, MSI tens, and LSI hundreds, we might expect VLSI circuits to contain thousands of gates. By the same reasoning, today's 32-bit microprocessors would be examples of ULSI (the U for ultra). Maybe we are running out of acronyms and need to conserve. In any case, for this article, a chip with several thousand logic gates or more qualifies as a VLSI chip.

During the 1950's, Texas Instruments, Fairchild Semiconductor, and others developed the photolithographic process for the fabrication of transistors on crystalline silicon. The steps involved in the design of early IC's are still qualitatively the same today. The first step is the definition and optimization of the process by which the devices and interconnections are to be fabricated. The second is the electrical characterization of the circuit elements. These two steps together are sometimes known as technology definition. Third, the user of the technology generates a design (circuit or logic schematic) to be implemented. Fourth, this logical design is reduced to a series of geometric patterns through which materials are to be added or subtracted in the fabrication of the circuit. Finally, a set of test input signal patterns and responses is generated to detect fabrication defects. Testing is an integral feature of IC manufacture because a significant percentage of chips come off the line with at least one defect. These defects are detected by applying the test patterns to the chip inputs and comparing the output signals to those expected. Defective chips are discarded.

In the 1960's, these five steps were largely manual. Process parameters, such as diffusion temperatures, times, and pressures, and metal line widths and spacings were worked out primarily through trial and error. Yields and electrical properties of the resulting devices were monitored. The process was characterized by a set of electrical and physical design rules for the user of the technology. For digital circuits, the switching characteristics were boiled down to rising and falling delays, fan-out rules, and the like. Physical design rules prescribed widths, spacings, and overlaps required to achieve acceptable yields.

The engineer-user would supply a circuit or logic schematic sketched on a piece of (yellow) paper. The correctness of the circuit could be verified by implementing the same circuit in discrete components ("breadboarding"). An expert layout designer then drew the mask patterns necessary to implement the circuit. The drawings were transferred to a red plastic material called rubylith which was cut away according to the drawing. This step was verified by a careful, independent visual inspection ("eyeballing"). The rubylith pattern was optically reduced to form photolithographic masks.

Testing was a manufacturing function. For small circuits, exhaustive functional testing was possible and ac characteristics could be measured.

As time progressed, the number of devices per chip started to double every year (Moore's law, [1]). This increased mask complexity, and in the early 1970's the rubylith patterns began to outgrow the space on laboratory floors. By the late 1960's this method began to give way to numerically controlled optical pattern generating machines. These required digitally encoded geometric patterns, and the layouts were transferred to data tapes by tracing over them with electromechanical digitizers. With the patterns now accessible to computer processing, the visual inspection could be enhanced with design rule checking (DRC) programs which detected shorts and spacing violations. Another advantage was that corrections to the drawing could be made much more easily than to the rubylith cutouts.

The next step was to display the patterns on a CRT screen, and interactive graphic layout was born—an activity almost synonymous with computer-aided design (CAD) for many years. Commercial turnkey graphics systems began to appear in the early 1970's, although large companies developed in-house systems earlier [2]. The power of interactive graphics was most evident for repetitive patterns such as memory arrays or gate arrays, where a set of geometric data called a cell could be replicated thousands of times in different positions and orientations on the array without having to be redrawn.

As the density of IC's increased, the need for circuit simulation programs became critical. Discrete circuits could be probed and monitored at all nodes, but IC's were inaccessible inside the chip. The only way to tell what they were doing internally was through circuit simulation and through effects

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accessible at output pins. A series of programs was developed in the decade from the mid-1960's to the mid-1970's: CIRCAL, SCEPTRE, ECAP, ASTAP, SPICE, and others [3]. A by-product of circuit simulation was the availability of the circuit schematic in machine readable form. This network information was entered on punched cards, then through alphanumeric terminals, and lately as drawings on interactive graphics equipment. The network information made possible not only simulation, but also automatic verification that the layout interconnections indeed matched those of the input network.

Because it was impossible to modify a chip to correct a design error, it became important to verify the correctness of the design prior to releasing the chip to manufacturing. Since the simulation of the full analog behavior of large digital circuits became prohibitively expensive, logic simulation with discrete Boolean values became the dominant software verification tool. Switching-level or gate-level simulators evolved through a series of stages ([4] and [5]) until event-driven simulators capable of handling unique delays for several thousand logic blocks became standard tools.

The automation of the layout function began with techniques borrowed from printed circuit board design. Routing algorithms based on work by Lee [6] and Moore [7] were available for finding paths for metal interconnections between pins of logic functions on the chip. A distinction can be made between this sort of automatic design activity and the verification mentioned above: one is synthesis and the other analysis. To facilitate layout, certain constrained design styles such as gate arrays and standard cell arrays were developed in the late 1960's. These led to the invention of the channel router of Hashimoto and Stevens [8], an algorithm unique to IC's. Over the years, routing has become one of the richest areas in design automation in terms of available techniques, and algorithms have been developed to handle the interconnection problem in almost all conceivable situations.

The regularity of standard cells and gate arrays also facilitated the development of automatic placement algorithms of very high quality [9]. The standardization of the size and shape of the units of logic made the placement task more tractable than that of modules on printed circuit boards. Automatic placement and routing together formed a complete automatic layout system [10], [11].

The gate array, or masterslice, was recognized by the systems manufacturers, notably IBM, as a design style which reduced design time while still providing reasonable silicon area utilization compared to free-form layout. It became very important to understand how much routing space was required on a gate array to ensure the automatic layout of almost all designs using the array. Too much routing space reduced the gate count, while too little led to low utilization of available gates. This need led to theoretical work on routing space estimation which found substantial usage and payoff [12].

For designs consisting of large functional units of different internal structure, tools were developed for the automatic generation of PLA macros, register stacks, memory macros, and bit sliced data flow macros [13].

Test generation also soon outgrew the capabilities of manufacturing organizations. Exhaustive tests based on the input-output specifications of the circuit require an astronomical amount of time even for moderately large IC's. An exhaustive test requires that all possible input patterns be applied for each internal state of the circuit. For a static (dc) test this number is two raised to the number of primary inputs times two raised to the number of internal latches. Even for an early microprocessor, the Intel 8080, an exhaustive test set would contain over 10^{33} patterns; at 1 μs per input pattern, the test time would be more than 10^{20} years!

One solution was to save the simulation patterns used to verify the logic design and to apply them during test. Unfortunately, this functional testing did not provide a high level of confidence that other valid input patterns would not uncover defects missed by the test. To estimate this risk, researchers studied the circuit structure and classified the likely local faults. One model, appealing because of its mathematical tractability if nothing else, was the single-stuck fault model. With a fault dictionary it was possible to include fault grading into simulation to compute the number of faults which would be uncovered by a set of patterns. The designer could also see which faults would have been missed and could add more patterns to find them. With the single-stuck fault model, test patterns could be automatically generated for combinatorial unit logic using methods such as Roth's celebrated D-algorithm [14].

Extensions of automatic test pattern generation algorithms to sequential circuits met with only limited success up to about 5000 equivalent gates, and it became obvious that the test pattern generators would need more assistance from the logic designers. At least in the case of the large systems manufacturers, special circuitry was added to the chips to increase the ease of generating and applying tests. The best known of these is IBM's Level Sensitive Scan Design (LSSD) [15]. Today testability is recognized as one of the key responsibilities of the logic designer. An untestable design, even if otherwise correct, is worthless.

State of the Art

The status of VLSI design automation is particularly difficult to assess because so much of it is carried on inside large electronics companies on a proprietary basis. Most of these activities are reported in the literature, but, since the systems themselves remain inaccessible, others are forced to develop their own tools or to turn either to university sources or to the relatively small vendor design automation industry. This makes for a very uneven state of the art.

VLSI design practices vary from the fully integrated highly automatic gate array design systems of the large systems manufacturers to the computer-assisted largely manual methodologies of the designers of high-density custom MOS microprocessors. The following is a composite state-of-the-art design system:

Hardware

A design automation facility usually consists of a family of interactive terminals attached to each other and to a host mainframe computer by a communications network. Alphanumeric terminals are sufficient for messages, status reporting, and job control. A low-cost graphics terminal for logic entry is desirable in each engineer's office. For layout, a high-function color system is most efficient. The advent of inexpensive VLSI memories and microprocessors is revolutionizing the interactive graphics business. The trend has been to supply more and more processing power and memory at the terminals or work stations. The mainframe computer is reserved for long-running jobs such as simulation, test pattern generation, or design rule checking and for maintenance of the central data base. A high-speed plotter is useful for displaying the finished artwork.

Control and Release System

This is software to track design status, to coordinate the contributions of many designers, to control engineering changes and other levels of design, to ensure that updates do not invalidate previous verification steps, and to prepare data in standard form for manufacturing. Data integrity is the key to success in VLSI design. Not only is the number of devices per design staggering, but the design automation process itself produces volumes of intermediate data which must be controlled.

Multimode Hierarchical Data Base

This is not a data base in the usual sense of small interactive transactions. The data needed for automatic processing are rather large specially organized files. These files are related to each other in at least three ways. The first was already mentioned: they may describe different versions or levels of the same thing. The second is that they may describe a different aspect or mode of the same entity. Thus a shifter can have a symbolic form for documentation, a behavioral simulation model, another model for test pattern generation, an outline shape for floor planning purposes, a symbolic track description for automatic routing, detailed polygon mask shapes, and "fractured" rectangle shapes for pattern generation. The data base must maintain consistency among these data modes. These modes contribute to the volume of intermediate data mentioned earlier. The third relationship is hierarchy. The same shifter behavioral model can have an expansion to behavioral models of interconnected latches, which, in turn, can be expanded to simulation models of unit logic elements and, finally, to individual transistors. The associated shapes will display a similar hierarchical structure. In a large systems environment, the hierarchy will extend to all packaging levels as well as the chip. The data base must allow for this multiple nesting of design entities. The trend toward relational data base organization (e.g., Mentor Graphics, Portland, OR) also deserves mention. The advantages claimed are simplicity of use and ease of reorganization for future enhancements without invalidating existing programs. The traditional disadvantage of poor performance seems to be yielding to improved software and hardware techniques.

Unified Interactive User Interface

Any large design system must incorporate tools from various sources. It is important, however, that the user be presented with a consistent, well-designed view of the system. Nomenclature, menu layout, message style, and job submission commands should be consistent. The Bell Laboratories Designer's Workbench is an example of such a system [16]. Redundant data entry should be minimized. Errors, especially simple syntactic errors, should be trapped by the system in real time. Even better is a system to guide the user by presenting only options which cannot produce trivial errors.

Automated Verification

With VLSI this is the key function which a design automation system performs—the avoidance of errors. The beginning of the design process currently is the specification of external system behavior. The verification of system specifications is accomplished through design reviews, emulation on existing hardware, and simulation using general-purpose or specially written simulation systems. The state of the art here is understandably rather uneven. The next phase is the design of the system in terms of functional components. For computer systems, these might be ALU's, PLA's, registers, and busses. The verification of this design is usually done using simulators which contain behavioral models for these functional components. The results are examined for consistency with the system specifications. This comparison is typically not automatic because of the lack of precision of the usual specifications. At this point, the designer should also have a plan for partitioning and packaging the system. On single-chip systems, this is the so-called floor plan. Tools are under development to estimate the shape, area, power consumption, pin requirements, and routability of the partitioned subfunctions, but the verification of the feasibility of a partition or floor plan still depends largely on human judgement. The ensuing refinement steps of detailed logic design can all be verified automatically against the next higher level of design. Static verification of logical equivalence and static timing analysis can take the place of simulation. Where simulation is desired, a mixed-mode simulator capable of combining behavioral, unit logic and possibly switch level, and analog circuit level models is ideal.

Layout verification consists of a comparison with the logic and a check of internal consistency. In a hierarchical system, each level of the layout hierarchy can be checked for spacing violations with the boundaries specified at the next higher level. However, at the lowest levels of design, the verification that a given mask geometry will produce the desired analog devices, and that these, in turn, will perform the desired digital functions is only partly automated today. The usual practice is to limit the design to a specified library of basic structures, to analyze these exhaustively using device analysis and circuit simulation programs, and to generate the appropriate digital models.

Automated Design

Modern design automation systems provide powerful tools for the synthesis of VLSI circuits. Logic entry is necessarily an interactive task. It is supported by intelligent graphic engineering workstations. The automatic generation of detailed unit logic from register transfer logic has met with practical success. PLA minimization programs are in common use. Layout is either computer assisted on high-function color graphic workstations for free-form designs, or highly automated for more constrained design styles such as PLA's, gate arrays, standard cell arrays, and even standard floor plan chips. There is now a trend to mix these design styles on single chips, using automatic generators to produce customized PLA, register, RAM, ROM, and random-control logic macros [13]. Test pattern generation is another sophisticated synthesis problem. The most advanced methodologies use special design rules and additional hardware to subdivide the circuitry into manageable combinatorial sections, or to condense the results of long test sequences, or even to administer pseudo-random test patterns on the chip itself.

Such a composite system does not exist, of course, but each of its components does. Clearly, the development of a state-of-the-art automation capability for fast turnaround VLSI design is a very ambitious undertaking indeed.

Problems for the Future

Fortunately, there are still problems, or, rather, opportunities for creative work. How does one manage the complexity of VLSI design? What happens when computer runs exceed weeks? When tester times exceed hours?

The complexity of VLSI designs has grown to the extent that there are substantial doubts about the designers' ability to keep up with process capability. The implication is that future chips will be designed inefficiently in terms of silicon utilization or performance because of lack of time and design resources. The phrase "silicon is cheap" has always had a certain irony about it, but we may actually be coming to the point that silicon utilization is less important than design time.

While the problems are serious, they are not insurmountable. Clearly some very spectacular chips are being designed. 32-bit microprocessors such as the Intel iapx432, the Bell Laboratories BELMAC, and Hewlett-Packard's 32-bit microprocessor chip set [17] are all near the limit of fabrication technology. There is no reason to expect the next generation of microprocessors to leave any unused silicon either. Even so, these projects are costly (50–100 person-years) and therefore rare. If VLSI were as simple to deal with as modules on wire-wrap boards, many more products would appear.

The problem of handling complexity has come up in other disciplines, notably software engineering, and a variety of promising techniques have been proposed. Prof. C. Sequin has a very interesting discussion of this subject elsewhere in this issue. One technique for dealing with complexity has been to use regular structures such as PLA's rather than try to squeeze out every square micrometer through local optimization. This approach, advocated by C. Mead of Caltech [18], has broad implications. How does one obtain a library of useful regular structures or macros to include in one's VLSI design? To be useful to someone other than the designer, a macro must be general, well documented, and configurable to other technology ground rules and to other system environments. Such macros would necessarily be encoded primarily as programs and only secondarily as pictures. This again is a feature of the Caltech approach. To be useful, each of these macro generation programs should be accompanied by a simulation model as well. All this implies a level of interface standardization which has yet to be achieved. Thus the challenge is the invention and development of commercially available VLSI macro generators and the creation of an environment to facilitate their transfer.

A closely related challenge has to do with interactive graphics. We need to develop graphic techniques for specifying not only pictures, but families of pictures with given relationships among their components. Procedural design or algorithmic macro generation is inherently a problem of expressing shapes and their relationships, yet we must still use programming languages which are patterned on speech, rather than use the seemingly more natural medium of interactive graphics. Why can these programs not be specified by diagrams which express the number of repetitions of a shape in two dimensions, the required clearances and overlaps of related shapes, the fact that some can be extended as necessary, and so on? We can generate families of pictures from programs; how can we generate programs from pictures?

Reusing standard macros is one way to deal with design complexity. Another is to automate the design process so that the designer deals only with high-level entities and the machine handles all the details of converting and optimizing the design. In layout, as was previously mentioned, there are automatic design algorithms for gate arrays and standard cells. For such chips the time spent in logic design far exceeds the time spent in layout. There is a need for automated techniques for converting high-level functional descriptions to lower level logic suitable for implementation. This logic synthesis task has always been thought of as impractical for large networks, but recent progress in optimization by local transforms [19] holds out the promise of a solution. The generation of functional chips from high-level functional specifications, whether for gate arrays with unit logic or for standard floor-plan MOS microprocessors, would be a true "silicon compiler" and a worthwhile goal.

The issue of simulation and test pattern generation run times is still a very real one. Despite the advances in static verification and other proofs of correctness, there is no better way to verify the initial specifications of a system than through real-time emulation or simulation. The designer often does not understand all the capabilities of a structure which he creates. A period of "playing around" with the design is required. Simulations of VLSI systems running even trivial test programs are almost prohibitively expensive. A potential solution is the hardware simulation engine—a large array of processors and memories tied together with a high-speed communications switching network. It can handle the number-crunching simulation operation at speeds thousands of times greater than a standard serial computer. These engines might have been included earlier in this article as part of the state of the art, but there are still too few of them in use, and their effectiveness in a production environment is undocumented. The simulation problem remains a major challenge.

Test pattern generation speed can also be significantly enhanced by using the same or similar engines. However, there is also the problem of applying the tests in fabrication. This is still a sequential process, carried out by expensive test equipment. One way to cut down both test pattern generation time and testing expense is to have the VLSI chip carry its own built-in tester. While self-test and other hardware-assisted testing techniques impose penalties on silicon utilization, the tradeoff appears favorable. In any case, if there are any fears about designers' ability to use everything the process people can provide, this added testing requirement should allay them.

The most exciting challenge of VLSI design is in the area of applications. There is enough capability today, both in technology and in design techniques, to create radically new electronic systems. In the 1950's computer experts were fond of speculating on the structure of the brain, on robots, and on automatic language translation. Then the IC revolution occurred, and most practical people turned to remapping Von Neumann's computer from one technology to the next.

Some of these questions are being revisited today. Indeed, the logic simulation engine discussed earlier is an example of a step in this direction. It uses the power of many concurrent processors to model the concurrent events in a digital system. The recognition and translation of speech are also composed of many inherently concurrent activities. The efficient searching of a data base is another example of inherently concurrent processing.

The technology exists to produce vast arrays of processing and memory elements. What is not clear is how to have them communicate with each other. The interconnect capability of integrated circuits is hopelessly outclassed by that of biological systems. The easiest arrays to build have interconnections only among nearest neighbors. When it is necessary for each processor to be able to communicate with any other, as it is in the logic simulation engine, the communication network quickly becomes a bottleneck.

Design automation can only play a supporting role in the process of creating these new concurrent systems. Improvements in logic description languages and in simulation techniques will help researchers to study the properties of alternate architectures. On the other hand, these unconventional new VLSI systems will have profound effects on design automation techniques. Programming general-purpose multiprocessor computer systems will require new techniques, but the resulting code should execute thousands of times faster than on uniprocessors. Compilers may begin to understand subsets of natural language. Spoken input and output may develop into an important medium of communication between man and machine.

Design automation will be transformed by the VLSI products which it will have helped create.

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Senator MATHIAS. Our next witnesses are Mr. Thomas Dunlap, corporate counsel and secretary of Intel Corp.; and Dr. Christopher Layton, vice president of operations of Intersil. And I understand that they will be accompanied by Mr. Stanely Corwin.

Gentlemen, I understand you have some paraphernalia. So, if you want to take a minute to set that up, please take your time.

STATEMENT OF A PANEL CONSISTING OF THOMAS DUNLAP, JR., CORPORATE COUNSEL AND SECRETARY, INTEL CORP., ACCOMPANIED BY RICHARD STERN, COPYRIGHT COUNSEL; AND CHRISTOPHER K. LAYTON, VICE PRESIDENT OF OPERATIONS, INTERSIL, INC., GENERAL ELECTRIC CO., ON BEHALF OF THE SEMICONDUCTOR INDUSTRY ASSOCIATION, ACCOMPANIED BY STANLEY C. CORWIN, PATENT COUNSEL

Mr. DUNLAP. Mr. Chairman, I appreciate the opportunity to address this committee on behalf of Intel Corp. and the Semiconductor Industry Association. I am accompanied by Richard Stern, who is the copyright counsel for Intel Corp. and the SIA.

What I would like to cover is basically the technology that we are trying to protect here—the basic technology of a chip, which is a collection of transistors which is going to be integrated on a single structure. That is what the bill has defined as a semiconductor chip product. It is also commonly referred to as an integrated circuit.

I also have listed some of the same things that you noted in your opening statement as far as what these chips are used for. I have here a couple of samples of an actual chip.

One has writing on it. It says "Intel," and it says "copyright," and so forth. This is the form that would be actually used in a computer system of some kind. Now, I have the exact same chip here, except that I have taken the lid off it, so that if you take off the scotch tape here, you can see the chip inside it.

Now, the basic building block of that chip is a transistor. The fabrication of the transistor is what I want to discuss. It is an electronic device which is going to be fabricated on a semiconductor material, and typically this material would be silicon.

Now, to show you what an actual wafer is, this is what would be an actual, real live wafer. It starts out looking shiny, like it is here on this side. When it is completely processed, you can see the rectangles on there. The rectangles are the actual chip and you will see it is a rougher surface.

So, we will start with that thin substrate, which is typically silicon and on which transistors are formed. We then are going to begin what we call wafer processing; we are going to process that wafer.

The bottom rectangle there is a cross section of the wafer. We are going to start by growing a thin oxide over the entire surface of the wafer. On top of that oxide—and now I refer to this crosshatched area—will be resist. And, again, this goes over the entire wafer. So, we put the oxide over the entire wafer and we put the resist over the entire wafer.

Now, we are going to imprint a pattern on that resist, and this is going to be the pattern that we are going to talk about later as mask works or masks which are intended to be protected.

But what happens is, basically, you are going to take a picture of the wafer, and in certain areas the resist, where the light has hit the resist, will be developed; in the other areas, it will not be developed.

You then subject the wafer to a chemical process and you etch away certain portions of the resist and the underlying oxide. So, where the resist was not developed, it is etched away; where it was developed, it protects the oxide. This is the basic concept of it.

Now, when you do this, remember this is one transistor. In reality, we are going to be making anywhere from 1,000 to 300,000 of these on the same chip. The chip that I have shown has about 120,000 transistors on it. It will have 120,000 of those and, in addition, it is not just one step. There will be maybe 10 steps to actually make this chip.

So, the way we make the chip is we start off with an idea that the customer wants to have a particular electronic function. The circuit design engineer then will develop a circuit which will implement the electronic functions that the customer wants.

The designer then will make what we call a schematic; it is a schematic representation which is used to document the electronic functions. Now, here I have this drawing which is a schematic, and on a chip like I just showed, you need about 20 of these to get the entire function of the chip.

Now, in that form, that circuit is patentable, and that form has nothing to do with the Chip Protection Act. That is what we could call the concept of the chip. It does not have anything to do with the expression of the chip that we are trying to protect.

Now, that document itself is not useful until it is transferred into a pattern which can be imprinted onto the wafer. So, we have another type of engineer, which we call a layout design engineer, who is going to have to transfer this circuit into a set of patterns which will eventually be imprinted onto the wafer.

If you take that chip that we had and draw it out 200 times, this is what it would look like. You can see there are multiple colors on it, and you can see that there is a very complex pattern to the design. Like I said, there are about 120,000 transistors on this particular one.

Now, historically, this was actually drawn out with paper and pencil, on mylar. Today, you can draw it directly on a computer terminal, but eventually you are going to get it into some sort of a magnetic tape which can be used to imprint the pattern on the wafer. Remember, we have to somehow get that onto the wafer.

So, we are going to have to make a mask from the tape for each individual pattern that we want to print onto the wafer. Now, the mask is a glass plate which has a pattern of a single layer on it. It has multiple chips on it. If you look at the wafer, there are also multiple chips on it.

So, this mask is going to be placed into something almost like a camera. The camera then will shine light through the mask and project it down onto the wafer. Again, the areas that are exposed will develop the resist and the ones that are not exposed will not.

Now, I will review the manufacturing process. These patterns are 50 times the size of the original chip and they are the same patterns that the masks would have on them.

Now, if we analogize the screen to a wafer and we analogize the light coming out of here to the printer, what would happen is—that the screen is analagous to a bare silicon wafer. We take the mask and put it into the printer and the printer then projects the pattern onto the physical wafer, and then the resist is developed.

Now, one question that a lot of lawyers have is, first of all, is that a copy? Remember, the Copyright Office has taken the position that the schematic is protectable as an engineering drawing; they have accepted these overlays as engineering drawings.

The mask then, I presume, they would accept as well as an engineering drawing. But the question then comes, when you project it onto a wafer, is that now a copy? New technology has other ways of projecting it on a wafer as well, but the idea is the mask, the plot that I showed, and these types of things are going to all be protected by the company on a physical security basis.

You are not going to be able to get this out of Intel without the appropriate security passes. So, the only way that anybody really gets access to these patterns, unless, of course, they steal them, is from the chip. So, that is why we have to stretch the copyright theories a little bit to protect the projection of the pattern as it appears on the chip.

This is one layer; the completed chip—we put down the next layer, then we put down these and we put down all these layers on top of each other. Again, each time we are putting them down, we are taking a picture and going through some kind of a chemical process.

We take another picture, and go through steps until we have the complete set of patterns imprinted on the wafer. I also have a picture of an actual chip as it would appear on the wafer.

In the words of the bill, we call the set of patterns, as they appear on the chip, a mask work, and that is really the core that we are trying to protect—this picture, the mask work, the intricate design.

If you want to copy the chip, you get the chip, which is available publicly; you take the lid off the chip and you make a photograph of the chip. Once you have a photograph, you now can measure the top layer, so you carefully measure the top layer and draw it on a piece of mylar like that, or on a computer of some kind, etch off the layer so that now the next layer is exposed.

You draw the next layer and you continue to do this until you have a tape with the entire set of patterns on it. So, if I put this back on—again, this was the actual chip. Again, you would measure the first layer on your computer; you etch it away, and now you have the second layer exposed. You measure that very carefully and etch it away.

You continue to do that until you have completely taken every layer off the chip and you have the set of complete patterns. That is the type of copying that we are asking that the copyright law should be expanded to include.

Now, there is something completely different from that type of copying, which I have called fair reverse engineering, which is equivalent to writing a copyrighted biography. A second writer can always write a biography on the same person as long as it is expressed in a different manner. In chip language, that would mean that a fair reverse engineering person has the right to analyze the chip, understand the chip, and come up with the circuit schematic that I showed because, first of all, that is protected under patent law. So, he has the right to do that.

So, he can make a chip with a different pattern which will perform exactly the same functions as the copyrighted chip, and that would be reverse engineering. It is implementing the same electronic functions but using different patterns.

Now, the advantage of this is that it does reduce the cost. It can often improve the performance and it may cost 25 percent or so of the original design. It is the type of thing that even the original designer is going to do. It is ongoing engineering, which is perfectly allowable.

I wanted to spend a moment here on development costs. This will be more fully covered by Dr. Layton, but I wanted to show from an Intel standpoint the type of money that we are talking about.

Now, I have been talking so far about a single chip. Now, in reality, a single, complex chip is not very useful by itself. We are talking about a complete system, a complete family of chips which have to be developed. To develop this family of chips may cost on the order of $80 million over a period of 3 or 4 years.

The main chip would typically cost in the neighborhood of $4 million, but in order to develop a market for this chip and to understand what the customers want, you are talking almost $36 million of market development cost.

Then, you are going to have to design more chips to allow development of a complete system, you are going to have to develop software to help the user use the chip, and you are going to have to have computers to help them use the chip. So, the development of those types of development tools is going to be another $40 million.

So, we are talking about a large development project, which then is going to also cost approximately $10 million a year just to maintain and to solve whatever customer problems come up.

Now, if you take the main chip that took $4 million, and if you do a reverse engineering job, which I have called fair reverse engineering, you are talking about $1 million. This is the type of thing that the industry is used to. We believe that we can live with this type of fair reverse engineering, and we agree that there has never been protection on concepts, so we feel that that is fine.

But the type of copy that we are concerned about is the straight forward photographic copy, where you are just taking a picture and etching off one layer at a time. The reason is that for the $4 million chip in this $80 million program, it would only cost $100,000 to photographically copy the chip.

So, the problem is that you have a pirate who has minimal R&D costs and no market development costs because the market is made for him. The pirate just selects out the specific chip that he thinks is going to be the high-volume runner and copies that chip, and then uses price as his only weapon to sell the chip.

So, I thank you for the time to explain our industry.

Senator MATHIAS. Well, we thank you for a very graphic explanation.

[The following statement was subsequently received for the record:]

PREPARED STATEMENT OF F. THOMAS DUNLAP, JR.

I represent Intel Corporation, a manufacturer of semiconductor chips and the Semiconductor Industry Association (SIA) an industry association comprised of chip manufacturers and users. I appreciate the opportunity to appear before this committee and explain the technology which the Semiconductor Chip Protection Act of 1983 ("the ACT") is intended to protect from piracy.

Chip Technology

The Semiconductor Chip Protection Act of 1983 gives copyright protection against pirates copying semiconductor chips (also known as integrated circuits). These chips are collections of transistors formed on a single structure which work together to perform a particular electronic function. The latest generation of chips on the market today contain upwards of 250,000 transistors which are compacted on a quarter inch square area of a silicon wafer. These chips have more computing power, compute faster, are more reliable, consume far less power, and cost a fraction of the mainframe computers built in the 1970s.

The most advanced semiconductor chips can be broadly classified into two categories: microprocessors and memories. The microprocessor is often referred to as a "computer on a chip" because it has logic circuits capable of electronically performing various information processing functions. It serves as the "brains" of many of todays electronic equipment. A memory, on the other hand, is a semiconductor chip who's function is to simply remember certain data. This data could be the input to the microprocessor. That is, it could be data upon which the microprocessor will operate. It could also be the output of the microprocessor, i.e., data which the microprocessor has already operated on and needs to be saved for future computations. Of course, the functions of a microprocessor and a memory can be integrated on the same semiconductor chip.

A typical use of a semiconductor chip could be to control the flow rate of fuel into a automobile carburetor. The semiconductor chip would be programmed to maintain a particular flow rate. A sensing device would measure the actual flow rate and provide data to the semiconductor chip which would compare the actual flow rate to the desired flow rate. The semiconductor chip would control the opening or closing of a valve to adjust the actual flow rate to make it equal to the desired flow rate. These types of semiconductor chips are used today in various electronic equipment such as automobile fuel and emission control systems, robotics, minicomputers, mainframe computers, calculators, telecommunication equipment, electronic games, medical equipment, wordprocessing equipment and computer aided design/computer aided manufacturing equipment (CAD/CAM), and of course, the personal computer.

Technology

The basic building block of a semiconductor chip is a transistor. A transistor is an electronic device which is capable of amplifying electrical signals and acting as an electrical switch. These transistors are then connected (integrated) to form a particular circuit which performs the electronic function desired by the chip designer. The transistor is fabricated on a material known as a semiconductor. Semiconductors can act as electrical insulators or electrical conductors depending on the electrical state of the semiconductor. Since a transistor can conduct or not conduct, and the properties of the semiconductor can be adjusted by "doping" the semiconductor with certain impurities, it is referred to as a semiconductor.

Production of a Chip

Transistors and chips are formed on a thin semiconductor substrate (typically silicon) which is known as a "wafer". Typically, it is a 5" diameter disk approximately .025 inches thick. Approximately 100-200 chips will be made at one time by processing a wafer. The wafer will be subjected to certain chemical, photographic, and heat treatments. Figure la-le shows a cross section of a typical transistor. The fabrication of a simple transistor would be as follows:

a) Grow a thin oxide over the entire surface of the wafer (see Figure la).

b) Next a thin layer of photoresistive material ("Resist") is deposited on top of the oxide. It will now be necessary to selectively remove certain portions of this resist as well as the underlying oxide so that the silicon surface will be exposed (see Figure lb). This is done by imprinting a pattern on the resist to develop certain areas of the film while leaving other areas undeveloped. The entire wafer is then dipped in a chemical baths and the undeveloped resist and the underlying oxide can be etched away but the developed resist will not be etched away and the underlying oxide will be protected. It is these patterns that allow a layout designer to connect 250,000 transistors in the appropriate manner on a single chip. It is these patterns that the Semiconductor Chip Protection Act of 1983 is intended to protect.

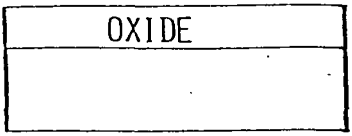

Figure 1.a

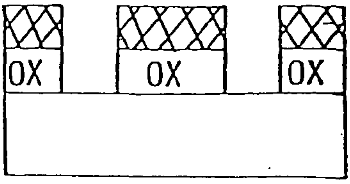

Figure 1.b

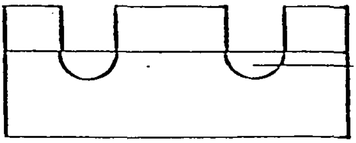

Figure 1.c

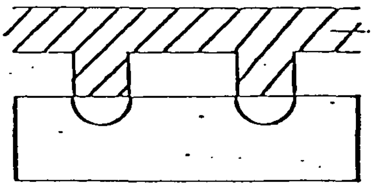

Figure 1.d

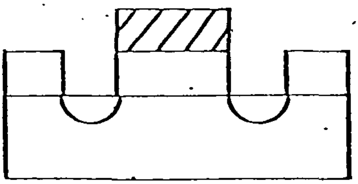

Figure 1.e

Figure 1.

The 3 dimensional set of patterns which appear on the actual chip are called "mask works" in the ACT. When the single patterns (or portions) are embodied in other forms which are necessary to manufacture the chip, they are called "masks" in the ACT.

c) Portions of the silicon substrate are now exposed and certain impurities can be deposited onto the substrate or directly implanted into the substrate (see Figure 1c). These impurities (typically boron, phosphorus or arsenic) will change the properties of the silicon substrate.

d) Now a layer of conducting material such as polysilicon or metal is again deposited over the entire surface of the wafer (see Figure 1d).

e) The polysilicon is then selectively etched away similar to the manner that the oxide was etched away. We are left with a basic metal, oxide semiconductor (MOS) transistor (see Figure 1e).

The actual production of a chip will require many additional iterations of this selective etching process to allow connection between the transistors and to the customers system.

When the wafer is completely processed, it will have 100-200 identical chips which perform the same basic functions on it. Only a fraction of these chips will be functional. A top view of a typical wafer would look as follows:

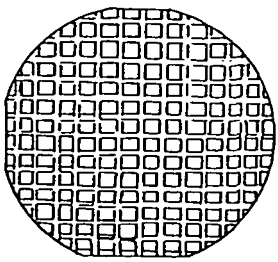

Figure 2.

Each chip is then tested by a computer to determine whether it properly performs the desired electronic functions. If a particular chip is good the tester moves on to the next chip. If a particular chip is bad it drops a spot of ink on the chip indicating that it is to be rejected.

Next, the chips on the wafer are separated from each other. The rejects are thrown away and the good chips are assembled into a package and shipped to the customer. Attachment 1 shows a picture of an unpackaged chip 50 times its actual size and Attachment 2 show a packaged chip which is capable of being used in a customer's system. In this form the chip can now be used in automobiles, computers and the like.

How to Design a Chip

A chip manufacturer must first conduct a marketing study to determine the functions which its customers would like the chip to perform. Once the functions of a chip are defined, it is the job of a circuit design engineer to develop a circuit to implement these electronic functions. The circuit engineer develops the circuit by making a "schematic" representation of the manner in which transistors must be connected to implement the appropriate electronic function. Often 20 sheets of paper will be used to draw the entire schematic of a complex chip. The schematic would be drawn on paper and look as follows:

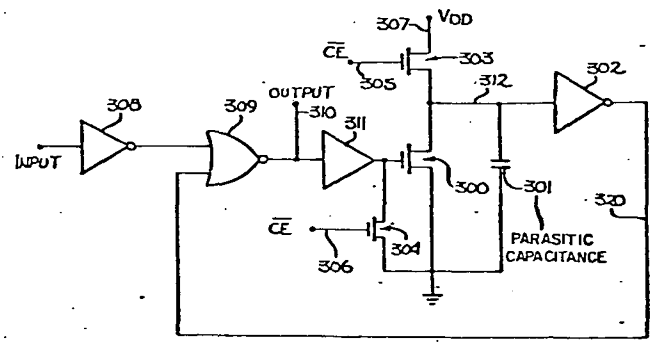

Figure 3.

The patent laws are available for protection of these electronic circuits provided that the circuit meets the useful, novel, and nonobvious requirements for the patent laws.

The circuit schematic is a paper document and is not useful until it is fabricated on a chip. A layout design engineer must take the circuit schematic and layout patterns which can be imprinted onto a wafer to form a chip. This is a very expensive and time consuming process. Typically, this layout will not rise to the level of invention required by the patent laws. The layout must be done in a timely manner so that the final chip can be available in the market place when it was needed. More importantly, the layout must be very compact to minimize the cost of the chip. The smaller the chip, the more chips which can be put on a single wafer and consequently, the better chance that the wafer will yield more good chips. The layout will be retained on a magnetic tape. Attachment 3 shows the 8 patterns used to manufacture a typical chip having 150,000 transistors on it.

Methods of Transferring the Pattern from the Data Base to the Wafer

The original method for transferring these patterns from the tape to the wafer consisted of converting the tape to glass reticles, converting the glass reticles to glass or chrome masks and then using the mask to imprint the pattern on the wafer. The tape is entered into a computer which converts the information on the tape into a glass reticle. A reticle must be made for each pattern which will be printed on the wafer. The reticle is referred to as a "Mask" in the ACT. The actual reticle is typically 10 times the actual size of the chip and has a single chip imprinted on it. The pattern which would appear on a reticle are those shown in Attachment 3.

Next, a working mask is made from the reticle. The ACT includes these objects under the definition of masks. One mask must be made for each pattern. The masks are glass or metal plates and multiple copies of the same chip are contained on the mask. The pattern is now the actual size which must appear on the wafer. The mask are placed in a printer which is basically a camera. The camera prints (i.e., projects light through) the mask and the pattern is then imprinted on the entire wafer. Multiple chips are imprinted at the same time. The set of all patterns successively imprinted is referred to as a "mask work" in the ACT.

The technology for imprinting these patterns has advanced to the point where the generation of the working mask can be eliminated. This can be done by the use of a "stepper" to imprint the pattern on the wafer. This is typically a more expensive manufacturing step but it also more accurate. When a stepper is used, the tape is again used to make a reticle for each pattern. As before, the reticle has a pattern for a single chip on it. The reticle is placed in a printer known as a stepper. The pattern is imprinted on the wafer one chip at a time and then it is "stepped" to the adjacent area of the wafer where another chip is imprinted on the wafer.

The newest technology eliminates the reticle. This is a even more expensive manufacturing process but it is even more accurate. The tape is entered into a direct write machine. The direct write machine writes the pattern directly onto the wafer similar to the way a picture is written on a television screen. The machine then steps to the adjacent area of wafer and writes the pattern for another chip. This is covered in Section 4 of the ACT, specifically Subsection (6)(D).

The Copies Which We Need to Protect

Today, many techniques exist to minimize errors in creating the pattern of the circuits. There are computer aided design programs which assist in comparing the circuit schematic to the layout before it is imprinted on the wafer. Nevertheless, it is very rare that a chip having upwards of 250,000 transistors on it will work the first time. Inevitably, there will be errors in the circuit design, the layout, or the interreaction between the layout, the circuit design and the wafer processing. It is only after numerous iterations at a cost of millions of dollars that the chip is fully functional and can be sold publicly to customers.

The pirates want to obtain a copy of the pattern only after all of these iterations have been completed. In this manner the pirate can minimize his overall cost. The goal of the pirate is to eventually obtain a copy of the pattern in the form of a tape. The pirate can convert the tape to the various different forms of the pattern needed to manufacture the chip.

The pirate's first problem is that these patterns are considered highly valuable property of the company which originally designed the pattern. Consequently, the paper layout, the tape, the reticles and the working masks are carefully protected by the designing company. They are treated as trade secrets within the company and strict security is used to insure that only employees having a good business need for the patterns may obtain access to them. Subcontractors are often used to convert the tape to the reticles and the masks. Again, there is a strict secrecy agreement between the designing company and the subcontractor. Consequently, the pirate cannot easily get access to the pattern in these formats. Other than stealing the pattern, the only practical way that the pirate can get access to the patterns is from the publicly available semiconductor chip itself.

Since the patterns are imprinted on the wafer (the mask work) to form a semiconductor chip, the job of the pirate is to reverse this process. He starts with a publicly available semiconductor chip which has been assembled in a package. He must remove the lid or plastic covering of the package so that he may get access to the actual chip. Now, he makes a careful photograph of the top pattern of the chip. He carefully blows up this photograph of the chip and draws it on paper or on a computer, just like the original layout design engineer did. The difference is that the pirate has a simple mechanical measuring job as opposed to the original trial and error exercise to minimize the layout which the original designing company had to perform.

Once the top layer has been carefully measured and the information preserved on paper or a tape, this top layer is carefully etched away until the next pattern is exposed. Now this pattern is carefully measured and drawn in the same manner. Each pattern is carefully measured and etched off to exposed the next pattern until every pattern of the chip has been copied. The pirate will now have a tape containing the key patterns which can be converted into the various formats which are necessary to manufacture the chip.

A Fair Reverse Engineering

Under current copyright law, a copyrighted biography does not prevent a second writer from writing a biography on the same person. The second writer must use different words in the expression of the second biography. The second biography cannot look like the first but the same information could be conveyed. This is analogous to reverse engineering.

The Semiconductor Chip Protection Act of 1983 is intended to protect the photographic copying of the chip but otherwise allows reverse engineering. There is a marked difference between fair reverse engineering and the chip piracy described above. The act of fair reverse engineering could involve the reproduction of the pattern from the semiconductor chip but would not allow this pattern to be substantially copied for use in the production of a semiconductor chip. Instead, the pattern would be used solely for the purpose of teaching, analysis of the chip or evaluation of the circuit concepts or techniques imbodied in the chip. A reverse engineering firm should be allowed to analyze the chip, draw a circuit schematic of the chip, and then layout a different pattern. This pattern could be used to fabricate a version of the semiconductor chip which is functionally equivalent to the original chip but has different visual patterns on it. The reverse engineering firm could then improve the performance of the chip, reduce the size of the chip and reduce the overall manufacturing cost of the chip. However, this type of cost reduction and performance improvement is also engaged in by the original designing company. Here we have a true cost reduction or advancement in the state of the art.

Economics of Pirating

So far we have been discussing the design and manufacture of a single semiconductor chip. In reality, a complete family of chips are needed so that the customer can develop a complete system. This means a total development would include a main chip, additional chips which are used with the main chip, computers to help the customer develop software to be used with the chip and certain software products to work with the family of chips. The manufacturer most also develop a market for these family of chips. The cost associated with developing this market into a substantial base of customers will often cost nearly as much as the Research and Development Cost. Typical cost of a complete family of chips would be as follows:

Research & Development Cost associated with the main chip approximately	$4M
Research & Development of additional chips, development tools and software	$40M
	$44M
Market Development Cost	$36M
Total Cost	$80M

Even after a complete family of chips are developed, the Research and Development Cost of upgrading the chips and correcting errors in the chips continue. These cost often run in the area of $10M dollars a year for a complete family.

As discussed earlier, it would be perfectly legal for a company to reverse engineer any part of the chips. Although it may cost $80M dollars to develop the complete family of chips and the main chip cost $4M dollars, it will only cost about $1M dollars to reverse engineer the main chip itself. This is something that the industry must accept.

The typical pirate will simply pick the high volume products in the family of chips and make photographic copies of these. He does not have to copy the entire family, only the main chip. A simple photographic copy of the main chip would only cost about $100,000. The pirate has minimal research and development cost and virtually no market development cost. He enters the market after the original company has fully developed the market. The pirate does not have to recover the research and development cost of the entire family of chips and certainly does not have to recover any market development cost. He is simply interested in making a profit above his manufacturing cost of the chips that he copies. The pirate simply uses price as his weapon.

The abilities of these pirates to copy particular chips within the family of chips dramatically reduces the incentive of the original company to continue to invest in research and development activities. In fact, every chip must be evaluated in light of the risk to chip piracy. As a consequence, many innovated ideas for design of new chips must be cast aside because the return on the investment cannot be justified in light of the threat of chip piracy.

Summary

Under the current copyright law it is not clear whether or not the printing of the pattern on the wafer is a copy. It is even less clear whether or not copying the mask work from the physical/useful chip is a copy under the current law. The bill makes it clear that the valuable masks and mask works are protected even though they may not be copies under the principles of current copyright law. It has taken the SIA 4 years to agree on this extention of copyright law to protect chips. It is our belief that this is the only practical method of protecting our valuable patterns.

The Technology to be protected by the Semiconductor Chip Protection Act of 1983 is the expression of the chip in a particular visual pattern. The masks and mask works would be protected from photographic copying. However, the same electronic functions could be implemented in a chip so long as different patterns were used.

Senator MATHIAS. Dr. Layton.

STATEMENT OF CHRISTOPHER K. LAYTON

Dr. LAYTON. Good morning, Mr. Chairman. My name is Christopher Layton. I am vice president of operations for Intersil. Intersil is a subsidiary of General Electric Co. I thank you for the opportunity to testify today before you.

I am testifying on behalf of the Semiconductor Industry Association, which is a trade association of small and large companies throughout the United States—U.S.-based companies. The members include diversified companies like General Electric and companies like Intersil, who are exclusively manufacturers of semiconductor products.

The Association represents 57 member companies, constituting approximately 95 percent of all U.S.-based semiconductor companies. The primary focus of SIA is semiconductor industry problems, and the SIA strongly supports the enactment of S. 1201, as do Intersil and General Electric.

While my testimony today is on behalf of the Semiconductor Industry Association, I would like to draw upon our experiences at Intersil, particularly. Where the previous testimony has perhaps spoken of large, complex circuits of the micro-processor type that you mentioned at the outset, we are by no means limited to problems of copying of large, complex chips. Much simpler chips are also subject to this kind of problem.

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Intersil is headquartered in Cupertino, Calif., in the heart of Silicon Valley. It is a small to medium-sized company and we have about 2,700 employees. We engage in the design, development, manufacture and sale of various integrated circuits, including analog circuits, data acquisition products, digital products, CMOS, bipolar, and large-scale integrated circuits.

Competition is a very healthy, necessary and welcomed part of doing business in this dynamic industry, but I submit that unfair competition in the form of product design piracy is not. Intersil has had direct experience and been a victim of such piracy. I would like to talk about that a little later.

I would like to focus my testimony today on the economics of design and the comparative cost of copying. Intersil is an innovator in chip design, particularly in the field of digital to analog and analog to digital converters. Such circuits translate the real world, which is essentially analog, into digital form for accurate measurement and display.

In the late 1970's, having developed and designed the industry first of an analog to digital circuit, Intersil became the victim of blatant copying of its product family. The designs in question were ones in which both analog and digital circuitry were included on the same chip for the first time in the industry.

I mentioned complexity; such chips contained only approximately 1,200 transistors—relatively simple by today's standards, and relatively simple compared to a large micro-processor of the type we have heard about.

Such devices, however, have many uses and one common use is to drive a multimeter similar to this one here [indicating]. This is a precision instrument utilized by electronics engineers and technicians for measuring voltages, current, et cetera.

The financial impact of having one's design copied can be better understood if the relative investments, not only of dollars but of time and effort by the originator as compared to the copier, are considered.

The previous testimony introduced the steps taken by a chip designer in conceptualizing and designing a new product. Following marketing studies to define the product need, there is an extensive engineering definition and design phase, culminating in the preparation of a composite drawing of the actual chip layout, which we have seen.

The composite drawing consists of all the masking levels, overlaid on one another at high magnification and is a key for the designer, as it permits error checking before committing the design to manufacturing. The originator, as was previously mentioned, goes to many lengths to protect this composite drawing and everything that leads up to it.

The composite may be generated by hand or it may be by means of computer-aided design methods. The latter technique, computer-aided design, is in common use today. It does require a significant investment on the part of the chip originator—typically, $1 million just for the computer-aided design capability.

The composite drawing is, then, a blueprint for the manufacturer of a chip. For a chip of the complexity of the Intersil product which was copied, such a marketing and engineering phase would consume 2 to 3 man-years, and in excess of $300,000. This entire phase, and thus the expense associated with it, is totally avoided by the copier.

Continuing the process towards manufacturing of the chip itself, the next step is to create a computer-generated magnetic tape utilizing the interactive graphic CAD techniques that I have just described, and this tape is used as the source for the actual mask generation.

The actual form of the mask may vary, but it is usually, as was shown, a repetitive array containing multiple images of a single layer—the device similar to the one that was held up earlier and you saw.

Such images are accurate, microscopic, reduced versions of the layers that made up the composite drawing. This procedure would be repeated for each of the layers required to make up the device.

Chip or wafer fabrication follows. The chip is comprised of sequential steps of fabrication, including the application of the mask levels. In finished form, the chip's surface resembles the composite drawing. Thus, the finished product—namely, the chip—contains its own blueprint. I know of very few products in which the product blueprint is indeed a part of the product itself.

Samples of the finished product are then evaluated against the original specifications, and, as is often necessary, design corrections made and the procedure repeated. Only when all the bugs have been eliminated and the product proven reliable is the product made commercially available.

The second phase from the creation of the composite drawing to the final production mask may require further investment of 1 to 2 man-years in addition to what has already been invested, and on the order of $200,000 or more. We are talking about a single product now, not a family.

So, we have a total investment for that single product of the complexity mentioned of $500,000 or more. For a more complex circuit, it could certainly exceed $1 million, and $4 million is not unusual for a complexity of several hundred thousand transistors on a chip.

In the case of the copier, market acceptability has been already established; bugs have been worked out of the design. The design is complete in all respects. All that is required on the part of the copier is a sample of the chip, a 400× magnification capability camera, and a certain amount of patience.

Working from an enlarged photograph such as this one and similar to the one you have behind you, I would estimate that a copy of the complexity of this one here, which is the analog to digital converter, would take no more than 3 to 6 months to complete and an investment of no more than about $30,000. This is less than one-tenth of the originator's cost and investment.

Now, the impact of such copying is many fold, but two stand out in particular. First, the ability to recover the investment made in the development of the new product is sharply reduced, and maybe even eliminated altogether.

Second, and perhaps most important, the motivation for creative design work will tend to be diminished and perhaps even destroyed. What incentive is there for innovation when it can be done cheaper and with less risk by simply copying somebody else's product?

As you mentioned in your opening remarks, the pirate, the copier, gets out there and will flood the market with these low-cost devices based on his copy. Having not had to invest in R&D costs, he can, of course, afford to do that.

Intersil, from it's own experience, is particularly sensitive to the need for expressed definition of the law that would be provided by S. 1201, and its experience illustrates why the semiconductor industry as a whole supports this bill.

In 1982, having experienced the copying of an entire family of its analog to digital circuits, Intersil filed suit under the Federal copyright law. Our case was based on our belief that mask designs and mask works, like other blueprints, are protected by the copyright law.

However, it was clear at the outset of the case that the defendant, a reputable company also located in Silicon Valley, believed with equal conviction that the copyright law did not cover masks and that what they had done was nothing more than permissible and legitimate reverse engineering.

This case, to my knowledge, was among the first, if not the first, of its kind. And while its prosecution through a full trial and appeal would have added definition to the law in this area and perhaps made legislation unnecessary, the costs of litigation, coupled with the very uncertainty of the law, led management of both companies to settle.

It is my belief that had the law been clearer and had it specifically addressed protection for mask designs and mask works of integrated circuits, there would have been no need for litigation, as there would have not been two opposite views of what the law is.

In my opinion, therefore, the Semiconductor Chip Protection Act of 1983 does bring the very certainty to the law that is now lacking.

Senator, that concludes my oral testimony. I appreciate the opportunity of being able to make it here this morning.

Senator MATHIAS. Thank you very much, Dr. Layton.

Let me ask you a general question, and I address it to both of you. Whenever you try to pass an innovative or controversial piece of legislation, the task becomes much more difficult, if not impossible, if the intended beneficiaries of the legislation are not agreed and if they are not certain they want to be benefited. This has been part of the problem in providing some protection to the chip, because the chip industry has been divided in its views on this subject.

Is there a unified position today, and if so what is it?

Mr. DUNLAP. Yes; there certainly is a unified position today. I think that the problem you are referring to in 1978–79 was a broader bill that some companies had a problem with. It would have encompassed too many things.

This bill was the subject of much discussion among the different members of the SIA and they all support it. There are a few comments on wording that might be changed here and there, but we basically determined that a modification of the copyright law in this limited manner to protect the chips would be the best thing for the industry.

Dr. LAYTON. The Semiconductor Industry Association, which is an association of 57 member companies, as I mentioned, is unanimous in its support of this bill at this time.

Senator MATHIAS. I do not know that it is fair to ask you, because anybody who is opposed ought to stand up and say so, but are you aware of any opposition to the bill within the industry?

Mr. DUNLAP. No; except to wording here or there.

Senator MATHIAS. Well, it is clear that we will haggle over semantics probably right to the end.

What is the significance of this industry to the American economy? What is a ballpark kind of figure for the gross on this industry?

Dr. LAYTON. That is a tough one to put figures on. The industry is obviously multibillion industry. The kind of competition that exists within the industry is very healthy. It is a rapidly growing industry; estimates of 20 to 30 percent per year are commonly mentioned.

Mr. DUNLAP. I think we are talking tens of billions when you are talking of the chip and things fairly closely related to it. But, of course, that expands out into the computer industry. You know, our customers are going to depend on additional technology advances, as well as the consumer in personal computers, and so forth. It is a domino effect.

Dr. LAYTON. Yes; the leverage which the industry itself is able to exert as it spreads throughout the economy in microelectronics—you mentioned many of them at the beginning and Mr. Dunlap mentioned some at the beginning of his talk.

Although the industry itself is tens of billions, the domino effect or the leverage throughout the whole economy—we are talking hundreds of billions of dollars. Without the innovation, however, that the chip designer brings to the industry, that could be severely curtailed.

Senator MATHIAS. And if the piracy continues, what would be the impact on growth of the industry in the United States?

Dr. LAYTON. Reduced innovation, and subsequently a reduced growth rate of the industry.

Mr. DUNLAP. For every design we do today, we have to look at our return on investment in light of the pirate, and say what is going to happen to our pricing? Are we going to be able to recover our research and development costs?

If it is a marginal decision, we decide not to do the product because when the pirate comes in and reduces the price, we will not recover our costs. So, we decide just not to spend the money.

Senator MATHIAS. Well, then what you are saying is that this could have the effect of blighting the growth of the industry?

Dr. LAYTON. Yes.

Mr. DUNLAP. If we do not have the protection.

Senator MATHIAS. You mean, the continued piracy, if it cannot be controlled in some way, would discourage growth in the industry.

Mr. DUNLAP. Yes.

Senator MATHIAS. Well, now, you have described and illustrated a specific way in which pirates can copy your designs. Are there other instances of unauthorized copying, or is this the primary method of doing it?

Dr. LAYTON. I believe this is the primary method of doing it, Mr. Chairman. Legitimate reverse engineering, we do not consider as piracy. We do look upon that as product improvement, product enhancement, and perhaps even market enhancement.

Piracy, I believe, in the photographic copying and subsequent translation to a pirate product, is a primary situation.

Senator MATHIAS. At one time, the United States dominated the world semiconductor chip market, is that not true?

Mr. DUNLAP. Yes.

Senator MATHIAS. And, we still account for about two-thirds of world sales, roughly?

Mr. DUNLAP. Yes.

Senator MATHIAS. Parts of the fields—Random Access Memories, for example—have moved to the Japanese market and there is intense and growing competition with the Japanese industry. If there is no copyright protection, what will be the effect on this competiton?

Mr. DUNLAP. Well, the way the Japanese caught up with American industry, really, in the dynamic RAM's, goes back to really what we call the 16K dynamic RAM—16,000 bits of memory.

They basically took an American design and copied it and then produced it cheaper and manufactured it in that manner, and competed very effectively and got a large share of the market.

Everyone knew that after you have 16K worth of bits, the next thing you are going to do is go to 64K, and so you just expand your copy. Again, you just manufacture it better and cheaper and do not worry about research and development. Basically, that is why we lost our dominance in the dynamic RAM area.

Now, in the case of the next generation, the 256K, which again is four times bigger, everyone knows you want to put four times more memory on the chip, but you cannot just expand your copy. It is going to take much more innovation to do that.

Now, it may be that the Japanese do innovation and we would like to copy their 256K RAM. But it is our belief that we can compete effectively with the innovation, and it is very possible that in this next generation we will come out with the leading dynamic RAM.

If we do not have protection against piracy, then the same thing will happen. Some competitor will just copy the thing again, reduce the price, and we will lose our market. But we are willing to take the risk. On the other hand, if they are more successful, we would have to take some kind of license.

Senator MATHIAS. What is the state of the market in Japan? Here, we have Americans pirating American chip designs, and we have international pirates preying on American chip designs. Do Japanese pirates prey on Japanese designs?

Mr. DUNLAP. I am not aware of any cases of that occurring or Americans preying on the Japanese.

Dr. LAYTON. There is less of a tendency, I think, for that to happen because of some of the industry cooperation that exists with the Government in Japan. They have an industry and trade associations there coupled with the Government, which puts them into more of a collective research and development type of mode, with the support of Government.

I think you will see, certainly, a lot of similarity between competitive Japanese chips, but I do not think it is by virtue of the fact of piracy of each other's products.

Senator MATHIAS. That aspect of deregulation has not hit Japan yet?

Dr. LAYTON. Right.

Senator MATHIAS. You make an interesting distinction between reverse engineering and photographic copying. Do you think that the bill that is before the committee would deter copying without interfering with legitimate reverse engineering?

Mr. DUNLAP. Yes. I think that although those terms could be the subject of dispute, I think that if you are taking 1,000 or hundreds of thousands of transistors and you are independently connecting them up, you are not going to come out with a picture that looks the same.

You will take the schematic that I showed and it is going to have 1,000 or 100,000 transistors, and then you will have two people make the drawing. There is no way they are going to come out the same.

If, on the other hand, you copy it and then you just want to use that copy, it will be clear.

Senator MATHIAS. Well, I suppose there must be some gray area between piracy and reverse engineering—situations where you are doing enough of one thing to look like you are doing the other, or perhaps not quite enough of one thing to look like you are not doing the other.

Dr. Layton, do you think S. 1201 provides adequate certainty in this area to prevent any kind of ambiguity or any kind of question on this subject?

Dr. LAYTON. Yes; I believe so. I think it is probably true to say that most reverse engineering begins with the same kind of approach as the straight pirate would take; in other words, taking a competitive product, analyzing it and taking it apart layer by layer.

Generally, the reverse engineering objective is to improve upon the product, perhaps make it a better performing product, a smaller product, and therefore a lower cost to manufacture.

In that effort, a large amount of development work is required. I think there is a distinction between that development activity as opposed to the straight copying where, as I said, all he needs is a camera and a certain amount of patience.

Senator MATHIAS. So, this introduces a subjective element of intent into the whole process.

Mr. DUNLAP. No, not intent. It is subjective to some extent on what a copy is. It is not the intent and it is not the fact that they reverse the layers.

Senator MATHIAS. Yes, but Dr. Layton says you go through pretty much the same process.

Mr. DUNLAP. You go through the photographic process to get to the schematic.

Senator MATHIAS. At that point, the question of what you intend to do becomes important. Do you intend simply to copy it?

Mr. DUNLAP. No. The bare fact of taking the chip and photographing the layer and etching it, and so forth, to draw out this schematic is not prohibited by the bill. You can do that.

The problem is, once you take the pattern off, then do you just make mask and put it right back on silicon? That is what is prohibited. But if you take it off, get the schematic, and then make a different picture, that would be reverse engineering. Is it a different picture?

Maybe I should say it would be like copying a book or in obscenity; you will know it when you see a copy.

Mr. CORWIN. I was going to say the difference is, was anything innovative done in the process or was it simply a reproduction of what was already there? So, you can look at the end result and see, was it a copy or was there something new and different created.

Senator MATHIAS. When I used the word "intent," I was not thinking of it in criminal terms or in terms of making you liable to an attempted piracy. I was just trying to differentiate clearly for the record what the difference between these processes is because this could become a critical issue at some later point in this debate or at some later point when cases are actually spinning out under any law that is enacted.

So, I think we are agreed that you can do the physical acts of copying without any violation of either existing law or of this proposed law. It is what you do thereafter that creates the problem.

Dr. LAYTON. Yes.

Mr. DUNLAP. That is right. In other words, the chip can have the same function; two chips have the exact same function, but they have different pictures. The layout looks different. That would be proper reverse engineering.

STATEMENT OF RICHARD STERN

Mr. STERN. Might I add something, Senator? In both piracy and in reverse engineering, you take the chip apart, you peel off the plastic, you photograph it, you etch away the layers in order to take more photographs. But the question then is what do you do with those photographs?

Both parties do things with the photographs. The legitimate reverse engineer person takes those photographs and he studies them and he takes the concepts out of them, and he makes his own, in effect, stencils or photographic plates with which to make chips.

The pirate just rephotographs those pictures, practically, measures them, and he turns them into stencils. He does not make his own stencils; he does not use the ideas. It would be like if I had a physical object, a plastic toy, and I wanted to make my own plastic toy, I took the original and used it to make the mold. I just plunged it into some plaster of paris, got a hollow space, and then I made my own plastic toys by pouring plastic into that mold.

In a reverse engineering situation, what you do is you measure the product very carefully and you make your own mold; you make your own product on the basis of the ideas and concepts that you have taken out of that.

Senator MATHIAS. I suppose, to make an analogy, if I see a passage in an article that attracts my attention and I photocopy it and incorporate it into my own speech without attribution, then I am guilty of plagiarism.

If I take the article and discuss the theme in my own language, then it becomes a question of how closely I stuck to the original text when determining I am plagiarizing or developing a new view of the same subject matter.

Mr. STERN. Yes; I think that is a very apt analogy, Mr. Chairman, and it also relates the concept of reverse engineering in the context of chip copyright to the ordinary concept of fair use under literary copyright law.

Senator MATHIAS. But, if I only change a few "ifs," "ands," and "buts," but otherwise keep the text intact, then you get to that gray area of what was I really trying to do. Was I taking an easy way to pad my speech by filling it out with somebody else's work, or was I really reworking a new thought into my own script?

Mr. STERN. Precisely, and if you have taken more than a substantial part of the original work and have changed it only in insubstantial ways by changing a few "ifs," "ands," and "buts" and leaving the rest of it there so that the part that you have appropriated is substantially similar to the original, then I do not think it is really a gray area.

I think as long as there is a substantial taking, it is pretty clearly going to be a copyright infringement, talking of literary copyright now. I think the analogy applies very well to a chip or a substantial part of a chip.

Senator MATHIAS. Well, of course, that raises the next question. The bill would make it a copyright infringement to "substantially reproduce" a chip design. Is that adequately defined in S. 1201? Some people have thought it is too general a standard.

Mr. DUNLAP. I think that a definition like that will discourage a majority of the direct copies. There will be certain situations where there is this gray area and that is what will be litigated.

But I think a situation like Dr. Layton talked about where it was clearly a direct copy, the bill will solve that type of problem. There are always going to be gray areas in this type of a bill, but I think it will discourage the blatant ones.

Mr. STERN. Moreover, Mr. Chairman, responding directly to your question, substantially to reproduce requires a closer copy than substantial similarity under the ordinary copyright law. This bill requires things to be closer, not more general; that is, to be an infringer you have to make a closer copy under this act than you do under the ordinary Copyright Act.

Senator MATHIAS. One of the things we have been burned on around here is the advance of new technology. When we passed the 1976 Copyright Act, we thought we had done that work for a generation. We even disbanded the Copyright Subcommittee because we thought it would not have any work to do. I do not want to make that mistake again.

What is the impact of new technology going to be? Suppose you do not have to go through the step of making the mask; suppose you find a method to transmit the design directly to the chip. Then you would have technologically eliminated the object which is afforded protection. What do we do then?

Dr. LAYTON. No. The circuit pattern will always be on the final chip. Whatever means you use to transfer the design to the chip, the chip will always contain that design.

Senator MATHIAS. So, it is the intellectual creation of the pattern that is, in your mind, the object of the protection?

Dr. LAYTON. Yes.

Mr. DUNLAP. It is not the chip itself; the concepts of the chip are fine to be used by other people. It is the mask work that the act talks about, which is those sets of patterns as they appear on the chip. Anyway that you get that pattern on the chip would be covered. In fact, today you do not need to use masks.

Senator MATHIAS. Well, I think this is one of the points we ought to be as sure as it is humanly possible to be that we are not just protecting the mask, but that the protection would extend to other technological means of manufacture.

Mr. DUNLAP. The way that that is done in the act is by the word "use." That whole section on use takes care of that.

Senator MATHIAS. Well, the bill refers to optical, electronic, or other means, but I am not sure that the Copyright Office, for example, will be happy with that and I think that is one point we have to look at rather carefully.

Going way out into the fringes of technology—I have been reading more and more about robots and am intrigued at what robots do. These very complex designs that you have shown us this morning are actually laid out in obedience to certain physical laws that are predictable. Am I right about that?

Dr. LAYTON. Yes, generally so.

Senator MATHIAS. In a general way. I am an English major, so do not presume that I understand very much about this. [Laughter.]

But I presume that we are dealing with reactions to physical laws, and since physical laws can be detected and determined, I would assume that you could program a robot of some kind to do a lot of this work, sooner or later; maybe not in the present state of the art, but someday.

If a robot made a design, would it be the creative work of a human mind and still be entitled to constitutional protection?

Dr. LAYTON. You are getting into the field of intelligence in robots.

Senator MATHIAS. Well, that is where we are getting, to the field of intelligence in robots, and that is going to create a lot of interesting questions. The lawyers will thrive. [Laughter.]

Dr. LAYTON. I am sure they will; yes; I am sure they will.

Senator MATHIAS. I am thinking of going back to it myself if it keeps on in this direction. [Laughter.]

Mr. DUNLAP. I think, generally, we do have what we call computer-aided design; we do have computers help us to do the designs. And if you are really not that concerned about the overall size of the chip, you could take blocks of standard circuits and glue them altogether, basically, and that could be done by a computer.

But the chips that we are talking about—if you can take a thousandth of an inch off of the chip in the size of it, you substantially reduce the cost. There will always be the need to have the human intelligence to shrink the design and to minimize it, so that it is very small.

Senator MATHIAS. Maybe it gets back to the plagiarism analogy as to what the human mind contributes. Is it the "ifs," "ands," and "buts," or is it a substantial part of the process?

I think we really ought to think about whether or not you could robotize yourself out of this protection. I do not know. I am not expressing any view on it; I am just raising the issue because it may be something that could be important down the line.

Of course, then you talk about a part of it, and that comes back to the question that Dr. Layton raised as to whether or not the protection ought to apply to a part; whether the piracy of a substantial part of a mask should not be prohibited as well as the copying of the whole mask.

Is that a good idea? Can you quantify in this way? I am asking a technical question. Can you quantify what is "a substantial part"?

Dr. LAYTON. I think you can break down a chip into its elemental parts. If you look at that photograph behind you, there are many component parts to make up the total. They are interrelated and they are interactive. Nevertheless, they stand alone as a function on a chip, whether it be a memory component or a logic unit within the chip. I think there is clear definition of the component parts within it.

Senator MATHIAS. Well, thank you very much for your presence and your advice and counsel.

Dr. LAYTON. Thank you, sir.

Senator MATHIAS. We will need to have the benefit of your continuing constructive thinking on this subject.

Our next witness is Prof. Arthur Miller of the Harvard Law School.

Professor Miller.

STATEMENT OF ARTHUR R. MILLER, PROFESSOR OF LAW, HARVARD LAW SCHOOL

Professor MILLER. Mr. Chairman, thank you for the opportunity to participate in this dialog. Nothing cheered me more than when you said 5 minutes ago that you were an English major. As a history major, at least I feel there is someone in the room I can communicate with.

Senator MATHIAS. Well, I hope you do not share my abysmal ignorance on these technological subjects.

Professor MILLER. Not only do I share your ignorance; I embrace it. [Laughter.]

I like English the old way. We start with the proposition that no one doubts the need for protection for these mask works. An important American industry is in jeopardy, as the last witnesses just indicated. The conduct the bill would get at is parasitic. Moreover, the values to be protected are worthy of protection, since they are the product of industry creativity and heavy investment.

These works have real merit. Loosely speaking, when I look at that blown-up version of a chip standing in the corner, the only thing that comes to my mind is that that is artistry on a chip, and it seems to me that that is the best way to look at this.

The only issue that seems to be in controversy before this subcommittee at this time is whether copyright is the proper vehicle for protecting these works. And I submit, and my prepared statement explains my reasonings at length, that it is.

When a mask is designed, what is produced is a writing. To be sure, it is not a writing in the literal sense of that word as used by the Founding Fathers when they wrote article I, section 8, clause 8 of the Constitution. But it certainly is a writing in any modern use of that word.

We have an author. I worry, as you just did, about the robot. I always think back about the little monkey or orangutan in the Dick Tracy comic—"little dropout," I think he was called—who used to paint by splattering on a canvas. I occasionally ask my class at Harvard whether or not that monkey is an author within the meaning of the Constitution. We do a lot of sterile exercises at Harvard. [Laughter.]

Senator MATHIAS. Well, I am not sure that that is as sterile as it might be. In Beverly Hills not long ago—of course, anything can happen in Beverly Hills—but they arrested a robot. [Laughter.]

Professor MILLER. I hope the officer read the robot its rights. [Laughter.]

Senator MATHIAS. Well, that is the question that I have been asking. No. 1, did it have any rights? No. 2, were they respected? It was passing out some kind of flyer or ad without a permit for doing so. [Laughter.]

Professor MILLER. If I could somewhat bastardize an old sexist cliche, behind every robot there is a good person. And I think when one explores the issue, as CONTU did, about the automatic production of works, one finds that there is generally human intermediation that precedes the conduct of the robot, or any other computer-based activity for that matter.

Once again, one has to take a somewhat Buck Rogers conception of the words in the constitutional provision, but I think both the words "writing" and "author" are susceptible of the construction that they embrace mask works, even if the formal production of the mask works is machine aided. I think that will be true for many years to come.

Now, what prevents us from moving straight ahead and saying, look, this is a writing, it is of authorship, it has originality, it is fixed—the preconditions to copyright protection as they exist in the constitutional provision in the 1976 act?

Surely, it is not the fact that the work is partially produced mechanically with rays of light and chemicals. We passed that hurdle years and years ago when we recognized the copyright ability of works produced by cameras, tape machines, and computer graphics.

Surely, it is not that the work is microscopic when it is configured and produced, because I suggest to you that no one would argue seriously that microphotography or scrimshaw is not copyrightable, and those art forms are barely visible to the naked eye.

Certainly, it is not that a chip is designed in a strange way and does not fall within traditional representational art forms, because I simply invite you to walk through the Museum of Modern Art or the east wing of the National Gallery and you will see strangely configured works that we all accept are subject to copyright, whether they are by Jackson Pollock or Mondrian or Albers or Calder.

It certainly is not that it is made out of a strange material, because just a few weeks ago, the great artist—and you can put quotation about great, if you wish—Cristo produced a mylar work around some islands in Biscayne Bay, Fla., that I think most people would recognize, despite its glandular size, was copyrightable. Indeed, in a general way of thinking, Cristo's Biscayne Bay shroudings may have been the first mask work copyright.

Surely, it is not that mask works are useful that disenables them from copyright protection. One would hope that every copyrighted work, at least to some degree, and in some instances almost in any degree, is useful. Dictionaries are useful; newspapers are useful. This concern has been around for centuries. I am sure the stationers in merry old England sat around the guild hall one day worrying about navigational charts and whether they were too useful to receive copyright protection.

Well, today, just looking at our environment, we recognize that we are literally bombarded by useful work copyrights, whether they are belt buckles or lunch pails or piggy banks. A nation that awards a 75-year copyright monopoly to an E.T. piggy bank or an E.T. cushion or an E.T. lunch pail, and then gets itself bollixed up in a conceptual debate as to whether a mask work is too utilitarian, has got its priorities fouled up.

There has never been any clear indication in American copyright law as to whether or not an 82-percent utilitarian work or a 94-percent utilitarian work is beyond copyright protection. There is no magic formula, nor should there be. I suggest that there is nothing in the proposed bill that does anything but extend the notion of copyright to new technology, thereby making explicit in now what I think was quite implicit in the legislation of 1976.

There certainly is no constitutional barrier to recognizing copyright in utilitarian works. The only barrier at the moment would be statutory, which would be negotiated by the bill before this subcommittee.

The biggest fear appears to be that by recognizing a copyright in a mask work, somehow Congress would be extending monopoly protection beyond the traditional idea/expression dichotomy; that, somehow, by recognizing the protectability of artistry on a chip, Congress would be creating a patent in copyright clothing.

This was an issue that the Commission on New Technological Uses of Copyrighted Works faced in the late seventies. It is an old chestnut. It is a conceptual problem which, when you scratch at it, tends to disappear.

Nothing in the proposed legislation undercuts section 102(b) of the 1976 statute. Nothing in the proposed legislation gives a monopoly in a chip. Nothing in the proposed legislation prevents anyone from producing their own chips to perform the same automated function as a copyrighted chip. Nothing in the proposed legislation prevents a second comer to a chip from analyzing and dissecting that chip and taking the programing and circuitry ideas embedded in that chip for his or her or its own use.

The only thing that the legislation would do would be to prevent someone from making a substantial reproduction of that mask work—this is traditional infringement concept, an idea that has been part of American copyright law since the beginning.

It is no different than the problem of worrying about whether Battlestar Galactica infringes Star Wars. These are the kinds of copyright questions the Federal courts have been dealing with for 200 years. Most recently the Federal courts, have been dealing with the infringement issue in the context of video games and they are doing a pretty darn good job of figuring out what is an infringement and what is not an infringement.

One thing that was made very, very clear to us on CONTU by a number of witnesses was the fact that the programing art—this technological art—is sufficiently rich so that the recognition of a copyright in the masks of a chip does not in any sense block access by others to the technology, to the process, or to the utilization of that technology.

The final objection to copyright seems to be that the protection afforded by the bill is in the wrong place. Well, mask protection certainly does not belong in the Patent Act. In my statement, I deal with that at length. It is not an invention under existing law. Putting it in the Patent Act would raise havoc with the Patent Act for dozens of different reasons. Moreover, extending patent protection to chip masks would entail a highly costly and bureacratic adminsitrative procedure. And, quite frankly, patent protection is too powerful for mask works; it would represent overkill because patent law blocks independent invention of equivalents, whereas copyright does not.

Trade secrets are wholly inappropriate, for obvious reasons, also explored in my prepared statement. So we are left with the possibility of putting together something that might loosely be called an anti-misappropriations statute for mask works. I suggest to you, Mr. Chairman, a rose by any other name is still copyright protection. As the Copyright Office's statement indicates, any protection legistated in this area would be copyright-like. To worry about its placement in title 17 versus title XX is worrying about a shell game.

The Copyright Act fits; it requires a minimum amount of distortion of that act to embrace mask works. The drafting of the bill before the subcommittee integrates mask works very effectively, although a rational alternative would be to place it all in a new chapter 9 of the statute. But I think that would produce a statute 10 times as long as the bill, and pose much greater drafting problems than the current bill has surmounted. And it would take far more time to draft and enact than I think this industry has at the moment.

There also has been some talk about the recognition in the bill of the concept of use. There is a problem with the word use if you assume that the word is being used synonymously with its patent sense, but it is not.

We add words to the copyright law everytime we change it. The original English statutes talked about copy. We now talk about reproduce, prepare, distribute, perform, display, illustrate, explain, describe, and embody.

I suggest to you that there is no statute of limitations running on the introduction of a new word in the copyright statute. The use of the word use in the bill designed to give a mask work copyright proprietor the ability to get at the end user of an infringing chip. In a sense, it gives that limited copyright proprietor a bit more than the average copyright proprietor would have.

But, of course, the copyright proprietor of a mask work gets a lot less in the first place. The mask work is protected only for 10 years. There is a compulsory liocensing provisions and there is broad protection given for innocent infringement. So, the proposal is a little bit of tit for tat.

What a statute on mask work needs is the ability, as you indicated in your questioning of the preceding group, Mr. Chairman, to make sense given future changes in the technology. To rely on words like copy and reproduce simply would be too risky for the future, because as the prior witnesses have already indicated, the industry already is producing these works in digital form.

So, the use of the word use hardly is letting the genie out of the bottle. Perhaps, with a little drafting clarification, the bill would not appear to be creating patent-like protection. As I indirected earlier, no one is seeking to create a monopoly in the chip.

Finally, there is a question about using both the commerce clause and the constitutional copyright clause: I frankly do not understand this argument. The use of two constitutional clauses to protect a copyrighted work is nothing more than using a belt and suspenders to protect that work.

There is nothing in existing constitutional doctrine that says Congress has no power to rely on two constitutional clauses. The only conceivable problem in relying on two constitutional clauses would be if, for example, the commerce clause were being used to undermine, say, the 1st amendment or the 13th amendment. There obviously is no such problem in using the commerce clause as a buttress to the copyright clause.

There is no notion of constitutional preemption that requires Congress to use one clause and one clause alone, because as we all know, the trademark statutes are premised on the commerce clause.

If one wants to be a purist about this, one might simply reproduce all of the proposed material that is seeking some buttressing support from the commerce clause in a separate provision, preambled by the commerce clause, and have all the traditional copyright in a different section, preambled by the copyright clause. That seems to me to be striking through the substance and getting at the form, and appears to make no sense whatsoever.

Once again, I appreciate this opportunity to appear, Mr. Chairman. I would be pleased to answer any questions.

Senator MATHIAS. Well, I think you make an interesting point that various artistic works are clearly entitled to copyright protection, even though the artistry does not appeal to everyone and even though utilitarian objects are incorporated into an artistic concept.

A case that comes to mind is the headquarters of the Renault Co. in Paris which was formerly presided over by the Ambassador of France in Washington, who is knowledgeable about modern art. In the lobby, there is a great montage of engine blocks, arranged artistically.

Now, engine blocks do not really commend themselves to most people as objects of art, but this is quite remarkable and it is so arranged that it is a work of art. Even an English major can detect that it is a work of art. So, it does illustrate that there are all kinds of concepts that the human mind is capable of creating, and I suppose the fact that they are very individual and very unique and very innovative is all part of the reason that they are ultimately entitled to copyright protection.

Professor MILLER. I entirely agree, I happen to be a great fan of the works of Alexander Calder, and the only possession I have which I prize is a small mobile of his. Nothing was more devastating to me than when a house guest wondered whether the piece had come out of a scrap yard.

But the notion that Calder could not be protected because 98 percent of the American public would not receive intellectual messages from the mobile would seem to me a strange, self-defeating concept of copyright.

Senator MATHIAS. Well, this has nothing to do with our hearing, but if you are a fan of Calder's, you will be interested to know that the U.S. Senate is about to acquire his last work which he designed for the atrium of the Hart Building, and which we, after great soul searching, decided that the American people could not afford.

Former Senator Brady of New Jersey has now taken it upon himself to raise the funds privately to construct the full-scale sculpture which Calder designed as his last work. So, on your next visit, you can revel in a giant Calder.

Professor MILLER. I am delighted to hear that.

Senator MATHIAS. What about the use right? That aspect concerns me somewhat. I think you were very persuasive on the constitutional question, but what about the use question?

Professor MILLER. As drafted, it is intended, as I understand it, only to permit the copyright proprietor to get at the end user of an infringing mask work. There are many, many situations in which these infringing works come in from abroad; there often is no domestic defendant to get at. The end user therefore is really the point of last resort; it is the only place to go after the injury caused by the infringing work.

The reference to use is not intended really, as I understand the design of the drafting, to be anything more than that. I think one would have to admit, however, that it goes a bit further than the notion as it would apply to a book.

Senator MATHIAS. Well, that is right. That is what worries me a little bit. Let us say I buy a pirated book, or, let us start with a copyrighted book. If I buy a copyrighted book, I can do anything with that book. I can read it; I can wrap up dead fish in it; I can use it to start a fire in the fireplace; I can crumple it up and use it as packing in a box. I can do anything at all with it. The copyright holder has absolutely no control over what I do with that book.

Professor MILLER. I think one would have to rely for a justification of this use concept on a combination of the fact that these mask works are unique; they move rapidly. Many of them come in from abroad. Many of them are produced by fly-by-night organizations that are unavailable when you are trying to seek legal redress and you have a very serious pragmatic problem in getting at them.

I think you would also have to reply somewhat on the very unique configuration of the copyright. With a book, we give it 75 years. We have no compulsory licensing; we have no protection for innocent infringers.

The bill puts significant limitations on these mask copyrights. It is only a 10-year copyright. A user can get a compulsory license. A user, if the user is innocent, is, in effect, exonerated.

So, we are really only talking about end users who are not innocent and who, in a sense, refuse to secure a compulsory license. Again, I would have to admit it is an extension over prior doctrine, but I think the shaving down of the size of the copyright provides justification for doing that.

I also think that as far as the industry is concerned, if the commerce clause and the copyright clause are belt and suspenders, this is something like a final rope tied around the waist. If the words "copy" and "reproduce" prove, over time, to be insufficient for protection, the word "use" is there as a final backstop to assure protection.

Senator MATHIAS. What about if I buy a pirated book? I go to my favorite bookstore and see a book on the shelf. I do not know that it did not come out of Random House in New York but was made off of pirated plates in Hong Kong. I can still do all the same things that I did with the copy-righted book.

Professor MILLER. Yes, that is right. But, remember, you are innocent when you buy that book. If you are innocent when you use the infringing mask work, you also have the protection of the legislation before the subcommittee.

It is only the person who is not innocent and who will not get the compulsory license who will be trapped by that use provision.

Senator MATHIAS. Well, I think that is the point that has to be emphasized and clearly understood. The first sale doctrine would apply in any case, right?

Professor MILLER. It would apply in any case, except as somewhat compromised by this provision in the case of a noninnocent, unlicensed, end user.

Senator MATHIAS. Yes, but it would apply so that the buyer could do anything that he wants with a noninfringing chip?

Professor MILLER. Yes.

Senator MATHIAS. That would be clear?

Professor MILLER. Yes. There is a modest alternative to the drafted proposal I might mention, and that is to provide that the ability to get at end users might be thought of literally as a port of last resort when there is no more obvious, more available individual or entity for legal redress.

Senator MATHIAS. You commented on the fact that it is probably inappropriate to seek patent protection. We asked the Commissioner of Patents for his views, and it might be appropriate at this point to submit the response of the Patent Office on that subject.

[The following letters were subsequently received for the record:]

25-554 O - 84 - 7

United States Senate

COMMITTEE ON THE JUDICIARY
WASHINGTON, D.C. 20510

May 16, 1983

The Honorable Donald Quigg
Acting Commissioner
Patent and Trademark Office
Department of Commerce
14th & Constitution Avenue, N. W.
Washington, D. C. 20230

Dear Mr. Quigg:

On May 19, the Subcommittee on Patents, Copyrights and Trademarks will hold a hearing on S. 1201, a bill to provide copyright protection to semiconductor chip design. For your information and review, I enclose a copy of this legislation.

As you will recall, at the oversight hearing on the Patents and Trademark Office, we touched briefly on this subject with Commissioner Mossinghoff, and on the question of whether chip design protection would be more appropriate under the copyright or patent laws. As we proceed to consider the copyright legislation which I recently introduced, I would be most interested to have the benefit of the PTO's considered views on this issue, for inclusion in the hearing record on S. 1201. Accordingly, I would greatly appreciate it if you would submit, within the next three weeks, a written statement on what protection, if any, ought to be accorded to semiconductor chip design under the patent laws. If you have any questions about this request, please contact Steve Metalitz of the subcommittee staff, on 224-5617.

Thank you in advance for your cooperation. I look forward to receiving your statement.

With best wishes,

Sincerely,

Charles McC. Mathias, Jr.

Charles McC. Mathias, Jr.
United States Senator

CM:smk

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

JUN 9 1983

Honorable Charles McC. Mathias, Jr.
Chairman, Subcommittee on Patents, Copyrights
and Trademarks
Committee on the Judiciary
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

This is in response to your inquiry of May 16, 1983, concerning the protection that should be accorded to semiconductor chip designs under the patent laws.

The semiconductor industry is a vital and rapidly growing part of the U.S. economy. The Bureau of Industrial Economics of the Department of Commerce forecasts that in 1983 the industry will ship more than $12.2 billion worth of semiconductor and related devices. This is sharply up from the 1982 estimate of $10.5 billion.

Your hearing on S. 1201 more than adequately demonstrated the importance of and the need for semiconductor chip design protection. Many of the speakers testifying noted the high cost of creating semiconductor chip designs and the ease with which such designs may be taken by chip design pirates. All the persons testifying agreed that increased protection is needed. The problem begs for a remedy. I applaud your efforts to provide a remedy in this area, and I look forward to a speedy and successful conclusion of this exercise.

Our own review of the subject reveals that a copyright-like form of protection seems to be the preferred and most practicable approach. Should future studies result in a proposal for a realistic and effective form of protection in the context of the patent laws, I will certainly inform you and your Committee.

Sincerely,

Donald J. Quigg
Acting Commissioner of Patents
and Trademarks

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
ASSISTANT SECRETARY AND COMMISSIONER
OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

Honorable Charles McC. Mathias, Jr.
Chairman, Subcommittee on Patents,
Copyrights and Trademarks
Committee on the Judiciary
United States Senate
Washington, DC 20510

NOV 22 1983

Dear Mr. Chairman:

I have been following with great interest your efforts to develop an appropriate form of protection for semiconductor chip designs (S. 1201). Being aware of your Subcommittee's unanimous approval of an amended version of S. 1201 on November 15, I wanted to report to you the Administration's position on this important subject, which is fully supportive of the action taken by the Subcommittee.

As you know, the Cabinet Council on Commerce and Trade (CCCT) established a Working Group on Intellectual Property to develop policy options on a number of important intellectual property issues. Recognizing the importance of the semiconductor industry to the U.S. economy, the CCCT directed the Working Group to consider the need to protect semiconductor chip designs. It found that while the United States dominates this important market, it faces a serious challenge from foreign competition. It also found that the R&D costs for a single complex chip could reach $4 million, while the costs of copying such a chip could be less than $100,000. This constitutes a significant disincentive for creators to invest in this technology.

There are no effective legal means of stopping the copying of chips under existing U.S. laws. While a patent would protect against the manufacture, use and sale of the electronic circuitry embodied in a semiconductor chip, the circuits actually placed on chips frequently do not satisfy the patentability requirements of being "new, useful and unobvious."

On the basis of these considerations, the CCCT recommended that the Administration endorse protection for the creators of this valuable technology. Specifically, the CCCT recommended the prompt enactment of legislation protecting semiconductor chip designs and that such legislation have the following characteristics:

(1) It should accord prompt, inexpensive protection to original semiconductor chip designs through a registration system without substantive examination.

(2) The protection should grant to the owner of the chip design the exclusive right to copy, for commercial purposes, the chip design, or chip embodied in that design, as well as the exclusive right to distribute such a chip.

(3) The protection should be relatively short term, e.g., ten years.

(4) As an exception to the exclusive rights, there should be an express right to reverse engineer -- for the purpose of teaching, analyzing or evaluating -- the concepts or techniques embodied in the design of the semiconductor chip.

(5) Unless there are overriding circumstances to the contrary, the protection should be prospective from the current time.

The prompt enactment of legislation along these lines would materially assist U.S. industry by providing protection for this valuable and important new technology. I would be pleased to discuss the recommendations of the CCCT in greater detail with you or your staff and to assist the Subcommittee in any way I can.

Sincerely,

Gerry M.

Gerald J. Mossinghoff
Assistant Secretary and Commissioner
of Patents and Trademarks

Senator MATHIAS. Now, you say that it might be unconstitutional to bring chip design within the patent system because new designs might not qualify as inventions. The general counsel of the Copyright Office, as you heard this morning, expressed a similar fear about whether mask works can qualify as writings, which raises the concern that we are dealing with a subject that might slip between the cracks here.

Do you share the concerns that were expressed about the constitutionality in this regard? If not, how do you differentiate it from an attempt to extend patent protection? In other words, do you see the same kind of difficulty in making the leap from the copyright side as you do from the patent side?

Professor MILLER. I do not see this as a constitutional problem under the writings provision. Rightly or wrongly, we departed from a classic 18th century conception of the word "writing" at the very beginning of our copyright history.

If there was one thing I learned on CONTU from my distinguished co-commissioner, John Hersey, it was the value of the word. However, the minute we departed from the word as the be-all and end-all of copyright, we obviously undertook a dynamic conception of the word "writing" as it is used in article I, section 8, clause 8 of the Constitution; and every judicial interpretation of the writings clause has made that clear.

It just seems to me that there is no rational way of distinguishing that blown-up photograph of a chip from Jackson Pollock or Mondrian or Albers. Indeed, I get more of a kick at looking at that than I get from Albers—which is, after all, just a bunch of boxes.

Senator MATHIAS. You are going to have a lot of art critics in here on me next, wanting to debate that point. [Laughter.]

Professor MILLER. That is perhaps for another set of hearings.

I just simply cannot see conceptually how you can negate the copyright ability of mask works and accept computer programs and accept code books, which are just collections of unintelligible gibberish designed to produce a utilitarian function.

So, I do not see it as a constitutional problem under the word "writings." Moreover, I think patent and copyright are very, very different. The patent monopoly is literally a monopoly that blocks equivalents.

If I invent the light bulb and you are hidden away in your garret also inventing the light bulb, you are blocked by my patent, even though it is independent creation, because you are using my embodied idea. But if I write "Death of a Salesman" and you, in your garret, write "Death of a Salesman," we both have copyrights. The patent monopoly is far stronger, far more preclusive, far more blocking of the technology or the art form than is the copyright monopoly.

Therefore, it is quite rational to take a more constrictive view of what "invention" means than what "writing" means because, as is very clear, people are able to do all sorts of variations on a literary, artistic, or musical theme, whether the theme is star-crossed lovers or whether the theme is the life of a great person.

There is no blockage in the art form by recognizing the copyright, and we can affort to be more generous with our protection for creators.

Senator MATHIAS. The language of this bill includes a provision which states that the copyright in a mask or mask work shall not extend to any other work of authorship embodied therein.

Now, as you heard this morning, there is some concern that the bill may have some effect on the copyright status of software or on other information which is embodied in the structure of the chip. I think that is clearly not the intention, but have we expressed it with sufficient clarity?

Professor MILLER. I think it could be brushed up a wee bit. You certainly do not want to affect, up or down, the copyright status of any work embedded in that chip.

Senator MATHIAS. That should be completely neutral.

Professor MILLER. Absolutely, absolutely. The mask work copyright should not recreate a copyright in Romeo and Juliet because it happens to be the data base implanted on the chip, nor should it destroy a copyright in an otherwise copyrighted work because of some technical malfunction in the copyright on the mask.

The statute should be absolutely neutral on that, and I think that is a very modest drafting problem to make that clear in the bill and to buttress it with a statement in the committee report.

Senator MATHIAS. Well, if you have any ideas on how we could overcome this modest problem, we would be grateful for them.

This committee has had some experience with compulsory licensing in other fields and we know the kind of emotions that it can evoke. The compulsory licensing provisions of S. 1201 are rather general. They refer to the fact that the purchaser would not be entitled to a license unless he has committed substantial funds to the use of the infringing product. He is entitled to pay the copyright owner a reasonable royalty.

Now, given the emotional nature of compulsory licensing, is S. 1201 specific enough?

Professor MILLER. In terms of statutory language, it seems to me that that is probably as specific as you can get. There are a variety of analogs in other statutes. Section 1498 of title 28, the eminent domain provision, uses similar language, and the Patent Act itself uses language concerning reasonable royalties being a damage element. There is a great deal of judicial development under that provision which provides, in effect, a picture for the reader as to what would qualify.

It seems to me that trying to get more fine grained, or certainly trying to put specific dollar or penny amounts into the legislation would be a mistake because the movement of the technology, as you have already indicated, makes provisions that are that rigid terribly obsolete in a very, very short period of time.

I think words like "substantial funds" or "reasonable royalty" are the kinds of words that lawyers, working with corporate people, can plan with, and they are the kinds of words that courts interpret every day. Certainly, lawyers are fully aware of "reasonable" as a concept, since they are dealing with 70 Federal statutes that speak of reasonable attorneys' fees. [Laughter.]

Senator MATHIAS. Of course, beauty is in the eye of the beholder always. [Laughter.]

Attorneys' fees are never reasonable.

Professor MILLER. That is the viewpoint of most clients, I suspect.

Senator MATHIAS. It may also be the view of many lawyers who consider that they are inadequately compensated for their creative labors.

Professor MILLER. In another context, Senator, I refer to the business under the 70 attorney fee provisions in the Federal laws as one of the fastest growing cottage industries in America.

Senator MATHIAS. But in any event, you think that that is not a problem?

Professor MILLER. No; I think the words are obviously not pristine or razor sharp, but any attempt to make them sharper, I think, creates a greater risk than leaving a certain amount of fluidity in there.

Senator MATHIAS. Well, we thank you very much for being with us this morning, and let me invite you to return to see the Senate's last Calder.

Professor MILLER. I congratulate the Senate on its usual good judgment in acquiring that work.

Senator MATHIAS. Well, the congratulations all go to Senator Brady because without him, we would not have it.

Our last witnesses are a panel of Mr. A. G. W. Biddle, the president of the Computer and Communications Industry Association; Oscar Schachter, president of Advanced Computer Techniques, representing the Association of Data Processing Service Organizations; and Jon Baumgarten, representing the Association of American Publishers.

I am advised that Mr. Schachter was unable to be here and that Mr. Palenski will represent him.

STATEMENT OF A PANEL CONSISTING OF A. G. W. BIDDLE, PRESIDENT, COMPUTER AND COMMUNICATIONS INDUSTRY ASSOCIATION; RONALD PALENSKI, ASSOCIATE GENERAL COUNSEL, ASSOCIATION OF DATA PROCESSING SERVICE ORGANIZATIONS; AND JON BAUMGARTEN, COPYRIGHT COUNSEL, ASSOCIATION OF AMERICAN PUBLISHERS, INC., ACCOMPANIED BY CAROL RISHER, DIRECTOR OF COPYRIGHT AND NEW TECHNOLOGY, ASSOCIATION OF AMERICAN PUBLISHERS, INC.

Mr. BIDDLE. Mr. Chairman and members of the subcommittee, my name is Jack Biddle. I am president of the Computer & Communications Industry Association.

Ours is an association of approximately 70 leading-edge firms—manufacturers and providers of computer and communications-related products and services. Together, our member firms generate annual revenues in these products of more than $7 billion, and employ over 125,000 U.S. citizens.

Among them are outstanding firms such as Harris Corporation, Amdahl, Wang, Northern Telecom, Western Digital, Perkin Elmer, and others. Virtually all of our member companies are substantial purchasers and users of semiconductor devices.

As you know, semiconductor technology lies at the heart of our industries' ability to build extremely complex but highly cost-effective information processing and communications equipment

In addition, a number of our member firms are themselves manufacturers of semiconductors; some for their own internal consumption, others for sale to third parties. Consequently, we are very familiar with the subject matter of the legislation before you and the importance of protecting the innovative chip designer and manufacturer from acts of piracy.

If our country is to continue to maintain its position of world leadership in computer and communications technology, we must insure that those who make significant investments of time, money, and creativity earn reasonable returns if their efforts result in commercial success.

It is for this reason that we support amendment of the Copyright Act to provide property right protection for developers of original masks for semiconductor chip fabrication. Clearly, the misappropriation of this property by photographic techniques represents unfair competition in its most blatant form.

We do have one area of concern, however, which leads us to urge the subcommittee to consider adding additional language to the final bill and its legislative history that will make it clear that the revised statute will not inadvertently impair the existing rights of third parties to produce functionally equivalent chips through the design of alternative masks of their own creation.

We raise this issue because the importance of interconnectivity and interoperability of the various systems and subsystems that comprise today's integrated information networks and systems becomes greater every day.

In order for my computer to talk to your word processor or computer, they must be able to speak the same language, as it were. They need a means to establish communication through recognized protocols and procedures to insure that what was transmitted by one was, in fact, accurately received by the other.

Without these standards, the consumer seeking compatability between products and services is virtually forced to procure all elements of the total system from a single full-line vendor who has provided for such compatability between its own products. Often, the logic and circuitry required to achieve this compatability is embodied in one or more semiconductor chips.

We would not wish to see a situation develop where a firm with a dominant market position could block competitive entry or competitor interconnection with its systems or services through the copyright protection afforded by this legislation.

While such a situation would not be common and would, in fact, be inconceivable in the case of chip manufacturers in the merchant marketplace, it is indeed possible in the context of manufacturers who design and fabricate chips exclusively for their own consumption.

For example, future situations may arise in which it is simply impossible to create alternative chip designs which are capable of performing certain interconnection or interoperability functions. If a company with substantial market power were the holder of such copyrighted designs and refused to sell or license the chip required to effectuate interconnection or interoperability, market participation by others would be blocked or severely limited.

We would ask that clarifying language be added to confirm a party's right to reverse engineer a copyrighted chip design, and language or legislative history that makes it clear that should a chip mask embody functions that are essential to interconnection or interoperability of computers or communications equipment or systems, the copyright holder must offer to sell, license others to manufacture, or disclose the specific details of the functions to be performed by the device, or, in the alternative, forfeit the copyright.

With these refinements in the legislation, we can wholeheartedly support its prompt enactment. If the chairman would like, we would be happy to work with members of your staff to try to perfect language to achieve these objectives.

I know that we are perhaps looking down the road a bit. Today, you can talk to many semiconductor engineers and their immediate reaction is, "Well, of course, we can reverse engineer it. We can understand the functions and we can come up with a chip that is not a violation of the copyright and will perform the same thing."

But as chips become more complex and as the functions that are carried out by the chips become increasingly important in providing the bridge between equipment of different manufacturers' origin, then we are particularly concerned that a manufacturer who produces solely for its own consumption would use that power as a monopoly tactic.

STATEMENT OF RONALD PALENSKI

Mr. PALENSKI. Good morning. My name is Ronald Palenski. I am associate general counsel of the Association of Data Processing Service Organizations, a trade association of this Nation's computer services industry.

Our more than 600 corporate members provide the public with a variety of computer products and services, including remote and local processing services; software for mainframe mini- and microcomputers; professional systems design and programing services; and integrated hardware and software systems.

Our industry has in large part been aided and created by the invention of the semiconductor chip. ADAPSO firmly believes that computer technology, whether it relates to hardware, software, or semiconductor chips, ought to be regarded as a vital national resource, and protected as such.

ADAPSO also believes that authors and inventors ought to be given incentives to write and to create, and that those writings and inventions ought not be copied or otherwise misappropriated with impunity.

However, ADAPSO is concerned that, at least as it is currently drafted, S. 1201 may not be the best means of protecting semiconductor chips.

First, ADAPSO shares some of the concerns that were voiced by the Copyright Office in defining the semiconductor chip product as a writing. This is sure to raise certain constitutional questions in the courts. Undoubtedly, it is an issue which, unless the legislative history is very, very carefully written, will be raised time and again in litigation, to the benefit of no one, except perhaps the misappropriators of semiconductor chips.

Additionally, ADAPSO is somwhat concerned about defining a semiconductor chip product as a discovery, thereby creating perhaps an inherent conflict with section 102(b) of the act which expressly excludes ideas, procedures, processes, and discoveries from the ambit of copyright protection.

Again, ADAPSO is somewhat concerned about the extent to which S. 1201 would create certain new rights. Until I came here today, I am not so sure that I fully understood the intent of S. 1201. But now that I have heard how other people are interpreting the words "right to substantially reproduce," "right to embody," and "right to use," I think that ADAPSO is very much in sympathy with the ideas of the proponents of S. 1201.

Finally, ADAPSO would like to endorse a notion that has been proffered here by the Copyright Office and by others that the compulsory license provisions of the proposed section 119—that limited term provisions not extend to computer programs, data bases and other works which may be embodied in semiconductor chips.

In summary, ADAPSO strongly believes that it is important for all to recognize the importance of computer technology to the U.S. economy. ADAPSO agrees with the notion of independent creation and would hope that any legislation would allow for such.

We agree with the concept of legitimate reverse engineering, and we agree that ideas ought not be preëmpted. However, we urge that in the legislative history care be taken that the words of the statute be defined with as much precision as is humanly possible so as to avoid an endless tangle in the courts, which benefits only infringers and, I am afraid to say, their lawyers as well.

Senator MATHIAS. That would not be innovative today.

STATEMENT OF JON BAUMGARTEN

Mr. BAUMGARTEN. Mr. Chairman, I am Jon Baumgarten, copyright counsel to the Association of American Publishers. I am accompanied today by Ms. Carol Risher, director of copyright and new technology for the association.

We would like to ask that our full prepared statement be entered in the record.

Senator MATHIAS. It will be admitted into the record in full.

Mr. BAUMGARTEN. Thank you, sir.

Our association represents a very broad range of publishers, both of conventional books and journals of all types—trade, educational, scientific, technical, medical, and professional—and importantly, and increasingly so, of newer media, including data bases, software and its educational forms, courseware, and computer-assisted learning materials.

We believe that S. 1201 will substantially impact upon the interest of all of our members and we appreciate the opportunity to present our views this morning.

I want to note at the outset that, like other witnesses this morning, the AAP does not question the skill or investment of the design industry or its claim to protection from piracy. More importantly, we do not take issue with the underlying premises of the legislation; namely, that creative investments must be protected from the onslaught of technologically simplified reproduction—in this case, reverse photolithography and computer probing—and that, in the chairman's words, innovative legislation may be appropriate to achieve that goal.

Alone, among all the witnesses you have heard today, it is our industry that has long looked to the copyright law for its lifeblood, has long experienced the ravages of piracy, and has seen its interests eroded by technologically simplified means of reproduction.

We have particularly noted and taken heart at the remarks of the chairman on similar issues in introducing this and other legislation referred to in our statement, and the chairman's further comments this morning.

Our purpose then is not to object to the principles of S. 1201, but to express concern and urge revision of its particular structure and approach.

Our points are essentially twofold. First, as noted in the testimony of the Copyright Office and some other witnesses, we believe that the bill makes such fundamental departures from basic copyright concepts as to call for a separately identifiable, unitary approach to chip protection, rather than piecemeal amendment to the Copyright Act.

Let me make clear, Mr. Chairman, that this does not mean that you cannot use copyright concepts. It does mean that you take the copyright concepts that you want, like independent creativity and originality rather than novelty in patent prosecution, meld them with the aspects of copyright you do not want, and put them together in one place.

I have great respect for Professor Miller, but on behalf of my clients I must take grave exception to one provision of his printed statement. He asserts that our argument is based on the desire for ideological purity in the stature, and that it elevates form over substance. Nothing could be further from the truth.

Our concern is very real; it is one of certainty, precision, predicatability, and of not eroding the rights in our existing works. I can think of no better illustration of this, perhaps, than the question of fair use and reverse engineering.

Mr. Chairman, we came here this morning somewhate concerned about accommodating reverse engineering within fair use. As you will see from our printed statement, it is dealt with in a footnote. We leave here quite troubled and ready to write a treatise on the issue. Let me explain this a bit further.

The remarks of the representative of Intel are, on the surface, not that troubling and are more palatable than some other descriptions of reverse engineering we have heard because it emphasizes the use of nonprotected elements, ideas, and electronic functions.

But what the assertion omits is that a copy has been made in the first place—an entire copy—and it is being used in a manner that will ultimately redound to the detriment of the initial owner of rights in the original chip.

However, our concerns go further. Intel's definition of fair use is not the only definition we have seen. I would like to know whether the "reputable defendant" in the *Intersil* case would agree with the Intel definition. Obviously, they did not agree with Intersil's.

The question, Mr. Chairman, is not so much one of whether there is or is not a gray area. There will always be gray areas in the law. Our concern is that some of the definitions of reverse engineering that we have heard, (going so far as to include making a complete copy, looking at it, and using just a substantial part, but not all of it) simply cannot fit within the doctrine of fair use without a wholesale distortion of its role, its parameters and its contours for all purposes.

Our association and its members face their fair use claims every day of the week. We are frequently a user of fair use. I would not want to litigate a fair-use claim with this kind of legislation history in the background. It totally skews and distorts the doctrine.

I think this issue of reverse engineering is a good illustration of our point, Mr. Chairman. Adopt the copyright concepts that you want—independent creation, originality, permissive registration rather than patent prosecution—but take the other concepts that do not work, spell them out with precision, identify them separately, and put them someplace in unitary fashion.

The only thing, I might add, that offsets the scare that my associate and I have received is that the chairman himself seemed to be sympathetic to our concern in anticipating our objection.

One final note, Mr. Chairman: We have spent a fair amount of time in our prepared statement expressing our concern with the sentence, "Copyright does not extend to other works. . . ." As the chairman points out, that sentence should read somewhere along the lines of: "The limitations on the protection of the chip in no way affect, impair or limit rights in or protection of any other works embodies in the chip."

It is our works—our computer programs, our data bases, and, tomorrow, our books—that are and will be embodied in the chips, and we do not want to be inadvertently limited in our rights by supporting the claim to protection of the chip industry.

Thank you.

[The prepared statement of Mr. Baumgarten follows:]

PREPARED STATEMENT OF JON A. BAUMGARTEN

Mr. Chairman and members of the Subcommittee, I am Jon A. Baumgarten, a member of Paskus, Gordon & Hyman, copyright counsel to the Association of American Publishers, Inc. ("AAP"). I am accompanied by Ms. Carol Risher, Director of Copyright and of New Technology for the Association. The AAP is a trade association representing America's "book and journal" publishers. The phrase "book and journal" appears in quotation marks because, if limited to its conventional paper-and-binding connotation, it does not adequately describe our members' activities. This is particularly the case with respect to the proposed legislation before you this morning. Our members do publish books—fiction and non-fiction trade books, textbooks at all educational levels and related materials, reference works and encyclopedias, self-help and do-it-yourself books, and others—and scientific, technical, medical, scholarly, and professional journals. But they also, and increasingly so, are intimately involved in the creation and publication of new media: computer programs and software of general consumer, business, and other special-market nature; computer-assisted learning materials (including educational and like games and audiovisual works) and "courseware"; and automated data bases. As will be shown below, the provisions of S. 1201 may substantially impact upon the interests of every segment of our membership, and we greatly appreciate the opportunity to appear before you.

Before turning to a more particular description of our interests and views regarding S. 1201, I want to make clear at the outset that the AAP is not questioning the creativity, skill, labor, or investment of chip designers, or their need for and entitlement to appropriate protection from piracy.

Nor do we challenge the twin premises of Senators Mathias and Hart in introducing this legislation—namely, that the proprietary interests of creative entrepreneurs must remain properly safeguarded from technological onslaught, and that innovative legislation may be the appropriate vehicle toward this end. Quite the contrary. The coypright interests of book and journal publishers have been particularly buffeted by indiscriminate application of the new technologies of disseminating and reproducing intellectual products, and we have taken heart at the insight and intentions reflected by your Chairman, and sponsor of S. 1201, in his remarks on like issues.[1] What we do question is the precise nature of the bill currently under consideration, and it is to this that I will now turn.

AAP's interests and concerns with respect to S. 1201 are essentially twofold:

A. AAP urges that the Committee approach chip protection as a severable, unitary measure and not as piecemeal amendments to the basic Copyright Act.

In making this recommendation, AAP supports what has been called the "sui generis" approach to chip protection. We have avoided this description both because it has broader connotations,[2] and in the event it offends those who assert that some copyright concepts—particularly automatic protection based upon independent creation or "originality" rather than patent prosecutions under standards of "novelty"—can and should be applied to these products. Our difference is not with this assertion; if the case can be made for the application of such concepts, Congress might consider doing so. Our concern lies with the obverse—that is, with the fundamental departures from the copyright system that accompany the proposal, e.g., the extension of Copyright Act protection to objects that, it is acknowledged, may not be "writings" under the Constitution (and, for example, the potential impact of this on the evidentiary advantages of copyright registration); the according of an apparent "use" right; the limitations on remedies against infringers and the extension of compulsory licensing; and, most notably, the limitation imposed on the duration of protection of this particular class, and the possible distortion of the fair use doctrine to accommodate reverse engineering.[3]

Our concern is not born out of a desire for ideologically "pure" copyright law, nor—as noted above—aversion to innovative legislation. It lies, instead, with the blurring or distortion of principles and the establishment of precedents that may have untoward and unintended consequences for copyright protection of our works, and those of other copyright proprietors.

In sum, S. 1201 and H.R. 1028, and their accompanying introductory statements in both Houses, would effect such basic modifications in copyright law that a unified approach to chip protection, identified as separate from the general Copyright Act itself, is called for.[4] We submit that the price to be paid in additional draftsmanship will be well worth the resulting greater cogency and precision.

B. AAP urges that the limitations on chip protection be expressly made inapplicable to other works fixed, represented, or embodied therein.

From the viewpoint of our industry, semiconductor chips and their associated products are essentially vehicles for the dissemination and efficient use of our works. Clearly, our software programs, data bases, and audiovisual works (as repre-

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[1] E.g., Congressional Record, May 4, 1983, at S. 5991 et seq. (S. 1201), Jan. 26, 1983, at S. 254 et seq. (S. 31, 32 and 33), Dec. 16, 1981, at S. 15723 et seq. (Am. No. 1333 to S. 1758).

[2] It is sometimes urged that "sui generis" protection be accorded, in lieu of copyright as such, to software. The AAP does not agree with this contention, and considers it distinguishable from the issue of chip protection. The Copyright Act generally appears to be operating acceptably for software protection and no basic departures from copyright precepts yet appear necessary. Indeed, part of our concern with S. 1201 is that it may inadvertently weaken software protection. See ¶ B., below.

[3] The discussion of "fair use" and "reverse engineering" at p. H645 of the Congressional Record of Feb. 24, 1983 (referred to in Senator Mathias' statement introducing S. 1201), is not entirely clear. For example, the fact that otherwise infringing activity may involve "teaching, analysis, or study," whether in an educational or business environment, cannot itself lead to a conclusion of fair use. E.g., *Wihtol* v. *Crow,* 309 F. 2d 777 (8th Cir. 1962). This appears to be recognized by Senator Mathias (Congressional Record., May 4, 1983, at S. 5992, referring to pirates "study[ing] the design"). And the House memorandum (p. H645) itself blurs the distinction between "fair use" and the mere adoption of ideas (see, e.g., 3 Nimmer, Copyright § 13.05 at 13-55), and reverse engineering. Additionally, it has been questioned whether the kind of "reverse engineering" intended to be privileged by the bill can fall within the general doctrine of fair use without distorting its role and contours. See. e.g., "Copyright Protection for Imprinted Design Patterns on Semiconductor Chips," hearings before the Subcommittee on Courts, Civil Liberties and the Administration of Justice of the House Committee on the Judiciary, 96th Congress, 1st session, Apr. 16, 1979, at 21, 54, 61.

[4] We note that a similar approach is taken in the recent introduction in the House of Representatives of H.R. 2985 on May 11, 1983. This measure, providing for the protection of designs, is a particularly applicable precedent. And we do not think the proponents of chip protection need become hostage or subject to the fortunes of that bill. There is no reason why protection for designs cannot start with (or even be limited to) chips. The principle of unified, separately identifiable legislation is the important point.

sented, for example, in instructional "games") will be—and in some cases already are—marketed in "chip form" for use in connection with business, home, and school computers and micro-processor based devices. And it would be mistaken and short-sighted to assume that this will not be the case with respect to the content of our books and journals. Thus, Townsend Hoopes, President of the Association, has described the forthcoming world of "books-on-a-chip" as follows:[5]

"Some computer scientists believe that computer technology, particularly the microcomputer, which today can compress information by ten thousandfold, will give us entire books printed on a single silicon chip by the late 1980s. Later it may be possible to store a whole library in about the same space now occupied by a paperback novel. According to this theory, books will be produced on silicon chips and mailed by the dozen in small envelopes direct to the reader. The reader will insert the chip into a reader-terminal, which may for aesthetic reasons resemble a traditional book, with leather covers and gold clasps. The terminal will translate the binary code into English, with adjustable print size, and the reader will take it from there."

Others have made similar forecasts.[6] There is no reason to believe that these hypotheses are too remote for contemporary Congressional consideration. Dr. Elie Shneour, in an essay entitled "A Look Into the Book of the Future" (Publishers Weekly, January 21, 1983 at 48) recently stated:

"The sociologist Wilbur Schramm has recently pointed out that it took not less than 5 million years for evolving humankind to go from the primitive elements of a spoken language to the written word. From the written word of the tablets and scrolls to movable-type printing required another 5000 years. From Gutenberg's Bible to television, less than 500 years proved necessary. It has been less than 50 years since the first electronic computer was devised. Each major advance in information handling has taken one order of magnitude less time than the preceding one. On that basis, may we expect the book of the future to be evolving before the end of this decade?"

We understand that both the protection accorded under S. 1201 and the limitations thereon—for example, the "compulsory license" of proposed § 119; the limited term of protection under proposed 302(f); and the provision for "innocent infringers" in proposed § 501(e)—are directed towards the creation and authorized use of chip architecture, topography, configuration or the like, but not toward software, data bases, or other literary or audiovisual works that may be fixed, represented, or embodied therein. We believe that it is imperative that this principle be expressed in any chip legislation moving forward from this hearing. Df., e.g., 17 U.S.C. 114(c) (limitation of rights in sound recordings "does not limit or impair" the right to control public performance of music in the same phonorecord). We would be pleased to work with committee staff in developing appropriate language.[7] In the absence of such an express reservation, particularly in light of the complex issues that will be brought before the courts under any chip legislation enacted, we fear that the Congress may, erroneously, be found to have limited the rights of publishers and those of authors in their creative endeavors by happenstance of the vehicle chosen for dissemination. Indeed, even the risk of such a result could dampen the ability or willingness of our industry to use or license chip distribution—a result that would be far from the interests of the bill's sponsors, proponents, and the public.

Thank you for the opportunity to present these views.

Senator MATHIAS. Well, just so that it is abundantly clear on the record, do I understand that you feel that some kind of protection is necessary and appropriate?

Mr. BAUMGARTEN. I think that is the position of all witnesses.

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[5] Remarks of Townsend Hoopes, President, AAP, before the NYU Workshop on Book Publishing: The Electronic Revolution and the Future of the Book, Jan. 22, 1982.

[6] E.g., Evans, "The Micro Millenium" 115–117 (1979); U.S. News & World Report, May 9, 1983, at A-8.

[7] Sec. 2 of S. 1201 does state that the "copyright in a mask or mask work shall not extend to any other work of authorship embodied therein." The genesis of this sentence, which does not appear in the related House bill (H.R. 1028) is not entirely clear to us; but, in any event, it does not make the point that we consider so important: that the limitations and restrictions of the protection of masks, mask works, and chips do not apply to, impair, prejudice, or in any way affect other works embodied therein. That both the "non-extension" and "non-limitation" principles can be expressed is seen in section 103(b) of the current Act, which suggests the equally appropriate provision that protection of the mask, mask work or chip "does not imply any exclusive right" in the other works embodied therein.

Mr. PALENSKI. Yes.

Senator MATHIAS. Well, then the record will reflect that there is an affirmative from all of us, and that we agree that some kind of protection is necessary.

Certainly, the purpose of the whole hearing process is to make sure that all the alternatives are considered, and I appreciate the fact that you have made some positive suggestions as to the kind of alternative language that ought to be considered. Very often, those who oppose legislation are silent as to what else can be done, but we may need your further advice and counsel on the specific points that you have mentioned.

What about the constitutional question that has been discussed at some length here this morning? Mr. Baumgarten, you say you think it is appropriate to use the copyright clause, but you would do it differently.

Mr. BAUMGARTEN. I believe I said, Mr. Chairman, it is appropriate to use some copyright concepts. For example, copyright protection is automatic and based on originality rather than the patent concept of a grant of patent after a lengthy and costly prosecution; and the copyright principle might form the basis of chip protection.

I would agree with Professor Miller that it is semantics to say whether that is copyright or not copyright. It is a concept of the copyright law.

I have not studied the constitutional issue. I would tend toward the view that it would be permissible for Congress to meld different portions of different parts of the Constitution and provide a form of protection that is sorely needed by that industry.

Our point to the chip industry is: Do not be so parochial in doing so that you totally ignore our rights and, in the rush to get quick passage, ignore the fact that this committee is fully capable of drafting a more extensive and precise provision to deal with chip protection.

Senator MATHIAS. Do any of you want to comment on that point?

Mr. PALENSKI. I think that ADAPSO would agree with that statement as well. Our concern arises principally from the whole series of litigations that have come about since the 1980 amendments which implemented the CONTU recommendations.

Even though Commissioner Hersey's dissent was a dissent, it keeps coming up time and time and time again, most recently in the *Apple* v. *Franklin* case.

Senator MATHIAS. What about the patent protection aspect? You say that there are some analogies here which seem to be closer to patent protection than to copyright protection.

Mr. BAUMGARTEN. I did not mean to imply that, sir. What I said was it seemed to me that the industry was claiming, and perhaps justifiably so, although that is your decision and not mine, that it would be easier and more fruitful to protect their efforts by copyright concepts. You do not have to register; it is quick and not expensive.

Senator MATHIAS. You do not wait as long to get the protection?

Mr. BAUMGARTEN. Yes, and I have no quarrel with that. It is a claim other industries have made, some successfully and some nonsuccessfully. The sound recording industry was successful; the type face design industry was unsuccessful. That is a decision that I think, with your leadership, this committee is fully competent to make.

Senator MATHIAS. Mr. Biddle?

Mr. BIDDLE. I think there is a clearer distinction beteen the copyright protection and the patent protection. As we have heard from all the witnesses this morning, the copyright protection is intended to prevent a pirate from making a direct photocopy of a substantial investment, and thereby bypassing that investment.

If you were to patent what we see up there on the wall, I think there would be an untold amount of litigation trying to establish whether anybody had, in fact, come up with a sufficiently different way of doing that to qualify as a patent holder.

I think that would retard innovation in the industry, and I think that is what our witnesses from the semiconductor industry were saying this morning. It is not their desire to retard innovation in the industry; it is merely to protect a substantial investment.

I am not a lawyer, but one of the famous cases of the book industry was where a publisher had invested heavily in setting authentic lead type, creating a fine piece of published art. And a pirate came along and, using photolithography techniques, instantaneously was able to produce a copy far cheaper than the original.

The courts clearly held that this was gross misappropriation of someone else's rights, and I think that is what the semiconductor industry is looking for. We in the consuming end of the industry are comfortable with that, particularly with the provision in the bill that says if we are the inadvertent victims of a pirate, we will not sustain substantial loss in having inadvertently incorporated a pirate chip into a product, which can be exceedingly costly in its own right.

But we would be very upset, I think, if you extended this to the patent concept.

Mr. PALENSKI. Again, I believe it is the term "use" in the statute that is creating some of the concerns.

Senator MATHIAS. Do you have any suggestion as to an alternative?

Mr. PALENSKI. No, but I would be very happy to work on it.

Senator MATHIAS. Well, we would appreciate your thoughts after you have had a chance to consider it.

Mr. Baumgarten used a phrase that I wanted to ask him about—what do you mean by a severable unitary measure?

Mr. BAUMGARTEN. I did that quite consciously, Mr. Chairman. I did not want to use the term "sui generis" for two reasons. One, it is a broad term that has been bandied about in a lot of contexts.

Our association represents software pubishers. The term "sui generis" has sometimes been urged as the way to protect software. We do not agree. We think the Copyright Act, without any modification, is fully capable of handling software.

So, I tried to avoid sui generis to avoid being accused of saying something broader than I intended. The second reason was that sui generis sometimes implies that it is totally on its own, whereas I—and I think every witness before you—you are in a very enviable position; there is no apparent opposition to this bill, in principle—have conceded that some copyright precepts may well be adaptable. There is no magic behind the phrase I chose. It was an attempt to find a phrase other than sui generis because of the connotations that term has come to acquire.

Senator MATHIAS. Does the term concern any of you?

Mr. BAUMGARTEN. It concerns us, Mr. Chairman. We are not particularly happy about the notion of a 10-year term being incorporated into the Copyright Act. I accept Professor Miller's references to the E.T. doll for what they are, but I do not think we should start making judgments on a per-work basis or on a per-class basis in terms of duration of protection.

I am very concerned, as are our members, about the precedential impact of an integral portion of the organic Copyright Act picking and choosing among the terms of protection for different works. To be quite frank we represent producers of scientific literature. I would not like to see a movement for a limited term of copyright on those works, and I would not like to set a precedent for it.

Senator MATHIAS. I appreciate the fact that several of you have noticed that we are trying to distinguish between protection for the chip and for the work embodied in the chip. We may not have been totally successful in that, but we are, I think, in general agreement on what we are trying to do.

We appreciate any advice you can give us as to an improvement in that language to clarify it further.

Mr. BAUMGARTEN. Mr. Chairman, in my statement I think you will find references to two other sections of the Copyright Act where similar concepts are already embodied—sections 114(c) and 103(b). If you merge those together and pick up a little additional thought, like considering the limited use of the word copies in this bill, I do not think there will be a problem at all.

Senator MATHIAS. Well, I think this is more and more important as events unfold, and they do unfold very rapidly. I assume that the Western Electric announcement that it is soon going to have on the market a chip with four times as much capacity as any previous commercially available memory brings us closer to the day when you can actually have a book on a chip.

Mr. BIDDLE. If Western Electric chooses to sell that chip to anybody who wants to put a book on it. That is highly unlikely.

Mr. BAUMGARTEN. Or if the proprietor of the book chooses to license anybody who has the chip. It works both ways, and one of our fears is that if the statute is not clarified, we will be inhibited in licensing.

Senator MATHIAS. Well, now is the time to try to make it clear, and that is the intention of the committee, I am sure.

Mr. Biddle, are you suggesting that no book would be worth putting on a chip?

Mr. BIDDLE. No, Senator. I am concerned that when Intel, Intersil, or one of the merchant semiconductor manufacturers comes up with a chip, it is their desire to sell that to as many potential users as possible. That is where their profit lies.

But we do have some chip manufacturers in this country, and I am speaking specifically of Western Electric and IBM—who historically have refused to sell any of their own chips outside. When you have firms of that size who have de facto standard-setting ability in an industry, and the ability to protect a chip that they will not sell or license, then you have potential barriers to entry and interconnection which are of quite some concern to us.

We would certainly not like to have the Judiciary Committee contribute to a further monopoly situation.

Senator MATHIAS. I do not think that the Judiciary Committee wants to be an accessory to that. That is why it is useful to have your views here now.

Now, you have suggested that it may distort the fair use doctrine to bring reverse engineering within its scope. What is your view? Do you think that reverse engineering ought to be considered an infringement of the designer's rights, whether those are copyrighted or otherwise protected?

Mr. BAUMGARTEN. I will leave that to the expertise of the industry. If they are willing to eliminate something that they call reverse engineering from the ambit of their exclusive rights, that is their prerogative.

My concern is that, depending upon how you define reverse engineering, you may not mean what we conventionally think of as fair use. I know one very jaundiced view, and that is that if the Russians do it, it is piracy; if the Japanese do it, it is unfair competition; if an American does it, it is reverse engineering. [Laughter.]

I do not think you have to be that skeptical. I think there is a legitimate area of uncertainty my problem is that if some of the explanations of reverse engineering this morning are forced into the concept of fair use, it may have destroyed my rights to make derivative works and translations of my books, because people study my books, they analyze the sentence structure, and they improve on it by coming out with a new version.

I am sure that is not what these gentlemen meant, but I am equally becoming sure that it would be preferable for Congress to spend a little bit of time—and I am sure it is capable of doing it, with the assistance of the Copyright Office, the proponents of the bill and our association, if necessary—to say what is meant and not try to twist and distort fair use to accommodate that result.

Senator MATHIAS. By that, do you mean you would prefer to see a specific reservation?

Mr. BAUMGARTEN. A reservation or a definition of reverse engineering, whatever one would call it. This is part and parcel of our first point, namely that is there are enough special provisions, special reservations, and other special provisions on this bill to warrant tying them all up rather than attempting to squeeze them into little cubby holes where you think they might apply in the Copyright Act.

It is not a question of title 17 or title 18. It is a question of cogency, precision, and meaning.

Senator MATHIAS. Well, you have said, at least some of you, that the hearings this morning have given you a more comprehensive view of the subject. I am grateful for that; I sometimes sit here for many hours and feel we do not move the subject an inch.

I would agree that it has been a useful hearing today, and I am particulary grateful to all of the witnesses who have appeared. I think it has been informative and has suggested some new concepts that ought to be considered and perhaps incorporated into the bill.

As far as I can see, we have had all points of view exposed to scrutiny. There are several witnesses, some of them representing organizations and companies, who have asked to submit testimony in writing, and I want to give them the chance to do that so we can have the fullest kind of expression of opinion on the subject.

Some of the members of the committee who were not able to be here may have questions as a result of today's hearings. So, to give time for members to formulate questions and witnesses to respond and to give a chance for those who want to submit written statements to do so, I will hold the record open for 20 days for the submission of this additional material.

Once, again, thank you all very much for being here. The Committee stands in recess subject to the call of the Chair.

[Whereupon, at 12:32 p.m., the subcommittee was adjourned.]

APPENDIX

Additional Statements for the Record

STATEMENT OF NEC ELECTRONICS U.S.A., INC.

NEC Electronics U.S.A. Inc. ("NEC Electronics") appreciates this opportunity to comment on S. 1201, a bill to bring semiconductor chip products and the underlying mask works within the protection of the copyright laws. As a manufacturer and marketer of integrated circuits, we welcome the effort to protect innovation and to bring certainty into this area.

Although NEC Electronics is a wholly-owned United States subsidiary of NEC Corporation, a multinational enterprise based in Japan, we consider ourselves to be an American company competing in this market against other American companies. We are headquartered in Mountain View, California where we have a plant which manufactures semiconductor chips and employs approximately 500 persons. We are currently building an additional plant in Roseville, California, the first phase of which will be completed in early 1984 at an estimated cost of $100 Million and will employ approximately 600 persons. We estimate that the total plant will be fully completed in the early 1990's at a total construction cost of approximately $300-$400 Million and will employ 1500 persons. The Roseville facility will manufacture completely (from wafer fabrication through assembly and test) very large-scale integrated circuits.

As a member of the Semiconductor Industry Association, we generally support legislation to create copyright protection for semiconductor chips because we believe that greater certainty in the area of proprietary rights will benefit the industry as a whole. Furthermore, in light of the tremendous commitment to research and development that will be necessary in order to continue the advance of semiconductor technology, we feel that legislation to protect future innovation is appropriate.

Like everyone else concerned with this bill, we believe that the twin goals of certainty and encouragement of innovation can be achieved only if legitimate reverse engineering is permitted. Existing "fair use" provisions of Section 107 of the Copyright Law may not be sufficient, however, as they tend to emphasize non-commercial purposes. The purpose of much reverse engineering activity is clearly to maintain a commercial position in a highly competitive industry. It should be established beyond doubt that such practices, which are generally accepted in the industry as legitimate, are not intended to be prohibited by the bill. Attached as an Exhibit is language that we suggest could be added to the bill to clarify the status of reverse engineering.

Even with the proposed language, there may be occasions where the permissible scope of reverse engineering activity is unclear. However, we feel that the advantages of establishing proprietary rights in this area outweigh the risks (albeit genuine) of litigation over the scope of permissible activities, so long as the principle is clearly established that reverse engineering will be permitted.

More importantly, while desirous of legislation in this area, we wish to call to your attention the danger that this bill could be applied retroactively. Such retroactive application could penalize manufacturers for conduct wholly lawful when undertaken. In addition, it is inconsistent with the traditional congressional practice in bringing new subject matter or rights within the copyright laws, which reflects a fundamental policy against "recapturing" works from the public domain.

The provisions of Section 9 of S. 1201 exclude semiconductor chip products and masks previously manufactured in the United States from retroactive application. Of course, many United States-based companies also manufacture their products outside the United States. A United States manufacturer may continue using masks that were created prior to the effective date of the legislation; a foreign manufacturer, however, could not continue to use its masks from the same time period if those masks were subject to an infringement action.

Senator Mathias has indicated that this bill is not intended to be protectionist. Moreover, we have been told by various Congressmen and their staffs that this bill is not to be in any sense retroactive. We respectfully submit that making the bill retroactive or singling out non-United States manufactured products for harsher treatment under the bill is inconsistent with these intentions.

We understand that additional language may be suggested to ameliorate this problem. We would be happy to cooperate with the Subcommittee on this point.

Once again, we are grateful for this opportunity to express our views.

Respectfully,

Robert C. Hinckley
General Counsel

EXHIBIT

New Section 5 to S. 1201; other Sections to be renumbered accordingly:

"SEC. 5. Section 107 of title 17 of the United States Code is amended by adding at the end thereof the following:

> 'In the case of mask works, any use constituting reverse engineering shall be deemed to be a fair use. For purposes of the preceding sentence, reverse engineering shall mean the reproduction of the pattern on a mask solely for the purpose of teaching, analysis or evaluation or the use of the concepts or techniques embodied in the mask or chip, such as the circuit schematic or organization of components.'"

Statement of the Patent Task Force
The United States Activities Board (USAB)
The Institute of Electrical and Electronics Engineers, Inc. (IEEE)

The IEEE is the world's largest professional, technical society with over 230,000 members worldwide. IEEE members perform semiconductor research, design and fabricate the semiconductor devices and electronic products that have made semiconductor technology a national wealth. The concerns of the semiconductor industry are our own. In this context, we welcome the opportunity to comment on S.1201, the Semiconductor Chip Protection Act of 1983.

The IEEE/USAB considers the issues exemplified by this bill to be of such importance as to maintain a full time volunteer committee. The Patent Task Force consists of approximately two dozen professionals drawn from the technical arts, business, and the field of intellectual property law. As Chairman of the Task Force, I have placed S.1201 before the members and obtained their concensus.

The Patent Task Force of the IEEE endorses the concept of legislation to prevent chip piracy. The problem is real, and present law is insufficient to deal with the problem. However, the concensus of the committee is that we have reservations about S.1201 that we wish to share.

To understand our reservations, it is helpful to restate the problems that generated the bill. We see the problem evidenced when a manufacturer who introduces new and commercially important integrated circuits soon finds inexpensive copies undercutting profit margins. Completely aside from whether the copies are pirate, the effect is to deny the original producer a reasonable return on the investment in the new chip. In turn, this stifles investment in new products and affects the viability of the industry. This is a legitimate national concern suitable for Congressional intervention.

Designing legislation adequate to the task is no small thing. It requires differentiating piracy from legitimate competition, and weighing protection against the realities of the free market. The many clauses, penalties, definitions, and conditions of such a law are a formidable challenge to create. Thus, it is not surprising that modification of existing law is proposed as a sufficient, expeditious approach. Certainly, the problems of a specific industry should not require the wholesale invention of new types of protection. And only the most ardent bureaucrat would propose creation of a new government agency!

Copyright law enjoys a universal, if uneven, recognition among industrial nations. Its protection is swift, existing from the moment of creation of an original work. It is also inexpensive, as the fees are modest and searches of prior art are not required. If copyright law could be adapted to electronic semiconductor products, than an existing wealth of registration and enforcement machinery could be brought to bear.

The approach of the bill is to copyright the masks used in semiconductor fabrication. Of course, the industry is not complaining about a mask problem: it isn't cheap masks that are flooding the market. Masks are targeted because they are seen as necessary tools for making semiconductors. Therefore, if masks are controlled, then presumably semiconductor piracy will also be controlled. This is a reasonable approach to take. It is being used succesfully in other situations, such as the control of photolithographic presses to prevent counterfeiting of paper currency.

Copyright law is not necessarily congruent with the needs of electronic semiconductors. All adaptations are a matter of degree. S.1201 deals with masks because they represent a closest fit to the statute. Even so, merely defining "masks" and "mask works" and appending "mask works" to the list of things covered is not sufficient. S.1201 proposes to add some novel features to copyright law to improve the fit of law to the object.

Our reservations about the bill do not question the economy of the approach. They revolve around specific features in the relationship between masks, semiconductors, and copyright. In a number of instances, the fit appears forced. We believe they may be fatal to the intent behind the bill.

Mask works are the best target for use of copyright, but they bring their own special set of problems. For instance, some circuits are so fundamental that essentially one variation serves the entire industry. An outstanding example is the single transistor dynamic memory cell. Copyright does not protect function, of course, so there is no danger of a manufacturer protecting an actual circuit based on copyright registration of a mask set.

However, a mask is necessarily determined by the circuitry. Any engineer with the requisite skill, working with a given circuit, will tend to converge on a single most reasonable mask layout. This is compounded by requirements to use popular "pinout" or connection arrangements, which impose another degree of similarity, and by the purchase of similar design and processing equipment from the limited pool of vendors. So as a practical matter, integrated circuit designers tend to produce similar masks for similar circuit requirements. The laws of physics do not allow the wide open possibilities as those in writing a novel. There is obvious potential for attempts at protecting actual circuitry by means of registering an optimal mask. The works of others will almost certainly appear derivative.

Copyright law applies to some aspects of this problem but not to other aspects. Generic expressions are not protected, and manufacturers could not protect generic portions of mask layouts using copyright registration. To the extent that this allows original design to flourish unhampered by unavoidable similarities, it is a key virtue of copyright. To the extent that it allows outright appropriation of mask design, as commonly practiced in semiconductor piracy, it represents a significant failure of protection. It is not copyright law that has failed, rather, it is the fit of copyright law to semiconductors.

Not all semiconductors suffer from this genericness. Microprocessors and related supporting devices are quite unique works, for the resources required to create such complex circuits are significant. Their originality lies in the enlightened interconnection of otherwise ordinary circuit blocks. Plagiarism is obvious since the chances of independently deriving the same enlightened interconnection is small. The fabrication itself might be rather straightforward. The essence of semiconductor piracy is the wholesale appropriation of chip design by reconstituting a mask set from a sample device. The effort of comprehending a microprocessor design to add even the modicum of originality required to avoid blatant copyright infringement should deter the average pirate.

At the other end of the spectrum are semiconductor memory devices, which are a model of generic functionality and appearance. These are commodity products purchased in huge volumes. Even so, they are also highly complex and difficult to design. They are ideal for piracy. They are heavily pirated.

Memory designs are highly tuned for optimum characteristics. The single transistor dynamic memory cell may be generic, but large sums of money are continually spent to determine exactly the best method of fabricating one. Unfortunately, to the untrained eye, they all look very similar. The industry has been highly succesful in this search, but the improvements do not especially translate into large mask changes. There are many small changes in processing that make a better memory.

To state the point from the view of copyright, even very subtle mask changes may represent significantly different designs, differences that reveal a great deal of originality. Exactly the sort of tests that demonstrate such differences are specifically disallowed as a defense against accusations of copyright infringement. Copyright is restricted to appearance or expression, and does not include functional features. We fear that devices with significantly different performance will not possess the visual differentiation of crucial features that a jury would require. The effect would be a stifling extension of copyright protection far beyond the intent of the bill.

Voltage regulators and other esoterica that fill semiconductor catalogs all fall somewhere in the continuum between the microprocessor type of originality and the memory kind. We have chosen memories as our example not because they fall at an extreme, but because being at the extreme, they are especially subject to the piracy that has prompted our interest in this hearing.

We have taken some pains to speak of the nature of masks when placed under copyright. The intent is to remind ourselves that the problem, after all, is silicon chip plagiarism. Masks are not the problem, but they are proposed as a conduit for protection to flow from copyright to the semiconductors themselves, and this generates its own special set of problems.

The point is made clearer by referring to the additions that S.1201 uses to augment its actual purpose. Section 4, entitled "Exclusive Rights", specifies the right "to use a mask embodying the mask work to make a semiconductor chip product...". This clause may appear appropriate for a bill to protect semiconductor chips. It is remarkable within the context of existing copyright law. Since we are proposing to copyright masks, or specifically, "mask works", we must differentiate between a copyrighted object, and devices fabricated with the aid of the copyrighted object. The courts have held, for instance, that a building does not infringe a copyrighted blueprint of the building. Dresses are not infringements of the patterns from which they are made. These are utilitarian objects which might have ornamental or expressive value as a secondary characteristic.

Semiconductors may have a photographic relationship to the masks used to specify their morphology, but we are not sure that it is any greater than that of other objects fabricated using optical methods. Semiconductor chips are utilitarian devices usually hidden in metal or plastic. Of themselves, they do not appear to be candidates for the remedies of copyright.

The bill goes further to add a compulsory licensing provision in Section 5. This is intended to provide a balance of equities like that provided in Section 252 of the Patent Act which protects the intervening rights of manufacturers of products that are subject to a reissue patent. In the case of a reissue patent, the manufacturer is presumed to have had knowledge of the original patent claims and is protected against a change in the claims after beginning production, as a result of the patentee discovering that through error he had claimed more than he had a right to claim.

On the other hand, S.1201 speaks of a situation where the copyright owner would not have changed his mask work, mask, or semiconductor chip, nor would he have made an error in copyright protection that he wished to correct. Rather, it would be the infringer who did not ascertain whether a purchased chip was copyrighted or not. This is a serious change of concept. Semiconductors are purchased like any other commodity, and purchasing agents are primarily concerned with price and delivery. Inquiries about the licensing arrangements between a semiconductor vendor and any third parties, especially on a product by product basis, are beyond the expertise or duty of these individuals.

Considering that parts are often ordered by generic part number through distributors who may have obtained stock through factory purchase, industrial surplus, stock trades with other distributors, or returns of equivalent parts in kind, the difficulties of even knowing who the manufacturer of an ordered part will be, much less his licensing, are obvious. Lumping end users with pirates may be justified if collusion can be demonstrated, but to include innocent end users at all suggests a "deep pocket" theory of infringement, based on ability to pay rather than culpability. Again, this is alien to existing copyright.

Our overall concern is that the amount of pioneering required to apply copyright protection to semiconductor chips may be excessive. The individual steps of going from semiconductors to mask sets, from mask sets to copyright, and then back around the loop with protection, are perhaps not too large individually. The aggregate may be too tenuous a connection to adequately control piracy. We have addressed a few selected issues to illustrate our point.

The best form of a bill is still undecided by the IEEE/USAB Patent Task Force. There is a great deal of merit to the approach of a narrow, specific bill, because it avoids the implications of extension that a wider bill would have. Historically, copyright has been a broad piece of legislation within its intended scope. Extension of even very narrow copyright amendments seems unavoidable.

An ideal bill would be able to cover semiconductor piracy directly, and allow tests of function as well as form. It would specifically deal with design plagiarism. If masks must be used as a vehicle of protection, then the definition of a mask should include such promising technologies as direct electron beam exposure, which uses no mask within the definitions of S.1201. In other words, the legislation should be adequate for the foreseeable future, and not just for the larger fraction of producers at the present time.

Finally, many task force members noted that a bill which does not need to specify the materials of the mask also does not need to specify the materials of fabrication. In other words, the topic itself may not be narrow.

The IEEE/USAB Patent Task Force stands ready to offer the expertise of the IEEE membership to help solve the problem of semiconductor piracy. Legislation is clearly needed, but it should have a strong basis in legal theory. Of the greatest importance, it should protect the innovative ability of industry that has served America so well.

Robert J. Frank
Chairman, Patent Task Force
IEEE United States Activities Board
June 6, 1983

Statement of the Semiconductor Industry Association

THE ECONOMIC EFFECTS OF CHIP PIRACY ON THE U.S. SEMICONDUCTOR INDUSTRY*

Executive Summary

The piracy, or photographic copying, of innovative semiconductor chips is a serious threat to the domestic semiconductor industry. Piracy causes substantial losses of revenue to innovative semiconductor firms because pirate firms, which bear no product or market research and development (R&D) costs, have far lower fixed costs than do innovative firms. As a result, pirate firms are able to set far lower prices than innovative firms, which innovative firms must meet, and take market share previously held by innovative firms. The combination of price suppression and market share reduction leads to a significant decline in innovative firms' profits and revenues, and may actually drive innovative firms out of competition in the product lines they pioneered. Existing evidence indicates that the total revenue loss due to a single incident of chip piracy can be in the tens of millions of dollars per year for an innovative firm.

The impact of these piracy costs is severe. Two significant economic disincentives to innovation result from chip piracy. First, piracy immediately reduces funds available to innovative firms for investment and further R&D. New investment and R&D are the lifeblood of the semiconductor industry, and any reduction in funds available for those purposes is a major blow to a semiconductor firm. Only through continued R&D and investment have semiconductor firms been able to remain competitive for any extended period.

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Second, the possibility of chip piracy must be taken into account by innovative firms in their planning for new product development. The threat of piracy has a significant negative impact on the willingness of firms to invest in new products, because the new products, if copied, may not provide the investing firm with an adequate return on its investment. Through both of these negative economic effects, chip piracy tends to reduce innovation in the semiconductor industry.

Savings to firms because of the elimination of chip piracy would likely be used by companies for R&D and reinvestment in new plant and equipment. U.S. semiconductor firms generally pay no dividends to their shareholders, nor has there been any significant level of merger activity between U.S. semiconductor firms. Furthermore, current high levels of demand for semiconductor products have made new investment in production capacity an even higher priority than under normal demand conditions.

I. COST TO THE SEMICONDUCTOR INDUSTRY DUE TO COPYING

Introduction

Aggregate data on revenues lost to the U.S. semiconductor industry as a result of the copying of semiconductor chip designs is not available. However, the general economic analysis presented in this paper clearly indicates qualitatively the nature of losses due to copying, and, together with some quantitative anecdotal evidence, can provide some general estimates of total sales lost to pirates each year. The following discussion illustrates the cost advantage available to a firm (hereafter "Firm B") which copies the chip design of an innovative firm (hereafter "Firm A"), and the way in which such copying threatens continued innovation. (Throughout this discussion, it is assumed that only Firm A and Firm B are active in the market. For a more detailed economic analysis, see Appendix 1.)

Pricing - Innovative Firm (Firm A)

Firms which develop an innovative semiconductor design must invest in the creation of far more than simply a new chip. They must also carry out a market research program to determine the characteristics to embody in the new design, they must develop other chips which can operate with the new product, and they must develop the software to accompany the new family of chips. For an advanced microprocessor chip, total development costs can reach $100 million.

When a semiconductor firm (Firm A) first introduces an innovative product, it holds a temporary position as the only seller of the new product line. As a result, Firm A is able to set its prices and its quantity of production at a level sufficient to cover its high development costs and yield some profit. This profit can then be applied to the development and production of still other semiconductor devices. Although firms in the semiconductor industry have always made every effort to reduce prices so as to expand the size of the semiconductor market, the prices charged by an innovative firm must necessarily reflect these past and future costs. This is the pattern of pricing and product development which has led the semiconductor industry to continually improved semiconductor capability, continually reduced semiconductor energy consumption and, ultimately, to continually declining semiconductor prices.

Pricing -- Copying Firm (Firm B)

A firm (Firm B) which chooses to copy the design of an innovative firm, however, faces a far lower set of development costs than does an innovative firm. The technology available for photographically copying and reproducing a semiconductor design permits the development of a copied product for as little as

$50,000. The piracy of a full family of the most complex semiconductor devices would cost less than $1 million. In addition, the results of market survey and software development efforts carried out by the innovative firm are often available instantly to the copying firm.

The price which Firm B could charge for a product identical to Firm A's innovative product thus reflects Firm B's extremely low development costs. Furthermore, Firm B would anticipate no particularly high future costs for the development of its next product. Firm B need only wait for another company to produce a new product and then copy it.

The copying firm could therefore set its price so as to appropriate as much of the market as it has the capacity to serve while enjoying a high degree of profitability. At the loss of some short run profits, Firm B might even, in some circumstances, be able to set a price so low as to drive the innovative firm out of the product line altogether.

Effects on Innovative Firm (Firm A)

Because buyers of semiconductor products are very sensitive to price in their purchasing decisions (given equal quality),1/ Firm B's choice of price will instantly become the market price for the new semiconductor device, and Firm A will achieve a reasonable volume of sales only by meeting that price. This price suppression is one effect of copying on Firm A.

The extreme situation would be for Firm A to leave the market altogether. This would occur if Firm B were to set the price of its product so low that Firm A would not only be unable

1/ A study conducted in 1977 by the FTC stated "Buyers of semiconductors are highly sophisticated in comparing prices and the electrical characteristics of different products. For that reason, price competition appears to be very strong." Federal Trade Commission, Bureau of Economics, The Semiconductor Industry: A Summary of Structure, Conduct and Performance 140 (1977).

to recover fully distributed costs on each sale but would not earn sufficient revenue to cover immediate (variable) costs of production for the product.

The other effect is a reduction in the quantity of sales made by Firm A. Although a lower price will result in an expansion in total market size, the level of sales that Firm A can make will be determined by the pricing and production strategy of Firm B which, because of its lower cost structure, now exercises effective control of the market.

The combined negative effects of price suppression and lost sales would be a substantial loss of revenue for Firm A. Existing evidence indicates that the size of these revenue losses can be in the tens of millions of dollars per year for a single firm.2/

Copyright legislation protecting against chip piracy would permit a U.S. semiconductor firm to initiate action to stop the sale of pirated chips in the U.S. market. Since the domestic market represents over half of the world semiconductor market, such exclusion would have a strong negative impact on semiconductor chip piracy. Alternatively, Firm A might license Firm B to continue to produce the pirated chip and thereby create a flow of royalty payments sufficient to offset Firm B's price advantage due to copying.

2/ In a case before the International Trade Commission, for instance, Zilog Corporation has alleged that Nippon Electric Company (NEC) copied its Z-80 microprocessor chip. Since NEC's version of the chip entered the market in 1979, Z-80 prices have fallen from $6.32 to $2.82. During the same time, NEC's annual sales of its version of the Z-80 reached 3 million units -- approximately the same level as Zilog's sales.

In another case, in August 1982, Intersil, Inc. filed a suit against Teledyne, Inc. alleging that Intersil had suffered total damages of $7 million in the copying of a family of relatively inexpensive analog-to-digital converter chips. The suit has been settled.

II. LIKELY USE OF FUNDS SAVED

It has been the long-standing policy of U.S. semiconductor firms to reinvest all new revenues in the semiconductor business. U.S. semiconductor firms generally pay no dividends to their shareholders, nor has there been any significant level of merger activity between U.S. semiconductor firms. This is the result of the investment intensive nature of the industry.

The development of a new chip can, as described in the previous section, can cost a firm as much as $100 million. Furthermore, a new plant to produce semiconductors can also cost upwards of $100 million. Costs of this magnitude are no longer unusual within the semiconductor industry, and they must be incurred if a firm expects to remain at the forefront of the industry. Development and production of semiconductor devices which are more powerful, more energy efficient, and smaller is essential if a firm wishes to expand or even simply maintain its level of sales.

As a result, the U.S. semiconductor industry has traditionally exhibited one of the highest levels of capital and R&D expenditures as a percentage of sales of any U.S. industry. Between 1976 and 1982 the U.S. semiconductor firms invested over $8 billion in plant and equipment as compared with $4 billion over the same period by Japanese producers.3/ Under current economic conditions in which semiconductor demand has outpaced firms' production capabilities, the pressure to increase output creates an additional requirement for capital investment. The following chart illustrates that the trend is for the level of these expenditures to continue to increase.

3/ Source: U.S. Department of Commerce Data.

R&D And Capital Expenditures As A Percent Of Sales
For The U.S. Semiconductor Industry

	1975	1976	1977	1978	1979	1980	1981	1982
R&D Expenditures	8.6	6.8	7.9	8.2	7.2	7.5	9.7	10.7
Capital Expenditures	5.7	9.3	10.9	14	13.6	15.5	18.4	14.7
Total	14.3	16.1	18.8	22.2	20.8	24	28.1	25.4

Source: Technecon, Inc.

Given the strong inherent requirement for R&D and investment in the semiconductor industry, any increase in a chip firm's revenues, such as would be obtained by the elimination of semiconductor piracy, would most likely be invested in new capital or used to finance R&D.

Appendix 1
Graphical Analysis

The graphs in this section depict various aspects of the cost of copying as described in Section I.

The X axes for these graphs measure the quantity of the semiconductors produced or consumed. The Y axes measure the cost per unit of production or price at a given level of production. This analysis is based upon the use of six types of curves.

Demand curves (D) are the series of points which show the quantity of a product which would be purchased at a given price

(or alternatively, the minimum price per unit at which a given quantity of a product could be sold.)

Marginal Revenue curves (MR) are the series of points which show the additional revenue a firm would earn for each additional unit of sales.

Average Fixed Cost curves (AFC) depict per unit fixed costs. Fixed costs are those expenditures on such things as R&D, plant and equipment which have been made prior to initiation of the production process or which, in the short run, must be paid regardless of production levels. Each point on the AFC curve is determined by dividing total fixed costs at a given level of output by the number of units produced. As a result, AFC curves are constantly declining as production increases.

Average Variable Cost curves (AVC) show the costs of those items such as labor, electricity, and heating which can be controlled by management in the short run. Each point on the AVC curve is determined by dividing total variable costs at a given level of output by the quantity of output.

The Average Total Cost curve (AC) for a firm is simply the combination of the AFC and AVC curves for that firm. Each point on the AC curve is determined by dividing fixed and variable costs (i.e. total costs) at a given level of output by the quantity of output.

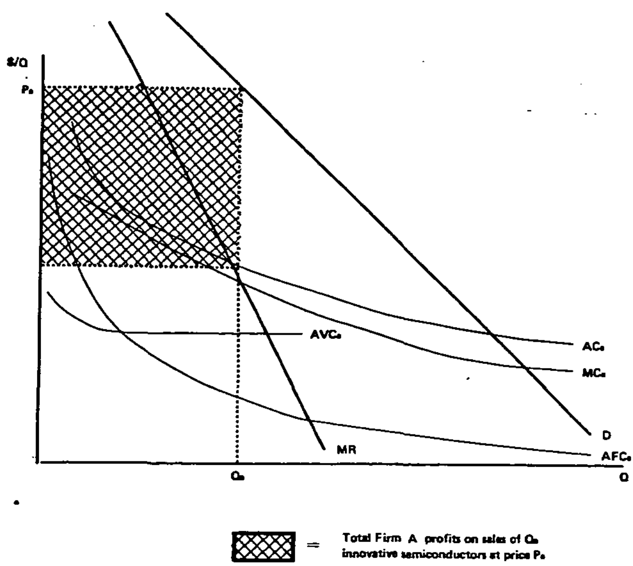
Marginal Cost curves (MC) are the series of points which show the additional costs experienced by a firm for each additional unit of production.

In all cases in this analysis, the Demand and Marginal Revenue curves are held constant and are identical for both firms because both serve the same market. The cost curves are different for each of the two firms, but are held constant for each firm throughout this analysis. All the cost curves shown reflect economies of scale -- a condition present for virtually every new semiconductor product -- and thus decline as total production increases. The primary difference in production cost between Firm A and Firm B is shown by their average fixed cost curves (AFC). Because of the difference in cost borne by each firm for product development, Firm A's AFC curve is considerably higher than is Firm B's.

Variable costs on the other hand, might be lower for Firm A which developed and introduced the new product and which may utilize more efficient production technologies and techniques. As drawn, therefore, Firm A's average variable cost curve (AVC_a) is lower than Firm B's (AVC_b). This small cost advantage to Firm A, however, is far outweighed by Firm B's lower level of fixed costs.

The equilibrium conditions which these graphs demonstrate are illustrative only. Other firms with different cost structures would exhibit different levels of profit or loss. However, the graphs drawn here do provide an accurate and vivid indication of the nature of the injury which can be caused by copying.

GRAPH A PRICE SETTING AND PROFITS FOR FIRM A's INNOVATIVE PRODUCT ABSENT COMPETITION FROM A COPIED VERSION



As illustrated in Graph A, Firm A which introduces a new semiconductor product would produce to sell a quantity Q_a of its new chips because that is the quantity at which its Marginal Costs (MC_a) equal its Marginal Revenues (MR) and is therefore the quantity at which profit is maximized. Because no one else had yet developed the new product, Firm A could expect to hold some degree of market power in that product line, and could be expected to price at P_a so as to earn a profit on the sale of the new product.1/ This profit is indicated on Graph A as the diagonally crossed area.

The average fixed cost curve (AFC_a), the marginal cost curve (MCa) and average cost curve (AC_a) reflect the costs associated with the development, production and marketing of the innovative new device by Firm A. Average fixed costs in this example make up approximately one-third of Firm A's total average costs at quantity Q_a. Product development costs can be assumed to represent approximately half of those fixed costs.

If another firm, Firm B, were now to copy Firm A's new chip, the economic outlook for Firm A would change dramatically. Graph B1 illustrates the price (P_b) at which Firm B, a copying firm, could sell its product if it were to choose to appropriate only half the market. This analysis assumes that Firm B has fixed costs 50% lower than Firm A because it bears no product and market R&D costs. Note also that once Firm B has decided to split the market with Firm A it faces a new demand curve (d') and new Marginal Revenue Curve (MR') which reflect a market half the size of the original market. Firm B would price at P_b -- a price

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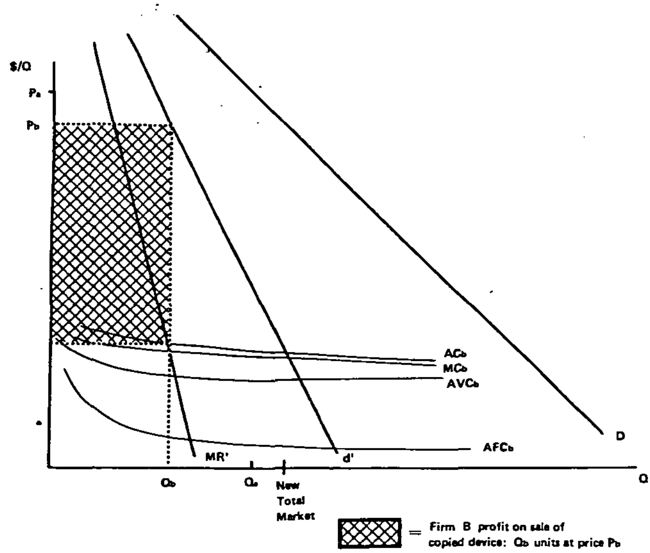
1/ A standard pricing practice in the semiconductor industry (said to have been introduced in the U.S. by Henry Ford in pricing the Model T) is to anticipate future reductions in production costs and to price according to predicted future costs in order to expand the size of the market more rapidly. The cost curves as drawn, therefore, would more accurately be viewed as anticipated future cost curves. Nevertheless, the graphs do portray the type of injury Firm A would suffer due to piracy.

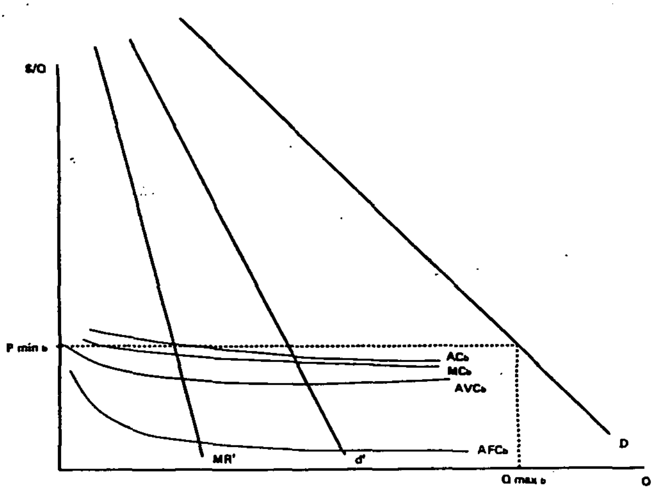
somewhat less than P_a-- and, because of demand elasticity, would sell a quantity Q_b which is less than Q_a and equal to one-half the new total market. At this combination of price and sales, Firm B would earn a profit as shown in the diagonally crossed portion of Graph B1.

GRAPH B1 FIRM B INTRODUCES COPIED CHIP WITH INTENTION OF DIVIDING THE MARKET WITH FIRM A



However, were Firm B later to choose to take as much market share as possible without losing any money it could price as low as P_{minb}. Graph B2 shows that at sales of Q_b or greater Firm B's revenues would exceed its average costs at price P_{minb}. In Graph B2, Firm B has taken over the entire market and therefore operates using the market demand curve (D). P_{minb}, however was set taking into account the level of production in Graph B1 because it is from that level of production that Firm B will begin to expand its sales. Only at a price of P_{minb} or higher can this expansion occur without Firm B ever suffering a loss.

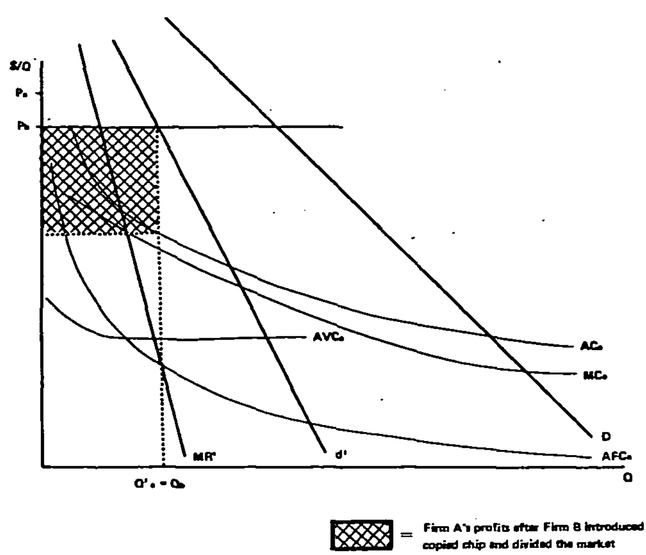
GRAPH B2 FIRM B CHOOSES TO DRIVE FIRM A OUT OF BUSINESS AND TAKES ENTIRE MARKET*



*Note that Firm B can price at Pminb and still operate at the breakeven point.

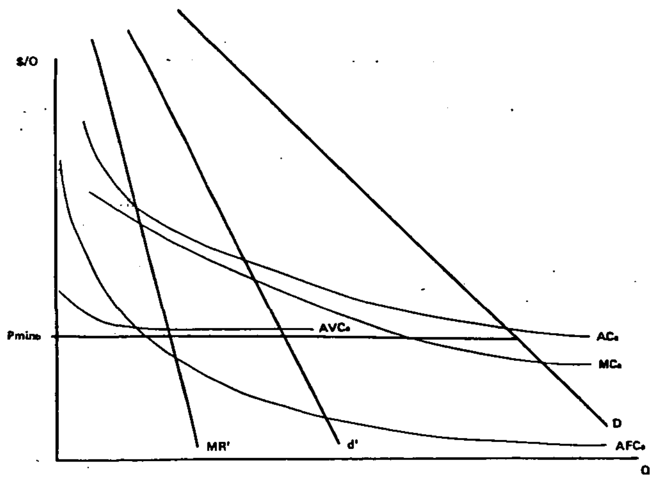
Graph Cl depicts Firm A's response to a decision by Firm B to evenly divide the market for Firm A's innovative product.

GRAPH C1 FIRM A's PROFITS AFTER MARKET IS DIVIDED EQUALLY WITH FIRM B's COPIED CHIP



Firm A must accept price P_b as set by Firm B and must also accept a decrease in its market size to Q'_a ($Q'_a = Q_b$ because the market has been evenly divided). At this combination, Firm A will continue to earn a profit (shown as the diagonally crossed area in Graph C1) but a much smaller profit than was earned by Firm B at the same level of production and far smaller than Firm A's profits before suffering piratical competition from Firm B's copied chip.

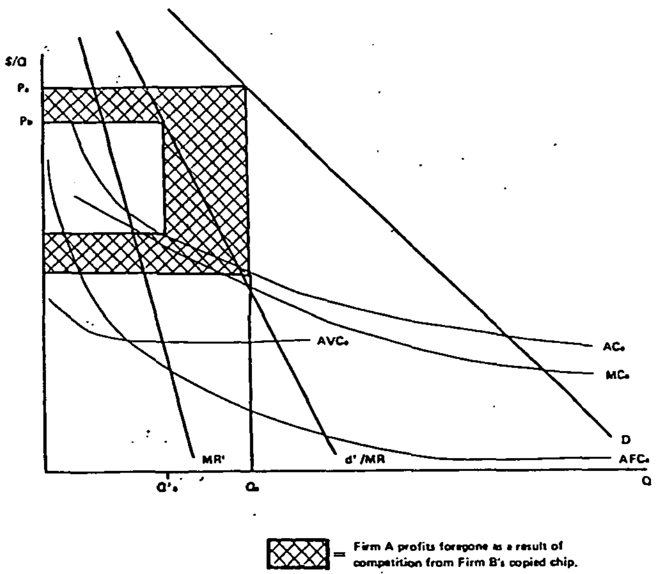
GRAPH C2 FIRM A IS DRIVEN OUT OF BUSINESS BY FIRM B WHEN FIRM B PRICES AT Pminb, BELOW FIRM A's AVC CURVE



In the extreme case in which Firm B elects to price so as to take over the entire market, Firm A would indeed be driven from that product line. Graph C2 illustrates that if Firm A were to lower its price to P_{minb} in order to meet Firm B's price, Firm A would not only forego its profits and sell at a loss but would be unable to continue production of its new chip because its revenues would be insufficient to cover its average variable costs of production (i.e., $AVC_a > P_{minb}$ at all points).

Graph C2 summarized the worst case scenario in which Firm A is driven out of business in the product line it developed -- without Firm B even suffering any temporary losses. Graphs D1 and D2 summarize the scenario in which Firm B elects to split the market evenly between the two firms.

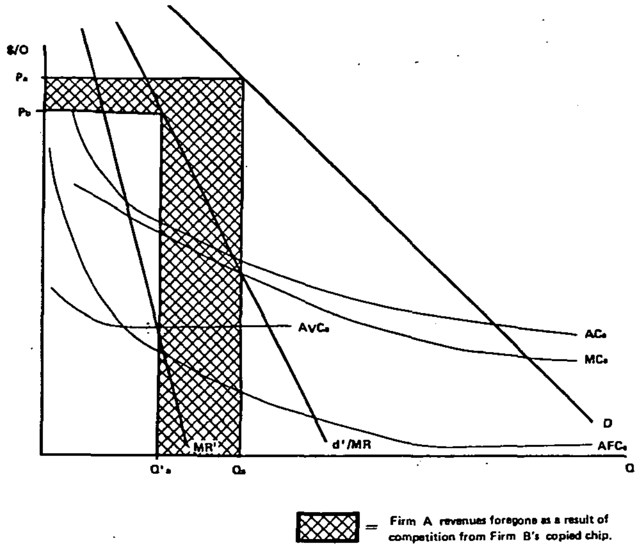
GRAPH D1 REDUCTION OF FIRM A's PROFITS WHEN MARKET IS DIVIDED EQUALLY WITH FIRM B



The diagonally crossed area in Graph D1 illustrates the difference between profits earned by Firm A before and after competition from Firm B's copied chip . The difference is the quantity of profits not available to Firm A for further investment.

Graph D2 illustrates the difference in Firm A's revenues earned before and after piratical competition from Firm B's copied chip, assuming an even division of the market after Firm B introduced its chip. This difference, shown as the diagonally crossed area of Graph D2, represents the quantity of revenues not available for future R&D efforts by Firm A.

GRAPH D2 REDUCTION OF FIRM A's REVENUES WHEN MARKET IS DIVIDED EQUALLY WITH FIRM B



In Graphs D1 and D2, however, Firm A has been able to cover its development costs for the new semiconductor device. In Graph C2 this was not the case. Thus total costs to Firm A would range from a severe reduction in profits and revenues (and thus a reduction in future innovative activity) to an inability to continue to compete in a product line it had pioneered.

The conclusions to be drawn from this examination of the economics of chip piracy include:

1. Pirate firms can readily earn a profit because their costs will not reflect the very high R&D costs borne by an innovative firm.

2. Pirate firms can price at a far lower level than can innovative firms, and in the process can appropriate market share from the original manufacturer.

3. One result of piracy will be an erosion of the innovative firm's profits and revenues.

4. In the extreme case, the innovative firm can be driven out of the market for the product it developed.

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May 6, 1983

Mr. Steve Metallitz
Subcommittee on Patents,
Copyrights and Trademarks
Senate Judiciary Committee
Washington, D.C. 20510

Re: Semiconductor Chip Protection Act of 1982

Dear Steve:

We have reviewed the proposed Semiconductor Chip Protection Act of 1982 ("the Act"), to be introduced by Senator Matthias this session, and have several comments regarding the legislation as currently drafted. Our comments are set forth below; the section numbers used in our comments correspond to the section numbers in the Act.

1. Section 2.

(a) We would suggest that the language added by Section 2 to Section 101 of the Copyright Act be divided into subparagraphs in order to clarify future citations to its provisions; for example, as currently drafted, there will be two subsections "(1)" and two subsections "(2)."

(b) Subparagraph 3 of Section 2 defines a semiconductor chip product as the final or intermediate form of a product "that is a writing or a discovery, or the manufacture, use, or distribution of which is in or affects commerce." (Emphasis added.) We are confused by the use of underscored conjunctive "or" in this language. Under its constitutional grant of authority, Congress has the power "to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their writings and discoveries." U.S. Const., Art. I, § 8. However, there is no requirement, in either the Constitution or the Copyright Act, that the writing or discovery be used in or affect commerce. Conversely, the fact that a product is manufactured, used, or distributed in a manner which affects commerce does not, by itself, bring it within the constitutional protection of writings and discoveries. If the purpose of the Act is to protect only those writings or discoveries which are used in commerce, as we suspect, then the conjunctive "and" should be used rather than "or."

(c) We note that the inclusion of subsection (3) in Section 2 requires the chip to be a "writing or discovery" in order to come within the protection of the Act. We can think of no situation in which a product having materials deposited or etched upon it would not constitute either a "writing" or a "discovery"; therefore, we question the necessity of this language. Moreover, the Copyright Act was originally enacted to protect original works of authorship, while patent laws were enacted to protect discoveries; accordingly, protection of discoveries is a patent concept rather than a copyright concept. We believe that it may be more appropriate to focus on the concept of "original work of authorship" rather than on the concepts of "writing" and "discovery" in this section of the Act. In our opinion, these changes would bring the definition of a "semiconductor chip product" closer in line with the history and purpose of the Copyright Act as well as broaden the protection afforded microchips under the proposed amendment.

(d) Our final problem with Section 2 involves the definitions of "mask work" and "mask." We believe that these terms must be more plainly defined. As presently worded, the definitions are unlikely to be understood readily by a lay judge unless he or she has received a good deal of education by competent counsel. In short, these are not good "working definitions" from our perspective as counsel to clients in the high technology industry.

We also believe that the definitions of the two terms incorporate concepts not required by the Copyright Act. For example, we see no reason why a mask work cannot be protected independently of its relationship to a chip. Furthermore, we do not believe that the Copyright Act requires that "predetermined" patterns must exist in order for work to come within its protection.

2. Section 5.

(a) Although Section 5 of the Act amends Section 119 of the Copyright Act to provide for compulsory licenses, it contains no requirement that the compulsory licensee include a notice of the original copyright on each unit of the product subsequently distributed or used pursuant to the compulsory license. Such a requirement is essential to the protection of the copyright owner and should be included in this section.

(b) Since licenses are often granted by a copyright owner on an exclusive basis, or on a limited geographical basis, the concept of giving an infringer the right to a compulsory license throughout the United States raises the question of what protection remains for the rights of bona fide, prior licensees who have paid for an exclusive or territorial license. We believe that this issue should be addressed within the provisions on compulsory licensing.

(c) Under the Act, the compulsory license is irrevocable "only for failure to make timely payment of royalties." In our opinion, there are additional reasons for which revocation should be permitted in order to protect the copyright owner's rights. Such reasons would include:

1. Failure to include notice of copyright on any units distributed under the compulsory license;

2. Producing or distributing faulty or defective units;

3. Additional or subsequent infringements.

(d) Finally, we would suggest that a provision be added to the Act which specifies that the compulsory license provisions in no way limit the copyright owners' rights to sue for and recover damages from the original infringer.

3. Section 7. Section 7 of the Act amends Section 501 of the Copyright Act by including the concept of "innocent infringement." The amendment provides that an innocent infringer will not be liable as an infringer for the use or distribution of units of semiconductor chip products that occurred before the infringer had notice of the infringement.

We question the concept of "innocent infringement" in the microchip environment and the absence of a provision requiring such an infringer to pay a fee or disgorge profits to the copyright owner. Under the current provisions of the Copyright Act, an innocent infringer of a copyright is liable for damages for such infringement, although the statutory damages provided in the Act for an innocent infringement are substantially less than the damages provided for other types of infringement. The point is that damages are allowed regardless of whether the infringement is "innocent." We would suggest that a similar approach to innocent infringement be included in the Act. As currently drafted, the innocent microchip infringer is relieved altogether from any remedies the copyright owners might pursue under other provisions of the Copyright Act. In our opinion, this provision is inconsistent not only with the remainder of the Copyright Act, but also with its history and purpose. It is unfair to allow a person freely to use a copyright owner's property without paying the owner for that use.

4. Section 9. Under Section 9 of the Microchip Act, its amendments do not apply to semiconductor chip products manufactured prior to the effective date or to masks made in the United States prior to the effective date. Such a provision may have dramatic and unexpected effects on the current state of the copyright laws. Although there are at least two cases to the contrary, see Data Cash Systems, Inc. v. JS&A Group, Inc., 480 F.Supp. 1063 (N.D. Ill. 1979) aff'd on other grounds, 628 F.2d 1038 (7th Cir. 1980); Apple Computer, Inc. v. Franklin Computer Corp., 545 F.Supp. 812 (E.D. Pa. 1982), a number of courts have held that certain types of program materials embedded upon semiconductor chips constitute copyrightable subject matter. See, e.g., Williams Electronics, Inc. v. Arctic International, Inc., 685 F.2d 870 (3rd Cir. 1982); Midway Mfg. Co. v. Arctic International, Inc., No. 82-1607, Slip Op. (7th Cir. April 11, 1983); Tandy Corp. v. Personal Micro Computers, Inc., 524 F.Supp. 171 (N.D. Cal 1981). In order to protect manufacturers who have relied upon these cases and attempted to protect their semiconductor chip products via the Copyright Act, we would suggest that subsections 1, 2 and 3 be deleted from Section 9. Instead, the Act could be offered as a clarifying amendment to the current copyright laws.

If you have any questions regarding our comments or if we can be of further assistance, please do not hesitate to contact us.

Sincerely,

Jocelyn West Brittin

Jocelyn West Brittin

James E. Ballowe, Jr.

James E. Ballowe, Jr.

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May 13, 1983

Senator Charles McC. Mathias
Chairman
Subcommittee on Patents, Copyrights and Trademarks
Committee on the Judiciary
U. S. Senate
Washington, D. C. 20510

Dear Mr. Chairman:

The Proprietary Rights Committee of the Information Industry Association is pleased to have the opportunity to provide comments with respect to the "Semiconductor Chip Protection Act of 1983".

The IIA is a trade association comprised of nearly 200 companies, with annual revenues in the range of $5 billion dollars, and non-profit professional and educational organizations. These companies and organizations are the entrepreneurs of the information age. Our members are in the business of collecting, organizing, abstracting, indexing, distributing, and otherwise adding value to information. We are vitally concerned with the economics and the public policy that affect information content in the marketplace. A list of our members is attached for your reference.

Prior to the introduction of S. 1201, the IIA Proprietary Rights Committee studied the provisions of the similar House bill, H.R. 1028, and counsel to the Committee prepared the attached memorandum, dated April 18, 1983, which substantially reflects the views of the Committee on such bill. Because of the hearing on S. 1201 scheduled for May 19 by your Subcommittee, we would like to furnish your Subcommittee with copies of such memorandum.

Although our Committee believes that S. 1201 and H.R. 1028 would present serious problems if enacted as described in the attached memorandum, we would like to emphasize that we believe clear protection for semiconductor chips is important. Accordingly, we would urge the Congress to give prompt consideration to legislation which would provide appropriate protection for such chips.

Sincerely yours,

Kurt D. Steele
Chairman, Proprietary Rights Committee

cc: Subcommittee Members

April 18, 1983

COMMENTS: H.R. 1028 (98TH CONG., JAN. 27, 1983) (EDWARDS), THE "SEMICONDUCTOR CHIP PROTECTION ACT OF 1983"

The bill seeks to amend the Copyright Act to provide for semiconductor chips the protection which such important contributions to high technology deserve and which they require if the necessary incentive for their development is to be maintained and enhanced.

The bill seeks to provide this protection while avoiding the imposition of catastrophic liability on those who have unknowingly purchased infringing chips and invested substantial sums in, for example, the manufacture or operation of complex computers or other expensive equipment designed around such chips.

Such protection is needed, and such safeguards are needed. However, it is not clear that H.R. 1028 is the appropriate vehicle to satisfy either of these needs.

* * * * *

1. The specific wording of various provisions in the bill can profitably be scrutinized for possible drafting improvements. However, it is more appropriate to focus on basic and broader questions which are raised by the bill. Among these is the question whether an amendment to the Copyright Act is the appropriate legislative approach to achieve the bill's goals; or whether it would be more appropriate to consider the drafting and enactment of a sui generis statute.

2. Since neither the patent nor copyright statutes can provide the much needed protection without substantial alteration, or perhaps distortion, of their basic structure, a sui generis statute should perhaps be enacted. An analogy would be the design proposal (H.R. 20, 97th Cong.) for protecting ornamental designs. Chips per se are functional and would not come under that proposal, but it illustrates an approach to sui generis protection for works requiring it.

3. Saying that a semiconductor chip product is (alternatively) "a writing" (bill, §2, p.2, line 8) doesn't necessarily make it so; and there is substantial doubt the Constitution and case law would so interpret the phrase.

4. Also, saying that a chip is "a discovery," as the bill (loc. cit.) would also provide in the alternative, doesn't necessarily make it so. However, if it is, it may be barred from protection by reason of the present 17 U.S.C. §102(b). That provision, by denying copyright protection to any "... system, method of operation ... or discovery," etc., implements the fundamental idea/expression dichotomy which permeates the entire copyright law. A "discovery" can of course, under the Constitution and Title 35, be patentable subject matter.

5. On the other hand -- in a legislative context, unfortunately, where interpretation should be capable of interpretation single-handedly -- it is conceivable that the bill's categorization of a chip as a protectable "discovery" (bill, §2, p.2, line 8) might have the effect of providing copyright protection for a "discovery" by overriding <u>sub</u>

silentio the prohibition under 17 U.S.C. §102(b) against copyright protection for a "discovery." The bill's effect, if any, on §102(b) of the Act is not clear but is most important.

6. If the proposed legislation were to be to so interpreted, a misappropriator of any trade secret in the chip "discovery" might be able to argue preemption more effectively than is now possible. Although most, but by no means all, authorities have expressed the view that §301 (the preemption section) of the present Copyright Act does not preempt trade secret protection, the bill might thus raise basic, and complex, questions in the relationship of the proposed statutory amendment to trade secret law.

7. One argument presumably to be made by such a misappropriator would be that trade secret rights would be "equivalent" under 17 U.S.C. §301 to one or more of those copyright rights which under the bill might now be afforded a "discovery," and that a "discovery" would be copyrightable subject matter under the Act as amended.

8. Even more important in the context of the preemption question is the fact that among the new categories of copyright rights which the bill would enact would be rights such as exclusive rights to "use" a mask to make a chip and to "use" the chip itself (bill, §4(3), p.4, lines 1-2, 8- 10). A "use" right is not presently a right which the Copyright Act provides under 17 U.S.C. §106 for any other category of work.

9. It is not clear under the bill whether the copyright, or quasi-copyright, protection under the bill would make it an infringement for a third party to reverse engineer the chip, even if the third party "uses" only what the chip discloses as to unpatented methods, procedures, systems, ideas, etc. (traditionally all unprotected under copyright) embodied in the chip and does not "use" from the chip embodiment any expression which is traditionally protected under copyright.

10. The bill presumably would not make independent creation of a mask or chip an infringement. However, it should be noted that any "discovery" (bill, §2, p.2, line 8), ideas, etc. which are protected against "use" would be given such protection without having to meet any novelty requirement.

11. In addition to enacting an "exclusive right ... to use," the bill would add basic concepts and terminology heretofore unknown to the Copyright Act -- such as a right "to embody" (a mask work in a mask) (bill, §4, p.3, line 23) and a right "substantially to reproduce" (images of a mask work) (bill, §4, p.4, line 4). The new right "substantially to reproduce" would be in addition to, and not in lieu of, the existing right under 17 U.S.C. §106(1) "to reproduce."

12. The substance of the basic rights which the bill would provide to chip proprietors would be those largely analogous to the patent rights to make, use and sell, not the traditional copyright rights (bill, §4, p.3, line 22 to p.4, line 10).

13. The bill would provide also a third alternative Constitutional basis for protection of chips: i.e., if their

manufacture, use or distribution "is in or affects commerce" (bill, §2, p.2, lines 9-10). However, such a provision is found nowhere else in the Copyright Act. If the bill were enacted we would have the anomaly of an entire Title of the United States Code relying for its Constitutional authority (and its theory and interpretation) on Article I, Sec. 8, Cl. 8., with the sole confusing exception of a single category of works which -- perhaps -- relies upon the Commerce Clause.

14. The bill (§2, p.3, lines 3-6) selectively permits the term "copy" to apply to chips only under only a limited number of sections of the Copyright Act (and presumably no others) where that term now appears. Such legislation would add a gray third category to what is otherwise a reasonably clear division of tangible fixations of works into only two categories throughout the entire Act: "copies" and "phonorecords."

15. In order to provide the protection essential for innocent infringers who may have invested in their own products far more than the cost of the infringing chip unknowingly used in their products, the bill would enact a complex compulsory license (bill, §5, p.4, line 12 to p.6, line 9). The recent history of domestic and international erosion of rights of authors, inventors and trademark owners suggests that the incursion of compulsory licenses into intellectual and industrial property statutes should be avoided if at all possible.

16. Moreover, the bill may inadvertently sweep into the scope of its provisions limiting copyright protection (e.g., compulsory licensing, limited duration of copyright, and other provisions) other copyrighted works which may reside on the chip or be generated thereby, e.g., computer programs and data bases.

17. The duration of copyright for "mask works" (bill, §6, p.6, lines 10-20) would be a ten-year period, thus setting such works apart as the only category of works under the entire statute for which a separate term of protection would exist.

18. The copyright term under the bill would be computed differently from that of all other works under the Copyright Act. The term would not be computed on the basis of any of the existing general criteria, such as the individual author's life-plus-50 years or, for corporate authors, the earliest of 75 years from publication or 100 years from creation. Rather it would be computed from the "first authorized ... distribution," "first authorized ... use in a commercial product" or "first authorized ... manufacture in commercial quantities" (bill, §6, p.6, lines 15-18). The concepts underlying the latter two of these three events appear not to have been employed by the copyright law previously.

* * * * *

As indicated at the outset of this memorandum, the specific wording of the bill can be reviewed in detail for possible modification of the language. It is suggested however that it may be more fruitful to review first some of the broader questions such as those above.

Legislation is much needed in this area. The threshhold question is whether the needed legislation should take the approach of H.R. 1028 or an alternative approach.

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May 17, 1983

Senator Charles McC. Mathias, Jr.
Chairman Committee on Patents, Copyright
and Trademarks
U.S. Senate Committee on the Judiciary
Washington, D.C. 20510

Attn: Mr. Stephen J. Metalitz, Staff Director

Dear Senator Mathias:

Thank you very much for your invitation of April 29, 1983 to testify on behalf of the Electronics Industries Association of Japan in connection with your hearings scheduled on Thursday, May 19, 1983, on legislation to provide copyright protection for semiconductor chip designs.

Your request has been communicated to the Association and I now have been advised to inform you that the Association has no position with respect to the proposed legislation at this time.

We regret that we cannot be more helpful to you and your Committee at this time.

Sincerely,

H. William Tanaka, Counsel
Electronic Industries
Association of Japan

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June 23, 1983

The Honorable Charles McC. Mathias, Jr.
United States Senate
Washington, D.C. 20510

Dear Senator Mathias:

I understand that two questions have been raised, concerning S. 1201, on which I would like my comments to be made part of the record.

I am an electrical engineer by training and have spent the last twenty-two years in the solid state electronics area involved in the design and development of semiconductors. As a result of my work, I was made a Fellow (the highest technical position) of IEEE. I received this honor for leadership in the design and development of semiconductor memories and microprocessors. I feel that gives me the authority to speak out on these issues.

First, it has been suggested that a copyright on a set of masks can somehow monopolize electronic circuitry so that later manufacturers will be prevented from using essential designs. In the same vein, it has been alleged that any engineer with the requisite skill, working on a given circuit, will tend to converge on a single most reasonable mask layout.

This is completely contrary to the experience of engineers in the semiconductor chip industry. For any desired function, there will always be a large number of different good layouts. A copyright on one layout will not keep engineers from using other functionally equivalent but visually dissimilar layouts. Engineers do not converge on a single most reasonable layout because no such thing exists. When an engineer creates his own layout instead of copying someone else's, he invariably comes up with something that looks different—probably even to a casual lay observer, but certainly to a trained eye. The likelihood of two engineers coming up with the same chip layout is equivalent to the likelihood of two college students independently writing the same essay on a final exam.

Second, it has been said that even very subtle mask changes may represent significantly different and original designs. This is true. It has been further said that exactly the sort of tests that demonstrate such differences are specifically disallowed as defenses in copyright infringement cases. I do not believe this is true, for I have been informed otherwise. But I feel that evidence of this type should be allowed in semiconductor chip copyright infringement cases and hope that the legislative history of S. 1201 would include a statement endorsing use of expert testimony to show subtle functional differences in circuit layouts.

Finally, a point deserves mention that has a bearing on both of the foregoing points. When a company decides to become a second source for a chip already on the market, it will probably want it to be equivalent to the first chip not only functionally but in terms of specifications and test data; that is, the second chip would be so fungible with the first chip from a production standpoint that it would not make any difference which one was placed into the equipment for which the chip is targeted. In these circumstances, a chip designer may feel that the fewer design or layout changes that are made from the first chip, the less likelihood there will be of a nonequivalence in specifications. This would lead to similarities in layout and appearance, but even when this happens, it is reasonably easy to tell the difference between a slavish copy and a reverse engineering job. Whenever there is a true case of reverse engineering, the second firm will have prepared a great deal of paper—logic and circuit diagrams, trial layouts, computer simulations of the chip, and the like; it will also have invested thousands of hours of work. All of these can be documented by reference to the firm's ordinary business records. A pirate has no such papers, for the pirate does none of this work. Therefore, whether there has been a true reverse engineering job or just a job of copying can be shown by looking at the defendant's records. The paper trail of a chip tells a discerning observer whether the chip is a copy or embodies the effort of reverse engineering. I would hope that a court deciding a lawsuit for copyright infringement under this Act would consider evidence of this type as it is extremely probative of whether the defendant's intent is to copy or to reverse engineer.

Sincerely yours,

Leslie L. Vadasz

Leslie L. Vadasz
Senior Vice President
Intel Corporation

cc: Steve Metalitz

GENERAL ELECTRIC

SEMICONDUCTOR BUSINESS DIVISION
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October 20, 1983

The Honorable Charles McC. Mathias
Chairman
Subcommittee on Patents, Copyrights
and Trademarks
198 Senate Russell Office Building
Washington, D.C. 20501

Dear Senator Mathias:

The General Electric Company appreciates your Subcommittee's consideration of S. 1201, the Semiconductor Chip Protection Act of 1983, and would like to add our support of the bill to the record of the hearings you have chaired.

Amendment of the Copyright Act to include semiconductors is vitally important to the semiconductor industry, and would update the act to accord with modern realities. No other form of intellectual property protection is as appropriate to semiconductor designs, and some form of protection is necessary to offset the ability of copying firms to take market share from innovative firms while deterring new product development.

We hope you will support S. 1201. With your support, the bill can soon begin to provide protection to firms in our industry.

Sincerely,

James E. Dykes
Vice President and General Manager

JED:rpr

cc: Rep. Don Edwards
Rep. Tim Valentine

SEMICONDUCTOR RESEARCH CORPORATION

COOPERATIVE RESEARCH

October 31, 1983

The Honorable Charles McC. Mathias
Chairman
Subcommittee on Patents, Copyrights
and Trademarks
198 Senate Russell Office Building
Washington, DC 20510

Dear Senator Mathias:

Your subcommittee is currently considering the Semiconductor Chip Protection Act of 1983 (S. 1201) which you have introduced. I write on behalf of the Semiconductor Research Corporation to express our appreciation of your efforts to hold hearings on this bill and to urge you to support this essential legislation and move it on to speedy enactment.

One of the major goals of the cooperative research currently sponsored by SIA member companies through the Semiconductor Research Corporation is the capability to automatically design semiconductor chips that represent the integration of literally millions of transistors onto a "chip" of silicon that is wafer-thin and about one quarter of an inch square. Manually, this task represents hundreds of thousands of man hours which is prohibitively expensive. The investment in research to automate the design process is negated if copyright protection is not granted under the law.

As a formal statement of our position, we ask that this letter be entered into the record of your hearings on S. 1201.

Sincerely,

Larry W. Sumney
Executive Director

LWS:mpr

cc: Rep. Ed Zschau
Rep. Don Edwards

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SIA SEMICONDUCTOR INDUSTRY ASSOCIATION
4320 Stevens Creek Blvd. • Suite 275 • San Jose, CA 95129 • (408) 246-1181

November 30, 1983

Senator Charles McC. Mathias
Chairman
Subcommittee on Patents, Copyrights
and Trademarks
Senate Judiciary Committee
198 Russell Office Building
Washington, DC 20510

Dear Senator Mathias:

The Semiconductor Industry Association would like to thank you for your efforts in connection with the Semiconductor Chip Protection Act (S. 1201).

Our industry has achieved and maintained very high rates of technological advancement since the development of the first commercial semiconductor devices in the 1950's. Today a one quarter inch square semiconductor chip which sells for under $10 is able to store far more information and perform more tasks than could the computers of thirty years ago, which occupied whole rooms and cost millions of dollars to produce.

This rapid technological advancement has been mirrored in our economic growth. Since the early 1970's, the U.S. semiconductor industry has enjoyed annual rates of growth in excess of 20%. The development of our products has played a direct role, as well, in the economic development of other U.S. high technology industries, which have grown at a real annual rate of 7% during the same period.

Much of this growth, both technological and economic, can be traced to the U.S. semiconductor industry's very high levels of research and development (R&D) and investment. In 1982 for the U.S. semiconductor industry as a whole, R&D expenditures as a percentage of sales were 10.7% and investment as a percentage of sales was over 14%. It is these expenditures which are threatened by semiconductor piracy.

As you are aware, the R&D costs which firms must bear in order to create a new family of semiconductor devices have risen dramatically in recent years and for a complex microprocessor can now reach $100 million. Since pirate firms are able to copy the main chip of that family for as little as $50,000 to $100,000, or the entire family for less than $1 million, pirate firms have far lower up-front fixed costs. Pirate firms are, therefore, able to sell their copied product at a much lower price than would an innovative firm. The innovative firm, forced to meet the price set by its pirate competitor, would then achieve a much lower rate of return on its investment than originally anticipated. In some cases, firms' revenues have been reduced by tens of millions of dollars per year as a result of a single case of piracy. The result is that innovative product development is discouraged and fewer funds are available to cover past and future R&D investment costs.

The attached study prepared for the SIA provides a more detailed description of the negative effects of piracy on the U.S. semiconductor industry, and we request that it and this letter be made a part of the official record on S. 1201.

The SIA believes that the Semiconductor Chip Protection Act offers the best way in which to protect U.S. semiconductor firms from losses due to piracy, and greatly appreciates your efforts to achieve passage of the bill.

Sincerely yours,

Warren Davis

Warren Davis
Director, Government Relations
Semiconductor Industry
Association

cdh/H-30:3

NEWS RELEASE OF THE AMERICAN ELECTRONICS ASSOCIATION (AEA)

PALO ALTO, CA., Aug. 2 -- The American Electronics Association (AEA) announced today that it supports passage of the Semiconductor Chip Protection Acts of 1983 which provide copyright coverage for semiconductor designs and masks (glass plates that incorporate circuit patterns).

Both bills (H.R. 1028 and S. 1201) are presently in committee.

The unauthorized copying of chip designs has become common practice, particularly by foreign companies. Development costs, including technical support, for a new design can range up to $50 million and it is tempting to avoid this expense by simply copying a sucessful semiconductor pattern. By photographically copying the chip design, an unscrupulous firm can reproduce the masks for as little as $50,000. This company can produce and then sell the original product at a much lower price than is possible for the innovative firm.

The bills amend the U.S. Copyright Act by establishing a new category of technical creativity designated "mask works." They provide a ten-year term of use rather than the usual 75-year period. However, the copyright owner is denied relief from innocent infringers and must agree on a reasonable royalty license should the infringing party unknowingly commit funds to manufacture the resulting semiconductor. Finally, competitors are guaranteed the right to copy and study the product and, if possible, reverse engineer their own chip.

"These bills will enable U.S. semiconductor manufacturers to remain competitive in an increasingly combative world marketplace," stated Ralph Thomson, Senior Vice President, American Electronics Association. "They provide incentives for these firms to invest in vital research and development programs and eliminate the unfair advantage presently available to those who would pirate and subsequently copy semiconductor designs." He added that there would be administrative costs and no new bureaucracy associated with implementation of the bills.

All United States semiconductor companies have endorsed the Semiconductor Chip Protection Acts as has the Semiconductor Industry Association (SIA).

The American Electronics Association represents both the electronics and the information processing industries and has a membership of nearly 2,300 companies throughout the United States. The 40-year-old trade association is headquartered in Palo Alto, California, has a government operations office in Washington, D.C., and regional offices in New England, New Jersey, Los Angeles and Orange County, California.

MAGAZINE AND NEWSPAPER ARTICLES

[Special Report from Business Week, May 23, 1983]

CHIP WARS: THE JAPANESE THREAT—WITH 30 PERCENT OF WORLD MARKETS, ITS SEMICONDUCTOR INDUSTRY IS GAINING FAST

Competing in the U.S. semiconductor business has never been easy. Chipmaking has always been a boom-or-bust affair where hordes of young, inexperienced managers often cut prices faster than they could reduce production costs. But now, as chipmakers emerge from their current bust and move into the next business boom, American companies are heading straight for their toughest competitive fight ever.

The outcome of this battle will be just as important to the nation as it will be to the chipmakers. Integrated circuits (ICs) launched the second industrial revolution; they are the starting point for much of the U.S. high-technology industry and have created dozens of new industries, ranging from computers to video games. U.S. chipmakers have dominated the world semiconductor market from its inception in the early 1950s. Last year, U.S. companies still accounted for 67 percent of the $14.6 billion worth of semiconductors sold worldwide.

Climbing out of past recessions for U.S. chipmakers usually meant worrying about one another's prices and new products. This time, though, the Americans are sweating out competition they once ignored—from Japan. Picking up speed rapidly, the Japanese are now a strong No. 2, with about 30 percent of the world market. This battle is causing wrenching structural changes in the U.S. semiconductor industry. The fight will revolve around these key issues:

THE ENEMY CAMP

Japanese chipmakers, which gained a U.S. beachhead after the 1973-75 recession simply by having production capacity when U.S. suppliers did not, are trying now to duplicate their earlier success with computer memories. They are going after such U.S. markets as the microprocessor—the computer-on-a-chip—and standard logic circuits, the basic building blocks used in electronic products ranging from TV sets to missile guidance systems.

CASH SHORTAGE

U.S. producers are finding that despite increasing sales, they will not be able to generate sufficient cash to continue expanding and upgrading their production capacities. The cost of capital equipment is climbing as much as 30 percent annually—far faster than the growth in either industry revenues or profits.

CAPTIVE COMPETITION

Increasingly, sales are being taken from the chipmakers by their biggest customers, who are accelerating a drive to build more of their own semiconductor devices in captive plants. Several of these corporate giants, led by Western Electric Co., are entering the commercial chip market in direct competition.

CHANGING TECHNOLOGY

Technology is transforming the way chipmakers conduct their business (page 92). The latest superchips are packed with so much electronic circuitry that they no longer serve merely as electronic components but as entire systems on chips. Gordon E. Moore, Intel Corp. chairman and Silicon Valley's acknowledged technology guru, flatly asserts that "technology is changing just as fast as ever."

For beleaguered U.S. chipmakers, many of their problems have to do with where the semiconductor industry is in its evolution. To some observers, the industry is simply maturing. "From an economist's viewpoint, most of the classic, textbook signs are there," says Frank A. Petro, Jr., head of Arthur D. Little Inc.'s office in San Francisco. The major players have been the same for a long time, it is increasingly important to be a low-cost producer, and most participants learned to sell and distribute their products efficiently.

"The semiconductor industry has started to go through an enormous transition, and future success in this industry is going to be very much dependent on such factors as long-term planning and marketing efforts," says Thomas C. Roberts, president of Fairchild Camera & Instrument Corp., owned since 1979 by Schlumberger

Ltd. He and many other industry executives believe the day is fast approaching when a mainstream chipmaker can no longer survive on good technology and engineering alone; it must also develop the skills of a very large company—financial discipline, marketing, and people management. Japanese producers will have a big advantage because they already are part of large, sophisticated corporations.

BREAKNECK PACE

But to most Silicon Valley executives, chipmakers still has the key characteristics of an industry in its entrepreneurial phase: a compound annual average growth rate of 15 percent, a bumper crop of several dozen startups since venture capital purse strings began to loosen in 1979, and a breakneck pace of new-product development and introductions. "It certainly is not a mature industry," insists Robert R. Dickey, president of Synertek Inc., Honeywell Inc.'s chipmaking industry, growing at three or four times the rate one would associate with a mature industry."

Mature or not, U.S. semiconductor makers are now gearing up for both a recovery and an anticipated onslaught from Japan. Layoffs in the recent downturn were not nearly as widespread as in past recessions, but the battle for the smaller market decimated profits, and even the leading chip suppliers had to adjust with capital spending cuts, short workweeks, and a few layoffs.

But the worst is now over, and signs of recovery abound. "It hasn't shown up in revenues yet, but the market has recently been very strong, and bookings are up dramatically," says Frederick L. Zieber, director of semiconductor industry research at California-based Dataquest Inc. After running almost flat for three years, the U.S. chip market in 1983 will grow 13 percent, to $7.1 billion, he says. Worldwide sales will jump 14 percent to $16 billion, predicts Daniel L. Klesken, an analyst at Montgomery Securities.

In 10 years' time, industry forecasters expect semiconductors, with sales of more than $90 billion, to be one of the world's largest industries. This business will also be the platform on which two of the world's four largest industries in 1990 will be built—computers and telecommunications. By then, some experts even believe that leadership in the world market could be a toss-up between the U.S. and Japan.

Japan's penetration of the U.S. market is still relatively small—12 percent of the business in 1982—because it is concentrated in one type of product: computer memories, or chips that store digital data in random access memory (RAM). Japanese chipmakers were able to enter the U.S. memory market partly because innovative design plays a less important role than manufacturing skills—the forte of Japanese chipmakers.

OFF GUARD

The Japanese first made their mark in the U.S. in 1978, when domestic producers could not keep up with demand because they had skimped on capital spending during the 1973-75 recession. Japanese companies, in contrast, had forged ahead with their investment plans and caught the capacity-shy U.S. suppliers off guard with chips of what turned out to be better quality. By the end of 1979, Japanese producers had won 42 percent of the U.S. market for what was then the latest generation of memory, the 16K RAM, capable of storing more than 16,000 bits of data.

When the next generation of computer memories came along in 1980, the Japanese did it again. They beat the U.S. to market with the 64K RAM chip. Then the battle for this business began: 1981 was a bloodbath, with prices falling almost monthly. Japanese chipmakers won out, and last year they produced 70 percent of all the 64K RAM sold worldwide.

Now the Japan's seem to be on their way to dominating the market for 256K chips, the next generation of memory circuits, if only because so many U.S. companies have been scared away from what is seen as a profitless business. More than a dozen U.S. producers were selling 16K RAMs in 1980; their number has since dwindled by half. And only three—Texas Instruments, Motorola, and Mostek—are churning out significant quantities of 64K RAMs, virtually a prerequisite, for making a 256K RAM.

BRAGGING RIGHTS

Several Japanese companies have been proudly showing off early versions of 256K chips for several months—and now are gearing up for mass production. Not one of the traditional U.S. memory competitors is close to starting volume production. So far the only American contender is Western Electric Co. The American Telephone

& Telegraph Co. subsidiary unveiled the first U.S. version earlier this year, when it announced that it would sell semiconductor devices.

Japanese executives are now so confident of success in memories—by far the largest semiconductor market—that they have shed their usual guise of modesty and boast of their victory over the Americans. Tsuyoshi Kawanishi, head of semiconductor operations at Toshiba Corp., says that in the future, Japan will continue to play a powerful role in the world market for memories. Tomihiro Matsumura, associate senior vice-president at NEC Corp., predicts that U.S. suppliers will at best gain "close to" half of the 256K market.

The stakes are huge. Dynamic RAMs are the workhorses of the computer industry and pop up in an enormous array of other products—virtually any equipment, in fact, controlled by a computer-on-a-chip. Each new generation of RAMs fast becomes the industry's best-selling product. Today's 64K RAMs, for example, will account for sales of $1.8 billion in 1985, the year when sales are projected to peak. By 1989 the annual market for the 256K chip will hit a stunning $3.7 billion, predicts Dataquest.

TARGETS, PRESSURES

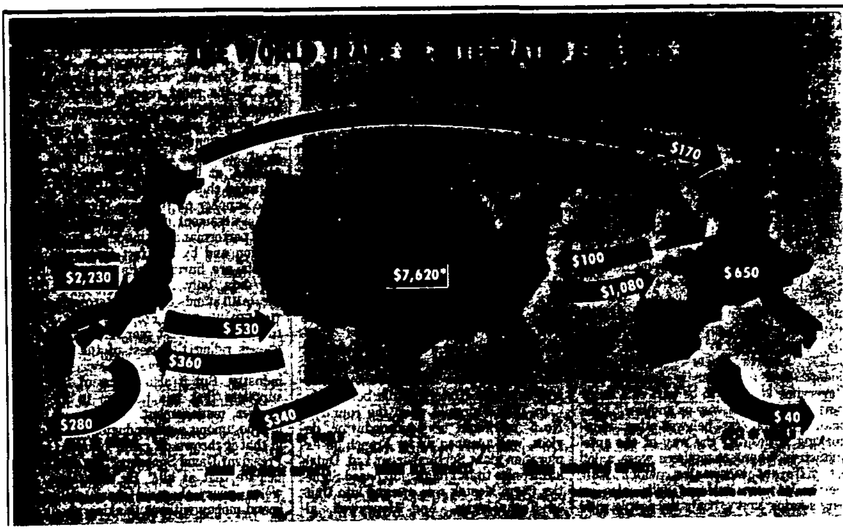
Now the Japanese intend to apply what they learned in memories to other markets. "We want to be a major semiconductor supplier [in the U.S.], and there's more to the semiconductor industry than memory," says Keiske Yawata, president of NEC Electronics USA Inc., the American offshoot of Japan's largest semiconductor maker. Matsumura, at NEC's Tokyo headquarters, says most of the company's research effort is going into microprocessors, a market now worth about $750 million—and one in which the U.S. today is preeminent. Fujitsu Ltd.'s main target is logic chips. And virtually all 13 of Japan's large chipmakers expect to carve out a piece of the booming new business in "gate arrays," a customizable chip with sales of $150 million in 1982 and heading for $600 million by 1985.

If the Japanese put the same kind of pricing pressure on the new U.S. markets they are entering as they did in memories, some U.S. executives worry about the industry's ability to fund future growth. "I'm not sure that even TI has the capital resources to last," says Harold L. Ergott Jr., president of United Technologies Corp.'s Mostek Corp. subsidiary. "Left to its own devices, TI won't be able to go up against the big, integrated companies."

Even if Japan relaxes its assault on prices, the semiconductor industry is stuck with a market-share strategy called "learning-curve pricing" that could hamper the accumulation of capital. Conceived by the Boston Consulting Group and most enthusiastically adopted by market leader Texas Instruments Inc., learning-curve pricing is designed to ensure continued market dominance. TI not only pegs its prices to falling production costs, which occur in any factory as volume grows and workers gain experience, but also moves initial prices down the learning curve ahead of actual costs reductions. The idea is to create bigger demand faster, spur cost reductions, and discourage new competitors.

MAKING INROADS

TI left its rivals with no option but to fight back with their own lower prices. The practice has "wrecked the industry," declares K. Carl Nomura, associated vice-president of Honeywell Inc.'s semiconductor group. Optimistically, Andrew S. Grove, Intel's feisty president, believes that learning-curve pricing is gradually going out of fashion. "I don't think it's being applied as broadly and with the same fervor as in the early 1970s," he says. "We are all applying more business judgment now."



Most chipmakers would like to see learning-curve pricing renounced altogether, but Normura notes that "there's a force that won't allow the industry to get away from it—and that's Japanese competition." In fact, the learning-curve philosophy could not fit better with a basic Japanese attitude. Says Yawata of NEC Electronics: "The Japanese perspective is that when you are still making inroads into a market, you can't afford the luxury of making money."

In any no-profits contest for market share, the odds are stacked heavily in favor of Japanese producers. More often than not, they are part of vertically integrated companies in the $15 billion-to-$20 billion class, so they can afford to subsidize their IC operations. This is a particularly telling advantage because of the chipmaking industry's daunting combination of enormous capital equipment needs, exceptionally high research and development spending (typically around 10 percent of sales), and brutal pricing policies.

To stay in step with technology, most U.S. chipmakers figure they need to refurbish their plants every two to three years. Ten years ago, a company could build and equip a chip factory for $15 milion to $20 million. Today it takes $50 million to $75 million. What propels these increases in equipment costs is the effort to pack more and more transistors onto the same quarter-inch-square chip of silicon. Much more elaborate production gear is needed for every big jump in the number of circuits on a single chip. But cramming more on a chip, which does not appreciably increase production costs, effectively cuts the price of computing power and makes it affordable to an ever-expanding base of price-sensitive applications.

DENSE CHIPS

The impact of increased chip density on the price of electronic circuitry has been dramatic. For example, in the 18 years from 1960 to 1978, the price for the simplest functional circuit—two transistors and five other parts—dropped from nearly $10 to just $0.1¢. The density of integrated circuits has jumped from 50 transitors in the 1960s to 1,000 in the 1970s and is now 500,000. By the 1990s each chip will contain as many as 20 million transistors. And the cost of the simplest electronic circuit is expected to be less than 0.001¢.

The big cost concern of American chipmakers now is the skyrocketing price of semiconductor production equipment. "Just 10 years ago," says Gilbert F. Amelio, the new president of Rockwell International Corp.'s Electronic Devices Div., "every dollar invested in capital equipment returned $5 to $5.50 in annual sales. Today, it's $2 and still declining." Adds Douglas L. Powell, Motorala Inc. vice-president: "This is a highly cost-intensive business, and it's getting worse. There's a 25 percent increase in the cost of equipment each year."

The industry will continue for some time to have a tremendous problem financing its own growth. "It's going to take as much innovation in financing as in technology," comments Roy H. Pollack, the hard-nosed executive vice-president who heads RCA Corp.'s semiconductor operations. He suggests that one solution might be combinations of lease and purchase of the expensive equipment—always becoming quickly obsolescent—that chipmaking requires. Another way is for large customers of chipmakers to establish special relationships and make an equity investment—deals like the $250 million injection by International Business Machines Corp. for a 12 percent interest inIntel (BW—Jan. 10).

SHACKLES

Other industry experts believe that such joint-financing arrangements are only in interim solution. Inevitably, asserts Mostek's Ergott, the independent IC maker is doomed, and "everyone is going to be part of a large corporation in one way or another." Like many others, he believes that chip-making is heading the way of the auto industry: Where once there were a lot of different companies, which won entrée into the business with sales or engineering savvy, "only the people with the capital backing for mass production survived."

Many customers that build equipment around ICs would be only too glad to help fulfill Ergott's prophecy by acquiring a chipmaker. For these companies, the rapid rate of chips' increasing sophistication is as much a shackle as an economic benefit. Chips today "have so much capability that they set the performance of the end product," explains Glenn E. Penisten, recently named executive vice-president of Gould Inc. That kind of dependence makes the customer wary of entrusting the design of such a key component to a supplier. So starting in the late 1970s, several large users began acquiring independent chipmakers, often for phenomenal sums—or they began building captive chip fabrication facilities from scratch. General Electric, GTE, and Honeywell did both.

In 1979, Fairchild, then the country's No. 5 marketer of semiconductor devices, was snapped up by French oil exploration giant Schlumberger Ltd. Dutch electronics titan Philips purchased Signetics Corps. Mostek was merged into United Technologies. And Honeywell already a sizable producer on its own, added Synertek, while GE acquired Intersil. In the most recent buyout, Gould picked up Penisten and American Microsystems 18 months ago.

Conventional wisdom now has it that most of these acquisitions have not worked, at least in the sense that the acquired chip company remains a profitable supplier on the open markets. While any assessment of the acquired company's performance is muddied by the recession and by the fact that sales and profits are buried in its parents' financial data, only American Microsystems Inc. (AMI) stands out as a star performer.

THE GOLDEN RULE

For one thing, AMI—the world's largest merchant of custom ICs—is riding the crest of the wave of customizable products now sweeping the industry. But it also is one of the few suppliers that has held on to its premerger management. "AMI is a little unique among semiconductor companies in that it throws off cash," muses Gould President David Simpson. "We didn't anticipate that at all." He adds that "all we've given them is more ability to spend money without thinking about it." AMI has seized the opportunity by spending twice as much on capital equipment since the acquisition as it did in the five preceding years.

Fairchild, which cost Schlumberger $400 million to acquire—not counting big losses in 1981 and 1982 and a smaller loss anticipated this year—has so far been a dismal failure. The chipmaker has slipped from No. 5 to No. 6 in the U.S. marketplace, despite a steady flow of capital—$600 million to date—for new equipment and a doubling of the R&D budget. "Schlumberger tried to impose its corporate culture on a fast-growing organism," says Gould's Simpson. A former Fairchild executive agrees: "They made it clear they were playing by the old golden rule: He with the gold rules."

Under Schlumberger, Fairchild has shed more than a third of its employees and recently it closed its plant for MOS (metal oxide semiconductor), the mainstream semiconductor manufacturing process. That leaves it with only one small plant to serve what is nearly two-thirds of the IC market, and the fastest-growing two-thirds at that. "It got to be frustrating," gripes a former manager, "to get new ideas endorsed by, basically, an oil-field company that didn't have the foggiest notion of what high technology is really all about."

The other acquired chipmakers have been lackluster performers at best. Of Synertek, for example, on semiconductor executive notes that "it's no disaster, but it's lost momentum." But there are signs that some of them may yet turn around. Mostek, for example, which so far has cost United Technologies a total of roughly $1 billion, showed black ink in December for the first time since it was acquired. And it is well on its way to becoming the leading U.S. supplier of 64K RAMs, now shipping more than 3 million of the memory chips monthly.

Despite the many problems that equipment makers have in acquiring and running chip lines, "most of the larger U.S. companies are now trying to acquire semiconductor capability," says James E. Dykes, general manager of GE's Semiconductor Div. As circuit density moves toward millions of devices per chip, manufacturers of proprietary equipment believe they must develop their own semiconductor design and production facilities. VLSI Research Inc., a San Jose (Calif.) market researcher that tracks the capital equipment business, lists a dozen captive plants in planning or under construction.

In fact, captive chipmaking—led by IBM, which, with a projected IC production value of more than $1.2 billion in 1983, is the world's No. 2 chipmaker (table, page 90)—has become the fastest-growing segment of the industry. "We feel that their growth will exceed that of the U.S. and Japanese merchant suppliers," says Glen R. Madland, chairman of Integrated Circuit Engineering Corp., a Scottsdale (Ariz.) consultant. Many observers expect internal suppliers to account for close to half of this country's IC production by the end of the decade, up from about 30 percent currently.

Attempting to rationalize chip production, some captive producers have recently moved into the market. Few electronic equipment makers are large enough to consume all the output of an IC line. "Our biggest barn-burner is the avionics business, where we make approximately 225 systems per day," reports Charles V. Kovac, marketing vice-president at Rockwell's Electronic Devices Div. "Each system uses 10 chips, so that means you're talking about 4,000 pieces—and we literally spill that much on our pilot line."

NEW RIVALS

Another reason captive producers are taking their semiconductor products to market is the high cost of chipmaking equipment. Selling on the outside generates a partial return on chipmaking assets and helps to achieve economies of scale that will reduce the cost of chips consumed in-house. "Today," complains AMI's Penisten, "our biggest competition is our customers."

Two years ago, NCR Corp. began offering its chips on the open market; this year, two-thirds of production—perhaps as much as $70 million—will go to outside customers. Honeywell will soon do the same with chips produced on its captive line. And by far the biggest captive to take the plunge is Western Electric, which will produce an estimated $400 million worth of IC's this year. In addition to its 256K RAM, the company plans to sell nearly every type of solid-state device is has been producing for the Bell System. "As we see opportunities in the commercial market, we will even be building new semiconductor capacity in the near future," says Philip E. Hogin, Executive vice-president for Western.

The Major reason why Western is selling on the marketplace is the breakup of its parent, American Telephone & Telepgraph Co. Bell's internal needs will now be "too small a market for products that require such tremendous amounts of capital," Hogin says. His charge is to make a profit, since AT&T now looks to Western Electric as a profit center. "If our costs are such that we can't price to the market and make money," he says, "we're going to do one of two things: Either we'll do something else, or we'll fix it. And more often than not, it'll be the latter." Observers believe that Western Electric, backed by the resources of Bell Laboratories Inc., could emerge as one of the semiconductor industry's leading players, if it does well in marketing and cost-sensitive manufacturing.

Heightened competition for the established U.S. semiconductor industry also comes from the new wave of startups. With the big chipmakers concentrating on standard parts that sell annually by the millions, entrepreneurs have spotted a promising niche in providing the semicustom or custom-designed ICs that equipment makers need in smaller quantities. Made possible by the advancing technology and the easy availability of venture capital, several dozen startup companies have sprung up since 1979, offering services for designing custom or semicustom chips.

CELL "LIBRARIES"

Most of these small companies are currently wooing customers from the traditional chipmakers with a product called a gate array. This chip consists of a standardized grid of transistors that are connected together in the last processing step to give the chip its unique design for performing a specific task. A few startups offer standard cell designs, where a custom chip can be designed more easily by putting together functional blocks of circuitry from standard cell "libraries" stored in a computer memory.

Yet some industry observers are skeptical about the potential of this crop of semiconductor newcomers. "I'm not going to argue that there's not a big business in custom chips, but it has still to be proven that it's a vible business for a startup," says Federico Faggin, founder of chipmaker Zilog Inc., who is now starting up his own systems company. "They'll do well for a while, but they will fail to generate enough cash to keep their technology sharp." Adds the top technologist for a major semiconductor producer: "This is the round where the venture capitalists get burned."

JAPANESE CHIPMAKERS CLIMB THE TOP 10

1983 rank	1979 rank	Company	Estimated 1963 integrated circuit sales (millions)
1	1	Texas Instruments	$1,276
2	2	IBM	1,262
3	3	Hitachi	958
4	7	NEC	942
5	5	Motorola	842
6	4	Philips	805
7	6	National Semiconductor	783
8	10	Fujitsu	692
9	8	Intel	655
10	11	Toshiba	597

Data: VLSI Research Inc.

A DECADE AWAY

The main reason for such lackluster appraisals is simply that the big chipmakers have recognized the potential of custom and semicustom chips and are moving quickly into this business. The large producers ultimately would have had to make the investment in any event, because the new superchips are so complex that they cannot be designed using traditional manual approaches. The chipmakers, however, are a decade away from perfecting the computer-aided design and computer-aided engineering tools needed for a totally automatic way to design custom chips. "But in 15 or 20 years, we'll have machines not much larger than a desk; you sit down and define your circuit, and it spits out the chips," says Gordon B. Hoffman, vice-president and general manager of United Technologies' Microelectronics Center.

By the early 1990s, Rockwell's Amelio believes that without the staying power to make the massive investments needed, most chipmakers will have been absorbed. By then, the semiconductor industry could well be mature. "When the industry gets as big as the automotive industry, say, its gross in going to be dictated by the health of the world economy," Amelio points out. "Then we won't have all this change and jockeying for position. It'll become a stable industry, like the automotive industry did 50 years ago, and it will go on like that for many, many years."

[Special Report from Business Week, May 23, 1983]

CHIPMAKERS POOL THEIR RESEARCH TO STAY COMPETITIVE

Leaders of the U.S. semiconductor industry have long believed that the central planning and coordination practiced by Japan's government and industry amounted to unfair competition for America's fiercely independent, entrepreneurial chipmakers. And despite intensive lobbying, U.S. producers for a long time had no luck in persuading their government that this problem posed a danger to the nation as well as to American industry.

But the times they are a-changing. Not too long ago, the Reagan Administration informally put out the word that the Justice Department would take a relaxed view of any collaborative efforts on the part of semiconductor manufacturers—and would, for example, encourage cooperative research. "It has finally dawned on the country that this is one technology we can't afford to hand to the Japanese," says John D. Shea, president of Technology Analysis Group Inc., a California company that tracks technology trends.

The U.S. chipmakers reacted quickly, enlisting many of their large customers to help fund generic research. "Microelectronic warfare," declares W. J. "Jerry" Sanders III, president of Advanced Micro Devices Inc., "calls for macroeconomic countermeasures."

Typifying this new approach is Semiconductor Research Corp. (SRC), which is emerging as the coordinator of the nation's chip research. The not-for-profit company was founded just a year ago by a handful of chipmakers to organize and sponsor basic research. It now includes most of the top-tier chipmakers and nearly all leading U.S. computer makers. "We're moving along," says Executive Director Larry W. Sumney. "We're currently signing or negotiating about 43 research contracts with 26 universities."

$30 MILLION BY 1986

SRC will plow $11 million into research this year and about $15 million next year. That may not seem a lot, but Erich Bloch, SRC chairman and a vice-president of International Business Machines Corp., notes that it represents a healthy increase in funding. He explains that the National Science Foundation last year anted up $7.5 million for basic research in semiconductor technologies, and all semiconductor companies combined spent only an estimated $20 million to $25 million. "So," says Bloch, "we are adding a significant amount of dollars to the total research effort." And by 1986 the research cooperative hopes to have an annual budget exceeding $30 million.

Three types of research are already being funded:

Permanent "centers of excellence" in several scientific disciplines will be supported with typical grants of $1 million annually. There have already been picked: Cornell University in micro-science, and Carnegie-Mellon University and the University of California at Berkeley in computer-aided design, SRC plans to select a half-dozen more centers over the next three years.

Project awards, each worth about $100,000, will be granted annually to about 30 selected professors for research in techniques for designing, producing, testing, and packaging intergrated circuits.

The research cooperative will probe frontiers with "new thrust" programs. For example, Massachusetts Institute of Technology will look into three-dimensional chip structures. And the new Massachusetts Center of North Carolina will look at new chip-fabrication techniques.

The co-op was established with the understanding that it would not overlap a sister organization, Microelectronics & Computer Technology Corp. (MCC), which was set up in January. SRC's Sumney reports that he and MCC head Bobby R. Inman are "trying to formalize a relationship." One idea would require a company to join SRC before it could become a member of MCC. Under another proposal, SRC would function as MCC's research arm in semiconductors.

PENTAGON CONNECTION

MCC will sponsor high-risk systems-level research in both computers and software. Unlike SRC, notes Inman MCC will support research done in members facilities by "a substantial body of people assembled from shareholders and from outside." John W. Lacey, executive vice-president for technology at Control Data Corp. and a director of both coops, adds that after MCC has helped members share the cost of developing new technology, they will have to "compete like sons of guns to develop products of their own."

Sumney previously ran the Pentagon's very high-speed integrated circuit (VHSIC) project, and he is now engaged in "extensive discussions" about collaboration with Richard D. DeLauer, Defense Under Secretary for research and engineering, and Robert S. Cooper, director of the Defense Advanced Research Projects Agency (DARPA).

DeLauer is a big booster of joint research. He made a last-minute appearance at an industry symposium on cooperative research earlier this year and pledged Pentagon resources to help the U.S. "keep the information processing market for the next decade." DARPA, he revealed at the meeting, had just asked Congress for $50 million to launch a five-year, $500 million project to develop a supercomputer that DeLauer dubbed the nth-generation computer. "I don't want to say it's a fifth- or sixth-generation machine," he quipped, "only that it will outperform anything the Japanese develop."

'A MINI MITI'

Already, SRC's tentacles stretch to every sector of semiconductor technology. One Silicon Valley executive characterizes SRC as "a mini MITI"—referring to Japan's Ministry of International Trade & Industry, which directed most of the research exploited so successfully by Japan's chipmakers.

More modest alliances—teams of two or three companies, usually—are also cropping up. "Look at the number of agreements between suppliers today vs. three years ago," points out John F. Mitchell, president of Motorola Inc. Then, everyone tried to reinvent the same thing. We were killing each other," not the Japanese, he says.

Collaborations big and small will continue to spread among U.S. electronic companies, predicts A. Douglas Ritchie, general manager of semiconductor operations at Burroughs Corp. To Sanders of Advanced Mirco Devices, how the industry nurtures much seeds as SRC and MCC may determine "whether America sinks to managing decay or rises to shaping the future."

[Special Report from Business Week, May 23, 1983]

JAPAN COULD SOON CATCH THE U.S. IN CAPITAL SPENDING

A good indicator of what direction the fight between the U.S. and Japan will take in the worldwide chip market is how much each is spending for new plant and equipment. And the latest figures on capital spending do not bode well for American chipmakers. Spending is fast approaching parity between the two adversaries—at least among the leading integrated circuit producers.

The problem is that the Japanese are spending a far bigger percentage of their sales on expanding their capacity. The baker's dozen of leading semiconductor makers in Japan poured $838 million, or 25.4 percent of sales, into capital investments, 27 percent more than in 1981, according to the Ministry of International Trade & Industry (MITI).

By contrast, the nine major U.S. manufacturers in 1982 invested $1.18 billion in plant and equipment, down 11 percent from a year before, reports Dataquest Inc. And their capital budgets dipped to 15 percent of sales, two points less than in 1981.

The gap in capital spending will narrow even further in 1983, predicts Integrated Circuit Engineering Corp. ICE warns that the eight biggest Japanese suppliers will invest $1.05 billion this year—against $1.1 billion for the top eight U.S. chipmakers.

DEEP POCKETS

The implication of such bullish spending is plan. "We'll easily take a good position over our American competitors," boasts Associate Senior Vice-President Tomihiro Matsummura of NEC Corp. NEC plowed $221 million into semiconductor investments in fiscal 1982. That amount was more than half the total capital spending done by the $5.3 billion company.

Unlike their U.S. counterparts, most Japanese chipmakers are diversified powerhouses that can roll over profits from a variety of product lines into their capital-hungry semiconductor operations, "Our sales amount to less than 10 percent of total Toshiba [sales]," says Tsuyoshi Kawanishi, group executive of Toshiba Corp.'s semiconductor group. "But the policy [governing capital investment] is not decided by our profit or loss."

Because of the Japanese companies' deep pockets, Thomas P. Kurlak, an analyst at Merrill Lynch, Pierce, Fenner & Smith Inc., takes a dour view of U.S. prospects. "If our industry is willing to really turn on its spending right now," he says, "we can prevent a major loss of market share—but some loss is inevitable."

The gap in capital spending between the two countries began narrowing in 1976. At that point, the U.S. industry was "outinvesting" its Japanese counterparts by $4.43 to $1. By 1981 that ratio had shrunk to $1.84 to $1. Philip L. Gregory, executive vice-president of the Semiconductor Equipment & Materials Institute, predicts that because of Japan's aggressive capital spending and its pricing practices, the Japanese will corral another 5 percent of the U.S. and European markets by 1985.

Some U.S. leaders are still optimistic. "I don't think Japan is sitting on that much more excess capacity than the U.S.," asserts James R. Fiebiger, assistant general manager at Motorla Inc.'s semiconductor center in Phoenix. Fiebiger points out that because they are also users of the devices, Japanese chipmakers buy hardware—especially testing equipment—that U.S. producers do not need. "We're going to be in a lot better shape than we were in 1974 and 1975," Fiebiger insists. "The U.S. is not so capital-starved that it won't be able to take advantage of new opportunities."

DOUBLING EXPORTS

But some U.S. observers are getting pessimistic. Kurlak of Merrill Lynch, for example, predicts that Japan's total semiconductor production will exceed U.S. output "relatively soon—within three years or so." In fact, Robert G. Simko, senior vice-president of Technology Analysis Group Inc., believes that in 1982 Japan for the first time produced more semiconductor devices than American producers. The U.S. remains ahead in dollar sales only because it makes more sophisticated products.

Last year, despite the recession, Japanese chipmakers more than doubled IC exports to the U.S., from $252 million in 1981 to $532 million, according to the U.S. Census Bureau. U.S. chip sales to Japan, meanwhile, inched up from $133 million to $159 million—less than Japan's sales in the U.S. of just one product, the 64K RAM chip.

[Special Report from Business Week, May 23, 1983]

THE TECHNOLOGY THAT WILL CREATE TOMORROW'S SUPERCHIP

For three decades, rapidly changing technology has given severe heartburn to chip designers and manufacturers alike. The next decade will be no exception. No design will be safe, and no production process will be the ultimate one. Technology will propel the fast-growing chip business even faster, providing new opportunities for laggards to lead—and possibly even making it easier for U.S. companies to hang on to first place in the world market.

The main technology thrust, as before, will be to fabricate as many transistors and other circuit elements as possible on a quarter-inch chip of silicon. However, the major changes will come not in the manufacturing processes but in the technologies needed to design the chip and its package. Not that manufacturing technology is standing still. The parade of better processing technologies continues, and there are even signs that the various methods of making integrated circuits (ICs) are merging into one, all-purpose process called CMOS (pronounced sea-moss) that will be able to turn out superchips for the next decade.

Today's chips are already so complex and powerful that they are doing more and more of the jobs once done by complete electronic systems, and that has unleashed a new set of problems. "By 1991 we'll have in the range of 15 million to 20 million devices on each chip, compared with a half-million on today's 256K RAM [memory]," predicts J. Jeffrey La Vell, technology strategist at Motorola Inc.'s semiconductor group in Phoenix. "There are simply not enough chip designers in the world" to design the usual complement of new chips at that level of complexity. So Motorola, like the rest of the industry, is furiously trying to automate the IC design process.

ASKING FOR HELP

Once that kind of automation is in place, the semiconductor companies will make it available to their customers, as well. With the chip now dictating the performance of end products, equipment makers are demanding ICs tailored specifically for each application, and they are pressing their semiconductor vendors to teach them the secrets of chip design. "Customers find it more and more difficult to give up the design of the thing that establishes the features they take into their marketplace," says Glenn E. Penisten, an executive vice-president of Gould Inc. and formerly chairman of Gould's American Microsystems Inc. subsidiary.

Few technical developments have changed the semiconductor industry as much as design automation will end up doing. "It's transforming the whole industry from mass-market, jelly bean producers to a value-added, engineering-service business," Penisten says. "Everything that made them successful in the past doesn't apply today." Agrees Douglas L. Powell, director of strategic marketing for Motorola's semiconductor group: "It's going to be difficult. Equipment designers are suddenly doing the same thing that chip designers do—which means they ask for a lot of help."

Already more than 100 semiconductor companies offer limited computer-aided design (CAD) facilities to help users. These parts are usually "gate arrays," or standard chips that are mass-produced in the factory up to the final one or two processing steps. Only then are the transistors, or gates, linked together to handle a customer's specific needs.

The industry is now advancing rapidly toward the next stage of automation, where functional circuit blocks, called standard cells, are stored in computer libraries. The designer calls up the standard cells—equivalent to older, simpler ICs—necessary to do his specific job, and the computer puts them together and chips the specifications off to the factory for fabrication. "Computers are the way to design ICs, and we're just at the beginning of it," asserts Gordon B. Hoffman, vice-president and general manager of United Technologies Corp.'s Microelectronics Center in Colorado Springs, Colo. Adds Motorola's La Vell: "The methodologies we see emerging in gate arrays and standard cells are forerunners of a new way of designing VLSI [very large-scale integrated] chips."

The large chipmakers, in fact, have been using computer aids for VLSI designs for several years. "As IC complexity increased, it got so that one man couldn't design a chip alone," notes H. Wayne Spence, a vice-president at Texas Instruments Inc. As early as 1975, he adds, "we had to come up with some method of describing, documenting, and sharing design details." Such tools were vital in the late 1970s, when families of microprocessors (the computer-on-a-chip) and memories blossomed.

Until recently, semiconductor manufacturers were reluctant to give away any of their design or process know-how for fear it might blunt their edge in the hotly competitive semiconductor marketplace. Another reason for their caution is that the design tools are still far from foolproof. Users often run into trouble because they fail to define their product properly to the computer or because the computer's models do not reflect a specific manufacturing process accurately enough. "When your customer has access to your CAD, it open up a Pandora's box," says Motorola's Powell. "You don't know what he's doing or how well he's qualified to do it. If he doesn't do it right, then you have to pull him out."

Putting the customer in charge of product design is forging new, tighter relationships between chip suppliers and users. No longer will a sale be just a pact between peddler and purchasing agent; instead, it will require the involvement of engineering staffs and, often, of managements. "We're going to see a total change in U.S. [semiconductor] markets and how we address them over the next five years," says James E. Dykes, general manager of General Electric Co.'s Semiconductor Div.

For one thing, custom-designed chips are expected to account for half of the industry's total output by 1990, up from about one-fourth today. Most custom production now is firmly lodged in customer's captive facilities, but virtually all chipmakers are developing more custom capability. Also, custom designs cannot be sold out of a catalog or through distributors. So the industry—both Japanese and American—is rushing to set up design centers in such electronics hotbeds as Silicon Valley, Los Angeles, and Boston, where customers can work with a chip supplier's engineers and software design tools.

The need for this extraordinary cooperation between vendor and user has spawned a rash of startup companies specializing in gate-array and standard-cell designs. Young companies generally are willing to spend time guiding customers. However, some experts feel that such approaches are bound to fail, that the startups will eventually have to grow into complete semiconductor houses to remain viable. These experts note that a full set of design tools, plus the test equipment required to check out small batches of completed chips, can cost as much as the latest version of an IC production line.

As chip design becomes more automated, designing an entire system-on-a-chip from scratch will become commonplace. Even with today's gate-array technique, such design becomes a powerful tool. Already, CXC Corp., a startup specializing in telephone exchanges (PBX), was able to design a complete exchange on just one silicon chip, replacing four printed-circuit boards full of components. "The economics are overwhelming," and the technology in the design tools is "awesome," marvels Gary A. Nelson, director of systems development at the year-old Irvine (Calif.) company.

But developing the in-house capability to do this designing with standard cells will cost an equipment maker or a new IC manufacturer substantial time and money. United Technologies, for example, has already invested $70 million in computer software and test equipment for its gate-array and standard-cell business. "Startups will find it hard to make the transition from gate arrays to standard cells.

The problem with standard cells is, you need a lot of volume to get a controllable process," UTC's Hoffman explains. Another stumbling block: Customers will want prototype chips a week after submitting their finished designs, and only the companies that control every step of the process will be able to meet that kind of turnaround demand.

TOO HOT

For Japanese chipmakers, the changing supplier-customer link will pose different obstacles. "Distance and language problems and all the other things that tend to get in the way of that kind of relationship will make it more difficult" for them, says Allan L. Rayfield, president of GTE Communications Products Corp. To succeed in gate arrays, Japanese companies "will have to build locally," agrees Takashi Kubo, who heads the electronic components section of the Japan Electronic Industry Assn. Several Japanese companies already intend to build in the U.S. Toshiba Corp., which now makes gate-array chips under contract to LSI Logic Corp., plans to build the semicustom chips at its Sunnyvale (Calif.) plant. And NEC Corp. expects to start producing custom chips in 1985 at its new facility in Roseville, Calif.

As the semiconductor manufacturers speed toward chips containing more than 1 million transistors, they all seem to be taking a crash course in the same CMOS manufacturing technology. One person is that CMOS, because of its peculiar design, is now the bet answer to the heat problem. All chips generate heat when they are working—the more transistors on a chip, the more heat it throws off—and this heat has to be removed to keep them operating. If tomorrow's superchips were built with today's technology, they would get too hot to function. "Anyone who builds large systems is interested [in CMOS]," explains William G. Howard Jr., vice-president for semiconductor technology and planning at Motorola, "because if you don't put the heat in, you don't have to take it out."

CMOS technology originally was a complex production process that industry leaders such as TI and Intel Corp. virtually ignored. T. J. Rodgers, president of six-month-old Cypress Semiconductor Corp. in Santa Clara, Calif., explains: "The U.S. companies said CMOS was going to be a niche market." That perception is now changing, Rodgers adds, "but the Japanese are way ahead."

CALCULATORS AND WATCHES

What kicked off CMOS was its low power consumption, which made it ideal for battery-operated products. Virtually all digital calculators and watches are now built with chips made with this process. But because American companies were beaten in the consumer electronics business, they started lagging behind the Japanese in CMOS in the mid-1970s. "When the Japanese took away the watch and calculator business, interest in CMOS just stopped in this country," recalls D. John Carey, chairman of Integrated Device Technology Inc., a Santa Clara startup focused on CMOS.

CMOS is now widely used for telecommunications ICs, which are powered by tiny voltages fed along telephone lines. Intel has decided to build its 64K RAM with CMOS, and the industry figures that by the mid-1980s most computer memory chips will be built using the technology. Because of all this action, CMOS sales are taking off. In 1979 the technology made up a scant 12 percent of all IC shipments, 47 percent of them produced by Japanese companies. By 1988, the industry figures, CMOS circuits will account for 16 percent of all chips—and the Japanese will turn out 53 percent of them.

"The main problem for U.S. makers is that we [Japanese] have the experience," says Susumu Kohyama, manager of CMOS technology at Toshiba's laboratories. Motorola's Howard points out that U.S. companies had huge investments in a technology called N-channel MOS, so they kept pouring money into that bread-and-butter process. "In the U.S., there was tremendous emphasis on N-channel MOS because [more circuits could be squeezed on a chip], and that paid off," Howard says. "Japan was starting without this kind of large base and was looking for future leverage and correctly guessed CMOS. But their lead is not insurmountable."

HOUSEHOLD CURRENT

Two years ago, U.S. companies began waking up, and some now claim they have brought their CMOS technology up to the level of Toshiba and Hitachi, the leading Japanese producers. "I think it's a parity situation," declares F. Josepy Van Poppelen, marketing vice-president at National Semiconductor Corp. "No Japanese company has a CMOS process better than National's."

Now the U.S. companies are starting to apply the tricks of CMOS to their older technologies. "There's a tremendous blurring of what used to be well-defined technologies," says Motorola's Howard. "MOS and bipolar [the other major semiconductor manufacturing process] and the discrete devices [individual transistors and diodes] are all growing together." Motorola, for example, has started building CMOS circuits on the surface of its bipolar power transistor chips.

The promise of power transistors with brains—or computer chips that can handle high power levels—is vast. Today's ICs require a transformer to reduce standard household current (110 volts) to the 5 volts they need to operate. "Anything that's plunged into the wall can eventually be using one of these chips in it," says GE's Dykes.

Detroit is interested in the smart power chips simply to untangle the maze of wires running to every light and motor on an automobile. "Anything that requires power for activation could be queried by computer and controlled by computer," says Neal E. Stouder, a supervisor at General Motors Corp.'s Delco Electronics Div. If the power switches that control lights and electric windows could also decode computer signals, then a single wire could carry the control signal to every relevant part.

For all the sophistication of chip manufacturing and design, the Achilles' heel of tomorrow's superchip could well be the centipede-like package that protects the chip and allows it to be plugged into an electronic system. "I think packaging is going to be the limitation of VLSI," says K. Carl Nomura, associate vice-president of Honeywell Inc.'s semiconductor group. More complex chips will mean more data to exchange with the outside world, and today's chip packages have a maximum of about 150 legs, the connections that carry data in and out. The industry has toyed with many approaches: flat housings with metalized edges, packages that look like an Indian fakir's bed of nails, even chips with bumps that are soldered directly on a printed-circuit board.

PACKAGING

Perhaps the most sophisticated package built so far is the water-cooled module with 1,800 connections that International Business Machines Corp. uses in its mainframe computers. IBM invested a lot of money in the package, says Paul R. Low, vice-president of IBM's General Technology Div., because "you need more than just bits on a chip to exploit the technology. [The package] shares at least a 50–50 role."

The new sophisticated packages, however, are either very expensive or do not satisfy enough of the industry's needs. Motorola has been working for five years—without success—to find the ultimate solution. "There's going to have to be a major change in packaging over the next five years, and it's going to require an invention," Howard predicts.

Much the same could be said for the whole design and fabrication process: Technology will be vital to anyone who expects to keep in the thick of the race for making and selling chips—at least for the next decade. "The 1970s was the decade of N-channel MOS. The 1980s will be the decade of CMOS," says Teruyuki Nishijima, a vice-presdient at Toshiba. "The 1990s? Nobody knows."

[From the Washington Post, May 2, 1983]

HIGH TECH: LEAVING HOME

BATTLING TO INNOVATE AND EMULATE: INTEL VS. NIPPON ELECTRIC

(By Dan Morgan)

Contributing to this series were Tokyo bureau chief Tracy Dahlby, who conducted interviews in Japan, and Hobart Rowen, senior economics writer. Staff researcher Carin Pratt assisted with the reporting and research.

Peering into a micrscope at a greatly magnified computer chip one day last August, Peter Stoll of Intel Corp. saw something startlingly familiar. In one of the tiny cells, two transistors were disconnected from the rest of the chip, and dangled uselessly in their bed of silicon.

Stoll, 33, a chip designer, recognized the defect as a small, last-minute repair job he had performed on Intel's 8086 microprocessor several years earlier. It had worked, correcting the minor flaw in the chip's logic, and the 8086 went on to become phenomenally successful as the "brain" in a wide range of business computers, robots and industrial machinery.

But what startled Stoll was the chip under the microscope was not Intel's. It was a product of Nippon Electric Co. (NEC) of Tokyo. Stoll concluded that he was looking at a Japanese copy so perfect that it even repeated the small imperfection in the original chip.

Intrigue of that kind in the $13 billion-a-year global market for computer chips has led to U.S. accusations of unfair Japanese practices, ranging from copying to protectionism. Critics of Japan say that its efforts to gain supremacy in computer chips, perhaps the single most important technology of the Information Age, are typical of the methods employed by "Japan Inc."

"We're at war, no doubt about it," said a computer scientist from a large U.S. research laboratory. "If I had money in Silicon Valley,' I'd get it out. . . . It's just like any other war zone."

U.S. politicians are in a mood to strike back.

Democratic Reps. Don Edwards and Norman Y. Mineta, from California's so-called Silicon Valley area, have introduced a bill to give copyright protection to chip designs. They say the measure is needed to stop "pirate firms" from "flooding markets with copied designs that undersell the innovating firms."

But some trade specialists caution that there is a Japanese side to this story. For one thing, U.S. companies are holding their own in the competition.

Japan, whose share of the U.S. chip market is well under 10 percent, has made inroads in some kinds of chips, such as memories, that store information. But the United States is dominant in microprocessors, the "computers on a chip" that serve as brains for computers and controls in dishwashers, jet aircraft, missiles, industrial robots, telephone systems, traffic lights and hundreds of other products.

Many experts insists that Japan's progress is not attributable to copying.

"The basis for the Japanese taking an ever larger share of the [chip] market is not transfer of American technology," said a patent attorney for a large U.S. company. "It's Japanese management, equipment and a degree of cooperation between firms that's prohibited in this country."

Even the issues in the Intel-Nippon Electric dispute about alleged copying of the 8086 microprocessor become fuzzier on closer inspection. Intel contended that NEC wrongfully copied the chip's microcode, the set of internal instructions laid out as a pattern of transistors on the chip's memory. Intel counsel Roger Borovoy said the microcode was copyrighted and could not be used without Intel's permission.

Officials from NEC's U.S. sales company acknowledge that the microcode on their chip is identical to that on Intel's, including the flaw engraved onto the original.

"If you're not 100 percent identical, you're dead. If you take the fatal flaw out, it wouldn't be compatible. We have chosen to be as close to the original as possible," said NEC's David Millet, who is in charge of nationwide marketing of microprocessors.

But NEC officials in Japan and the United States deny that the company did anything wrong, contending that they had a right to produce their own version of the chip under a 1976 agreement allowing both companies to use the other's patents.

NEC officials in this country say the question of whether the microcode can be copyrighted has never been decided in court, and Intel agrees. And they say that NEC even sent Intel a 1979 announcement of NEC's version of the 8086.

The story of the NEC-Intel dispute is representative of the suspicion, tension and, often, grudging admiration that characterize the competition between the two countries. It begins with the markedly different cultures and societies from which the two have emerged.

The roots of competition

Compared with the 84-year-old NEC, Intel is an upstart company, an example of American boldness and nerve that began with a few dozen employes in Santa Clara, Calif., in 1968 and grew into a business with 19,000 employes worldwide.

Intel's stock in trade has been innovation. Since it was founded, the company has spewed out firsts, including the first microprocessor in 1973. A founder, Robert Noyce, is one of the inventors of the integrated circuit, which became a basic component of modern electronics.

Intel is also a sort of corporate melting pot that, like the nation itself, has drawn its brain power from all over the world. Its current president came to America as a refugee from Hungary in 1957; a senior vice president was born in Hungary, and an Israeli, an Italian and a Japanese are credited with helping to develop several new Intel products.

NEC has succeeded in typical Japanese fashion: through dogged determination, aggressive marketing and initial reliance on U.S. technology, including that of Intel.

From the outset, NEC had financial and structural advantages over Intel. While Intel makes more than 80 percent of its income from the sale of chips, NEC is a conglomerate that produces computers, electrical equipment and other products. Chips account for less than 20 percent of its revenue, so a temporary decline in that business can be offset by gains in other products.

As a member of the influential Sumitomo industrial group, NEC could draw on the financial resources of the Sumitomo Bank and on the marketing connections of the Sumitomo trading company. But Intel has depended for its financing on the vagaries of the U.S. stock market and bank loans. For most of the last 10 years, Intel has had to borrow money at much higher interest rates than NEC.

Until the early 1970s, NEC was no match for American chip makers. The U.S. computer chip industry was expanding rapidly, thanks in part to heavy government spending on chips for the Apollo man-on-the-moon space program and the Minuteman intercontinental ballistic missile.

In 1973, computer scientists in Intel's laboratory scored a major breakthrough with invention of the first microprocessor. This was a watershed not only for Intel, but also in the history of the information industry.

Until then, chips generally had performed only a single talk, such as adding, subtracting, multiplying or dividing. Combining those tasks required wiring together several chips on a bulky board. But a single microprocessor chip could perform all those functions. This meant, for example, that one computing chip could run a pocket calculator, shut off a microwave oven, analyze blood or control traffic signals.

It was possible for general-purpose microprocessing chips to replace more expensive, customized ones previously needed by industry. As microprocessors became more sophisticated, they increasingly began to do jobs that previously had required large, cumbersome computers.

NEC claims to have developed an early microprocessor on its own at about the same time as Intel. This chip, the uCom 4, could handle simple tasks such as oparting a pocket calculator. But Japanese officials acknowledge that they have had trouble keeping up with U.S. advances in microprocessors. To do so, Japanese companies have repeatedly relied on U.S. patents and "reverse engineering."

Industry representatives make a distinction between reverse engineering, a generally legitimate practice in which one company's designs are used as a model by another company's engineers, and copying, in which imprints of circuitry are taken by using photographic and lithographic techniques.

In the late 1970s, for example, NEC produced a version of Intel's 8080 microprocessor, the first chip complex enough to handle word-processing programs. A new generation of micrprocessors was making possible the era of small, compact personal computers, and Intel was again in the lead.

Tomihiro Matsumara, NEC's senior vice president for research, acknowledged in an interview that NEC attempted to make and sell its own comparable chip, "but we did not succeed." So, he said, NEC engineers analyzed the 8080, then laid out their own "completely different" version, using NEC manufacturing techniques.

Roger Brorvoy, Intel's general counsel until he left the company last month, said Intel had no objection because NEC had used the 8080 only as a model and not "copied" it.

Japan, he acknowledged, was becoming an innovator in chips in its own right. Between 1974 and 1977, the government had poured at least $300 million into a research consortium that included NEC and five other companies. "They had come a long way with their own development. They'd attained a status of their own," Borovoy recalled.

Evidence of NEC's progress come in April, 1976, when Intel and NEC signed an agreement that enabled each company to use the other's patents. In the next several years, Intel was to utilize several NEC patents for specialized types of chips.

By the late 1970s, NEC, Hitachi, Fujitsu and Toshiba were grabbing significant shares of the world market in memory chips, devices that store information but do not perform the complex tasks of microprocessors. But these companies still had problems with the far more complex microprocessors.

In 1978, a year before NEC completed its version of the 8080, Intel introduced a much more advanced microprocessor, the 8086. It crammed 30,000 transistors onto a quarter-inch-square piece of silicon, producing as much computing power as some 1960s' computers that filled rooms. The 8086 could handle not only word processing but also complex mathematics, and it and comparable microprocessors are being used in most sophisticated personal and business computers, such as IBM's popular personal model.

NEC's representatives recognized that the 8086 gave the United States a decisive edge in silicon brain power. In 1978 they approached Intel about supplying technical aid to produce the 8086 in return for a percentage of the money NEC would get from selling the 8086 in Japan.

But this time, Intel turned NEC down. NEC, in the midst of a U.S. expansion program, was preparing to enter the international chip market in a big way. It had just purchased a California computer memory company called Elctronic Arrays and was planning a second California facility for making memories and logic circuits.

"We weren't anxious to help our competitor," an Intel official said.

Instead, Intel made a deal with NEC's Japanese rival, Fujitsu. Thwarted, NEC decided to go ahead with a version of the 8086 without special help from Intel.

NEC's Matsumara acknowledged that the resulting chip is "interchangeable" with the Intel version, but he strongly denies that it was "copied." Similarly, Robert Hinckley, an attorney for NEC in San Francisco, contends that NEC had a right to reverse-engineer the chip because of the patent cross-licensing agreement of April, 1976.

NEC officials said it was no secret that they would produce the 8086. Electronic News reported it and, NEC officials said, they sent a copy of their announcement to Intel and received no protests.

NEC, however, had several problems.

For one thing, the Japanese company apparently had difficulties reproducing a version of the Intel device without American help. It was not until 1980, two years after Intel's 8066 appeared, that NEC's comparable chip was sold in the United States.

There was also the problem of Intel's copyright on the chip's microcode, a sort of brain within a brain. It is the part of the microprocessor that takes electronic commands from a keyboard and tells the rest of the chip's parts what to do with the commands and in what sequence.

Like a video-game cartridge, the microcode is a computer program that has been written by a programmer and then is built into the chip. In a Pac Man videgame, the microcode tells the Pac Man what to do. In a microprocessor, the microcode tells a computer what to do. Although the microcode appears in the 8086 as hardware—a pattern of 10,752 tiny transistors—Intel maintains that it is not a mere piece of electrical circuitry but is "intellectual property" covered by copyright law.

Copyrighting the microcode had seemed to Borovoy a way to protect the company's intellectual effort from infringement. Borovoy said his "knees wouldn't shake" at bringing a lawsuit against a company that copied Intel's microcode.

But Hinckley, NEC's San Francisco attorney, said no cases have been adjudicated establishing any company's copyright claim on such material.

"Copyright is designed to protect works of authorship—artistic works—and we don't think microcode qualifies," he maintained.

Whatever the merits of their respective cases, NEC and Intel reached a settlement on the 8086 in March after several months of negotiations and without litigation. Borovoy, who said he could not discuss details of the settlement, said the agreement would save hundreds of thousands of dollars in court costs.

The battle for market share

But the dispute over the 8086 is seen at Intel as only one chapter in what will undoubtedly be a continuing battle.

"The Japanese see themselves locked in a warlike struggle, determined single-mindedly to reach their objectives by any means, regardless of the impact on the U.S. . . . It's going to be a very, very bloody battle out there," Intel's Noyce said.

He argued that Japanese tactics have denied American companies the fruits of their innovation, profits that enable them to pour money into creating new technical breakthroughs needed to maintain the U.S. lead.

U.S. studies have accumulated a mass of evidence buttressing Noyce's contention that the Japanese government has shield local chip companies from U.S. competition while they prepared for an onslaught on traditional U.S. markets. U.S. companies have never been able to capture more than 20 percent of the Japanese chip market even when their technological lead was overwhelming.

Before 1978, only Texas Instruments was permitted to establish a wholly owned manufacturing subsidiary in Japan, and even TI had to share some of its patents with Japanese companies to secure that concession.

Few deny that the Japanese challenge is serious. Japan is running a $250 million trade surplus with the United States in chips. And NEC and Hitachi ranked just behind Motorola and Texas Instruments as world leaders in sales last year.

A detailed study issued in February, 1982, by the congressional Joint Economic Committee warned that the main casualties of the relentless Japanese export drive could be small, innovative Silicon Valley companies. With them out of the running, it warned, Japan would be in a position to beat the United States at innovation.

Some industrial experts say the United States should keep its sense of perspective as it responds to Japan's challenge.

Robert B. Reich of the Kennedy School of Government at Harvard University said Japanese chip companies made headway after 1975 primarily because they plunged ahead while U.S. companies, hard hit by the recession, "stood still."

U.S. companies have recently regained some of their lost share of the world market in memory chips and still have an impressive lead in microprocessors. In typical U.S. fashion, Intel is on the verge of marketing an even more advanced microprocessor, the 80386, which the company claims will be far ahead of anything produced in Japan.

Intel has also announced that it will soon sell the first magnetic, bubble-type memory capable of storing 4 million bits of information, the equivalent of 240 typewritten pages.

"Despite trade barriers and protection and copying, we're still winning, although that's no guarantee for the future," said Bob Derby, who ran Intel's marketing operations in Japan.

That, free traders say, should be a warning to those in Congress who want to wield the big stick of government retaliation in the computer chip battles with Japan.

CHIPS: A GLOSSARY OF TERMS

Silicon: the hard, gray, lightweight material from which chips are made. Wafers of silicon are "doped" with impurities in selected places to change electrical properties and affect the path of the current. Lithography is used to imprint tiny wires, or circuits, on a chip's silicon layers.

Transistor: on electrical switch in a chip that can be turned on and off in a controlled way to store or process data.

Integrated circuit: a combination of transistors. The latest generation contains as many as 100,000.

Memory: a chip that stores information.

Microprocessor: a chip that performs some of the same tasks as a computer; the "brain," or control, in hundreds of pieces of equipment, from car engines to computers.

Microcode: a software program that is the permanent set of instructions on a microprocessor chip.

Bit: A single "on" or "off" signal, a single piece of electronic code. It takes several bits together to represent one letter, punctuation mark or numeral.

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