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ARTICLES

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INTRODUCTION

In the late 1970s, the American semiconductor industry matured from adolescence into adulthood. The industry moved from the hustling days of its youth to a midlife crisis. Semiconductor manufacturers met stiff competition within the industry, particularly from foreign manufacturers. A group of leaders of the industry believed some of their competitors were competing unfairly by stealing product designs. Some of these leaders, proponents of chip protection, went to Congress to ask for special legislative protection for their products. These industry spokesmen cited instances of direct, photographic copying of semiconductor chips. They presented graphic evidence of copying by both foreign and domestic manufacturers. The industry asked Congress for an amendment to the federal copyright law[1] to outlaw such piracy. The initial proposal, in 1979, was an amendment to the definition section[2] of the copyright code to include expressly the masks used to produce integrated circuit chips as "[p]ictorial, graphic and sculptural works" under the Copyright Act.[3]

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1. 17 U.S.C. §§ 101-914 (1988 & Supp. III 1991).

2. 17 U.S.C. § 101 (1988 & Supp. III 1991).

3. The bill would have added the following sentence to § 101 of the Copyright Act: "Such pictorial, graphic, and sculptural works shall also include the photographic masks

However, this proposal was resisted by other leaders of the industry, the opponents of chip protection. This group asserted that chip protection would prohibit the practice of reverse engineering. Reverse engineering is an established industry practice in which a chip manufacturer photographically reproduces a competitor's chip. In this way, the manufacturer can analyze and improve the chip design and thereby enter the market for that chip. The goal of reverse engineering is generating a new product with "form, fit and function" compatibility with the old product. Stated another way, the goal of reverse engineering is producing a chip which directly replaces the competitor's chip and which can be manufactured for less. Lower manufacturing costs allow lower sales prices and allow the manufacturer to capture market share. Opponents of chip protection regarded reverse engineering as essential to a competitive marketplace. They therefore resisted efforts to protect chip designs.

Due to this resistance, the 1979 effort to amend the Copyright Act to protect chips failed. In 1983, however, industry representatives gave unanimous support to a sui generis approach to the problem. The Semiconductor Chip Protection Act of 1984[4] ("the Chip Act") was a wholly new type of intellectual property protection independent of copyright and patent[5] protection. The Chip Act was more than an amendment to the Copyright Act. Most importantly, the Chip Act provided for legitimate reverse engineering. The semiconductor industry insisted this protection was absolutely vital to its continued good health. Congress agreed.

During the 1983 hearings on the bill that became the Chip Act, Representative Norman Mineta, a Member of Congress from California's Silicon Valley, made a statement urging passage of the bill.[6] Representative Mineta contended that protection of the semi-

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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." H.R. 1007, 96th Cong., 1st Sess. (1979).

4. 17 U.S.C. §§ 901-914 (1988 & Supp. III 1991).

5. 35 U.S.C. §§ 101-376 (1988 & Supp. II 1990).

6. *The Semiconductor Chip Protection Act of 1983: Hearings on H.R. 1028 Before the Subcomm. on Courts, Civil Liberties and the Administration of Justice of the House*

conductor industry was essential to long-term American economic interests and that chip makers needed incentives and protection. According to him, the Copyright Act should be kept up to date by including integrated circuits within its scope. Representative Mineta stated "[o]ur laws must be adapted to fit the realities of our times."[7] Unfortunately, the Chip Act passed by Congress was adapted to the realities of the 1970s, not the 1990s.

After seven years, only one appellate opinion involving the Chip Act has been reported.[8] The "vital protection" provided by the Chip Act has played only a small part in protecting the rights of chip makers. This Article examines the background of the Chip Act and what happened to the American semiconductor industry during the 1980s. Part One of this Article examines the problems cited by the industry in 1979 and 1983 in attempting to justify the Chip Act, as well as the arguments by those opposed to the Chip Act within the industry. Part Two of this Article presents the elements of the protection provided by Congress in the Chip Act, including limitations, such as reverse engineering, which restrict the effectiveness of the Chip Act. Lastly, Part Three of this Article examines these limitations as well as changes in the semiconductor industry and in semiconductor technology which have largely mooted the Chip Act.

I. What the Semiconductor Industry Was Complaining About

A. Introduction: The Problem

The semiconductor industry grew up as one of the miracles of American industry. Semiconductor design and manufacturing technology leapt ahead each year. The industry attracted bright, aggressive men and women. They created new devices and ways to make those devices. They put those devices in new products. They sold those new products to customers in government and

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Judiciary Comm., 98th Cong., 1st Sess. 7 (1983) [hereinafter *1983 House Hearings*] (statement of Rep. Mineta).

7. *Id.*

8. Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 155 (Fed. Cir. 1992).

industry. They made a lot of money in the process.

During the first twenty years of its existence, the semiconductor industry displayed a gold-rush mentality. In the 1960s, the industry's growth was fueled by government expenditures on the space program and the Vietnam war. The 1970s saw the advance of semiconductors into consumer and business applications. These early years frequently featured twenty percent annual growth in revenues for the industry and even more spectacular results for particular firms and individuals. From a single parent—Fairchild Camera and Instrument Corp.—dozens of start-up and spinoff companies were created to capitalize on the drive and innovation of its founders.[9] Venture capitalists flocked to Silicon Valley to mine this boom. The Federal Trade Commission captured the spirit of the industry in a 1977 report:

> The most important feature of this industry is its rapid rate of innovation and technological change. Although it has a high rate of expenditures in research and development, those expenditures can only partly explain the rapid rate of innovation. Other features that seem equally or more important are the use of second sourcing, the mobility of technical personnel, and the relatively low cost and ease of entry into the industry. The fact that companies can rapidly copy each other is very important. This rapid copying is the result of the mobility of personnel from firm to firm and the unwillingness of most firms to bring trade secret or patent infringement suits. The rapid innovation and copying can also be explained by the number of times executive and technical personnel have left large firms to set up their own small, spin-off firms.[10]

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9. By 1979, approximately 35 companies had been formed by former Fairchild employees, including National Semiconductor Corp., Intel Corp., and Advanced Micro Devices Inc. *Copyright Protection for Imprinted Design Patterns on Semiconductor Chips; Hearing on H.R. 1007 Before the Subcomm. on Courts, Civil Liberties and the Administration of Justice of the House Comm. on the Judiciary*, 96th Cong., 1st Sess. 59 (1979) [hereinafter *1979 House Hearings*].

10. *Id.* at 52 (statement of John Finch, Vice President and General Manager of Semiconductor Production, National Semiconductor Corp., quoting FEDERAL TRADE

Thus, the Silicon Valley gold rush was fueled by the ready portability of intellectual property.

The booming semiconductor industry of the 1970s was largely an American phenomenon. Most of the companies involved were American; most were located in a few square miles of the Santa Clara Valley in California. Japanese and European manufacturers trailed the Americans in manufacturing technology. The bulk of the market was American, too. Seventy percent of the market for integrated circuits was in the United States.[11] Technology flowed easily between American semiconductor manufacturers and was readily available to international competitors.

The Japanese, in particular, took an interest in this market. Large Japanese corporations began investing in semiconductor technology. The factors cited in the Federal Trade Commission report eased the Japanese entry into the industry.[12] The relaxed attitude of U.S. manufacturers toward second sourcing and mobility of personnel and intellectual property allowed the Japanese access to American technology. Japanese chip makers used reverse engineering to develop market share in the same way that American manufacturers did. U.S. reluctance to press trade secret or patent infringements suits made taking technology a low-risk venture. The Japanese firms which developed semiconductor technology were vertically integrated manufacturers of consumer and electronic goods. Thus, they already had in place in-house markets for their semiconductor products. In time, these firms sought to profit from in-house technologies through external sales. The Japanese took what the Americans had, learned from it, and began to compete.

At the same time as competition for American firms increased, the cost of designing and making chips escalated. Innovative designs required increasingly expensive manufacturing processes to overcome physical limitations. Manufacturers had to retool with expensive new capital equipment for each new product generation.

COMM'N, BUREAU OF ECONOMICS, STAFF REPORT ON SEMICONDUCTOR INDUSTRY (1977)).

11. *1979 House Hearings*, *supra* note 9, at 71.

12. *See supra* note 10 and accompanying text.

Meanwhile, the mechanisms for technological mobility—lax enforcement of intellectual property rights and highly mobile technical personnel[13]—remained in place.

The increased competition and cost of capital prompted a group of U.S. integrated circuit manufacturers to seek protection from Congress. These proponents of chip protection sought to control the mobility of technology by limiting access to existing designs. They believed the wholesale copying of chip designs, or "piracy," threatened their investments in capital equipment. They demanded protection from pirates' ability to steal market share by stealing design and manufacturing technology.

No existing form of intellectual property adequately covered integrated circuits. Most integrated circuit layouts lack the novelty or nonobviousness necessary for patent protection.[14] Once a product such as an integrated circuit is marketed, any trade secrets it contains are no longer secret, a prerequisite for protection.[15] Some other form of protection was necessary. Copyright protection, available for both two-dimensional pictorial and graphic works as well as three-dimensional sculptural works,[16] was an obvious choice for protecting chips.

The article to be protected was a chip made of silicon or other semiconductor material. Patterns etched in its surface define transistors and other circuit devices as well as the wires which interconnect them.[17] The patterns originate on a mask, a plate of clear quartz containing opaque geometric shapes corresponding to the patterns to be etched. Production of a completed semiconductor chip may require up to 20 masks, each containing patterns for a

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13. *See id.*

14. H.R. REP. NO. 781, 98th Cong., 2d Sess. 3 (1984), *reprinted in* 1984 U.S.C.C.A.N. 5750, 5752; *see* 35 U.S.C. §§ 101-103 (1988) (statutory standards for patentability).

15. *See, e.g.*, Illinois Trade Secrets Act, ILL. REV. STAT. ch. 140, para. 352(d)(2) (1992) (owner must make reasonable efforts to maintain secrecy of a trade secret).

16. 17 U.S.C. § 102(a)(5) (1988).

17. A detailed description of semiconductor manufacturing technology is beyond the scope of this paper. For such a description, see H.R. REP. NO. 781, *supra* note 14, at 11-14, *reprinted in* 1984 U.S.C.C.A.N. at 5760-63.

different layer.[18] Each mask acts as a stencil in patterning the silicon. The patterns are "written" on the mask by an electron beam controlled by a computer and using coordinates that describe the geometric shapes stored in a computer file. The computer file is created by a layout designer using a graphics workstation.[19] The integrated circuit thus consists of a series of patterns which cooperate to form a functioning circuit.

Thus, copyright protection seemed closest to what the semiconductor industry wanted in 1979, proprietary rights in a two- or three-dimensional manufactured article. In 1979, however, the application of copyright law to integrated circuits was not clear.[20]

The Copyright Act prohibits registration of "useful articles" as pictorial, graphic or sculptural works.[21] The Copyright Office took the position that integrated circuits were purely utilitarian and had refused to register them.[22] Consequently, supporters of protection for integrated circuits determined to petition Congress to amend the Copyright Act to provide protection specifically for integrated circuit chips.[23]

B. The Argument For Protection

The supporters of integrated circuit copyright protection cited the skyrocketing expense of chip development and the relative ease of chip piracy as motivation for the bill. In 1969, a typical integrated circuit required 10 person-months to design. In 1979, owing

18. *See infra* note 25 and accompanying text.

19. *See infra* note 68 and accompanying text.

20. In 1979, issues of copyright in technologically new media such as computer software had not yet been addressed by the courts. *See, e.g.*, Apple Computer Inc. v. Franklin Computer Corp., 714 F.2d 1240 (3d Cir. 1983) (computer program embedded in a ROM is copyrightable; computer object code and operating system programs are copyrightable), *cert. dismissed*, 464 U.S. 1033 (1984). The copyright for a computer program in a ROM, however, is different from the copyright for the ROM chip itself in the same way that numbers recorded on a business form are different from the blank form itself.

21. *See infra* notes 57-59 and accompanying text.

22. H.R. REP. NO. 781, *supra* note 14, at 4, *reprinted in* 1984 U.S.C.C.A.N. at 5753.

23. *See supra* note 3.

to increased complexity and higher levels of integration, the typical circuit required 200 person-months to design.[24] This increase in complexity was made possible by advancing the level of manufacturing technology, primarily the ability to create finer line widths on masks and to print those on silicon chips reliably.[25] The ability to put smaller devices closer together on a chip in turn allowed engineers to put more devices on the same size chip. The close packing and interconnection of these additional devices accounted for the additional design time.[26] More devices per chip allowed design of more advanced chips such as microprocessors.

These more advanced chips were often created as members of a related "family" of devices.[27] For example, a microprocessor family often includes a math coprocessor to speed mathematical calculations. The family may include a separate chip to handle input-output operations between the microprocessor and a variety of peripheral devices. DRAMs[28] require a periodic refresh operation in order to maintain stored data. Chips were developed to handle the refresh operation independently. The supporters of integrated circuit protection cited the development costs of these families of advanced chips as justifying the legislation.

At the 1983 hearings, Intel noted the enormous cost of developing a family of chips for a legitimate semiconductor manufacturer.[29] In addition to the main microprocessor chip, the manufacturer had to develop additional chips in the family, software for the chip, and

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24. *1979 House Hearings*, *supra* note 9, at 39 (statement of Dr. Andrew S. Grove, President of Intel Corp., appearing on behalf of American Electronics Association).

25. More advanced semiconductor processes also typically require more mask layers to produce a completed device. For example, the advance from NMOS technology to CMOS, while having the advantage of greatly reducing power consumption, adds several more masks to the manufacturing process.

26. Of course, the additional devices form a more complex circuit which itself requires additional design and debug time.

27. *1983 House Hearings*, *supra* note 6, at 28.

28. Dynamic Random Access Memory chips.

29. *1983 House Hearings*, *supra* note 6, at 34 (statement of F. Thomas Dunlap, Jr., Corporate Counsel and Secretary of Intel Corp., appearing on behalf of Semiconductor Industry Association).

computers to help the customer develop his own software.[30] Intel also noted that the cost of developing the market for the family of chips could equal the research and development cost for the chips.[31] Intel summarized the "[t]ypical cost of a complete family of chips":

Research and Development Cost for the Main Chip	$4 million
Research and Development Cost of Additional Chips, Development Tools, and Software	$40 million
Market Development Cost	$36 million
TOTAL	$80 million[32]

For Intel and other supporters of integrated circuit protection, the stakes were very high.

The great fear of the supporters of the bill was chip piracy. The pirates were competing semiconductor manufacturers who legitimately purchased integrated circuits, copied them, and began manufacturing and selling competing chips. The pirate removed the lid of the package containing the chip in order to access the chip.[33] The pirate then photographed the top layer of the chip at high magnification. This layer contains the final layer of interconnect metal.[34] The pirate then duplicated the layout of the chip's top level on his own graphics workstation using the precise measurements taken from the photograph. When the top level of the pirated copy was completed, the pirate then etched away the top level of the chip he was copying to expose the layer beneath, containing the first interconnect layer.[35] This layer, and all the layers beneath, were photographed and duplicated in the same manner. The result was a precise duplicate of the layout of the pirated chip.[36] From this layout, the pirate could manufacture[37] and market in direct

30. *Id.* at 28.

31. *Id.*

32. *Id.*

33. *1983 House Hearings*, *supra* note 6, at 27.

34. Interconnect metal is analogous to wires that interconnect portions of the circuit.

35. This layer is typically made of metal or polysilicon and is used to interconnect individual devices such as transistors and resistors.

36. *1983 House Hearings*, *supra* note 6, at 27.

37. The pirate's ability to manufacture the design which he has pirated assumes he has access to manufacturing process technology compatible with that of the original design. *See 1983 House Hearings*, *supra* note 6, at 211 (statement of Dr. Christopher K.

competition with the original chip.

The supporters of chip protection had graphic evidence of piracy. Dr. Andrew S. Grove, president of Intel, presented photographs of an Intel DRAM chip and an exact copy of the Intel chip produced by the Japanese firm Toshiba.[38] Intel had purchased the Toshiba chip on the open market, where it was competing with Intel chips.[39] Intel also produced photos of a Soviet-made memory chip that was a copy of another Intel product.[40] A representative of Intersil testified that in the late 1970s, his company produced a successful line of analog-to-digital converter chips.[41] The chips were copied by another Silicon Valley manufacturer and marketed in competition with Intersil's chips.

The potential profits to the pirate were tremendous. As noted by Intel, the pirate need not copy an entire family of chips.[42] The pirate chose the high volume products where his total profits could be maximized. The cost to the pirate of photographically copying the chip was around $100,000.[43] Other than copying and manufac-

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Layton, Vice President of RTP Operations, Intersil Inc., appearing on behalf of Semiconductor Industry Association, noting that the pirate's job is done after copying the chip if "the copier's manufacturing process is substantially the same as the chip originator's process"); *see infra* note 162 and accompanying text.

38. *1979 House Hearings*, *supra* note 9, at 40.

39. *Id.*

40. *Id.*

41. *1983 House Hearings*, *supra* note 6, at 207.

42. *Id.* at 28.

43. *Id.* This is the figure cited by Intel at the *1983 House Hearings*. The House Report on the Chip Act gave the pirate's cost as "less than $50,000." H.R. REP. NO. 781, *supra* note 14, at 11-14, *reprinted in* 1984 U.S.C.C.A.N. at 5751. The $50,000 figure appears to come from the statement of L. J. Sevin, President of Mostek Corp., during the 1979 hearings. *1979 House Hearings*, *supra* note 9, at 31 ("There is a company in Japan that can be hired to copy it in less than three months for less than $50 thousand."). The Semiconductor Industry Association submitted an analysis of the economics of chip piracy to the 1983 hearings which also cited the $50,000 figure. *1983 House Hearings*, *supra* note 6, at 178.

It is not clear what either of these amounts include. Expenses for the pirate should include cameras and film, microscope, probes, chemicals and related equipment, computer aided design workstation, mask costs, manufacturing costs, and other labor and materials. A one-time pirate would have to recoup these costs from a single chip. Repeated piracy would allow amortization over several copied chips.

turing costs, the cost to the pirate was small. He capitalized on the legitimate manufacturer's research and development costs as embodied in the copied chip.[44] The market for the chip was fully developed by the legitimate manufacturer.[45] After recapturing his minimal copying and manufacturing expenditures, the pirate was in a position of pure profit. The pirate had a significant economic advantage over the legitimate manufacturer.

The legitimate manufacturer initially set its new product prices high. When the legitimate manufacturer first introduced the family of chips, it had a monopoly over the market for those devices. The legitimate manufacturer thus could set prices high enough to cover its high development costs and earn a profit.[46] These profits could then be invested in other research and development costs.[47] Short-term monopoly pricing created the incentive that allowed the innovative firm to conduct research and development.[48]

In contrast to the high prices required by the legitimate manufacturer, the pirate required a price high enough only to cover his

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44. *1983 House Hearings, supra* note 6, at 28.

45. *Id.*

46. *1983 House Hearings, supra* note 6, at 183; *The Semiconductor Chip Protection Act of 1983: Hearing on S. 1201 Before the Subcomm. on Patents, Copyrights and Trademarks of the Senate Judiciary Comm.*, 98th Cong., 1st Sess. 136 (1983) [hereinafter *1983 Senate Hearings*] (submitted statement of Semiconductor Industry Association).

47. *1983 House Hearings, supra* note 6, at 183; *1983 Senate Hearings, supra* note 46, at 126.

48. More recently, firms such as Intel have attempted to retain monopoly profits by limiting legitimate access to their chips by other firms and by aggressively protecting their intellectual property rights on all fronts. *See* Fred Davis, *AMD 386 Chips Make It to Market Despite Intel Impediments*, PC WK., Apr. 15, 1991, at 150 (Intel liable in arbitration for damages for breach of contract with AMD to second source Intel's 80386 microprocessor, arbitrator calling Intel's conduct "a classic example of a breach of the covenant of good faith and fair dealing, preaching good faith but practicing duplicity"); Intel Corp. v. Advanced Micro Devices, Inc., 756 F. Supp. 1292 (N.D. Cal. 1991) (memorandum of intended decision concluding that the unregistered trademark "386" is generic and therefore not able to be protected). This aggressive posture reflects the increased competition in the market and the failure of the Chip Act to accomplish its goals. See Part III, *infra*. This also reflects the revitalization of patent law following Congress's establishment of the United States Court of Appeals for the Federal Circuit. *See* Robert L. Risberg, Jr., Comment, *Five Years Without Infringement Litigation Under the Semiconductor Chip Protection Act: Unmasking the Spectre of Chip Piracy In An Era of Diverse and Incompatible Process Technologies*, 1990 WIS. L. REV. 241.

copying and manufacturing costs. Also, the pirate had no need to fund research and development of future products.[49] In order to gain market share from the legitimate producer, the pirate is in a position to use price as a weapon.[50] At the extreme, the pirate could set a price so low as to drive the legitimate manufacturer from the market.[51]

Thus, the argument in favor of new protection for integrated circuits focused on the disincentive to innovative research and development created by pirating.[52] Increasing product complexity is an inherent attribute of the semiconductor industry.[53] That increasing complexity created increasing design costs and design risks. The increasing costs resulted from new process development and the added design time. The risks resulted from the uncertainty that a new chip would function, or would be successful on the market, or would be copied.[54] As business entities, semiconductor manufacturers can gauge the technological and marketing risks. By seeking legal protection for integrated circuit designs, the proponents of protection for integrated circuits sought to eliminate the risk of copying, which was largely beyond their control.

C. The Argument Against Protection

Other members of the semiconductor industry, the opponents of chip protection, were less concerned about this risk. The opponents of the 1979 bill to provide copyright protection for integrated circuits asserted several legal and commercial arguments against the bill. According to these arguments, by adding integrated circuit masks to the definition of "pictorial, graphic and sculptural

49. *1983 House Hearings*, *supra* note 6, at 184; *1983 Senate Hearings*, *supra* note 46, at 127 (submitted statement of Semiconductor Industry Association).

50. *1983 House Hearings*, *supra* note 6, at 28 (statement of F. Thomas Dunlap, Jr.).

51. *Id.* at 184; *1983 Senate Hearings*, *supra* note 46, at 127 (submitted statement of Semiconductor Industry Association).

52. *1983 House Hearings*, *supra* note 6, at 28 (statement of F. Thomas Dunlap, Jr.); *id.* at 212 (statement of Dr. Christopher K. Layton); *1979 House Hearings*, *supra* note 9, at 27 (statement of L. J. Sevin); *id.* at 32 (statement of Dr. Andrew S. Grove).

53. *1979 House Hearings*, *supra* note 9, at 40 (statement of Dr. Andrew S. Grove).

54. *Id.*

works,"[55] the bill violated fundamental principles of copyright law. Also, opponents believed the bill created unpredictable hazards for businesses in the industry.

Opponents of the bill relied primarily on legal arguments against amending the Copyright Act of 1976.[56] They asserted that copyright protection would not be helpful because of the Useful Article Doctrine of copyright law. Under this doctrine, copyright does not subsist in "useful articles."[57] A useful article has some "intrinsic utilitarian function that is not merely to portray the appearance of the article or to convey information."[58] The rationale of the Useful Article Doctrine is the denial of copyright where the use of the idea requires copying the work itself.[59]

Opponents of H.R. 1007 believed that integrated circuits are useful articles.[60] They asserted that the semiconductor industry of 1979 was built on second sourcing other manufacturers' products.[61] Chips which are second sourced must have identical functionality at each pin. Duplicating functionality required copying, especially in smaller, less complicated chips.[62] Thus, use of the chip required its copying, the very definition of a useful article. Under the Use-

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55. 17 U.S.C. § 101 (1988 & Supp. III 1991).

56. 17 U.S.C. §§ 101-914 (1988 & Supp. III 1991).

57. *See* Baker v. Selden, 101 U.S. 99 (1879) (copyright does not extend to any idea or method); 17 U.S.C. § 102(b) (1988) (codifying the doctrine of *Baker v. Selden*); 17 U.S.C. 113(b) (1988) (limiting rights in works portraying useful articles under the Copyright Act of 1976 to those under the Copyright Act of 1909); 37 C.F.R. § 202.1(b) (1992) (Copyright Office regulation providing that "[i]deas, plans, methods, systems, or devices, as distinguished from the particular manner in which they are expressed or described in a writing," are not subject to copyright).

58. 17 U.S.C. § 101.

59. *Baker*, 101 U.S. 99.

60. *1979 House Hearings, supra* note 9, at 53-54 (statement of John Finch).

61. Second sourcing is the production by one manufacturer of a product functionally identical to another manufacturer's product. Second sourcing may be done by agreement between the manufacturers and may even involve the transfer of technology, including masks, between the manufacturers. *1979 House Hearings, supra* note 9, at 68 (statement of James M. Early, Director of Research and Development, Fairchild Camera and Instrument Corp.). The rationale is to provide customers with multiple sources for the product, thereby assuring the customer of product availability.

62. Arguably, such chips were the bread and butter of the companies opposing H.R. 1007 in 1979.

ful Article Doctrine, no copyright could subsist in such a work.

Opponents of the bill also analogized integrated circuit masks to architectural plans.[63] Traditionally, the copyright in a set of architectural plans protects only against copying the plans to produce another set of plans.[64] The copyright in the plans does not include any exclusive right to construct the building described in the plans nor any right to prevent others from copying the completed building made from the plans.[65] This rule is based on the Useful Article Doctrine of copyright law. According to the opponents of integrated circuit protection, integrated circuit masks are useful articles like architectural plans. Therefore, copyright in the masks would not give the owner the right to prevent copying of the completed chip made from the masks.[66] Even if copyright subsisted in the masks, the protection would be useless to stop chip piracy.

Opponents of protection also analogized integrated circuit masks to the end product produced by a numerically controlled machine tool.[67] According to this analogy, the structure and design of a chip is so complex that a substantial part of the design is typically accomplished by a computer. Computer simulations of the circuit verify the function and performance of the design. "The computer also 'draws' the layout of the chip,"[68] then generates the

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63. *1979 House Hearings*, *supra* note 9, at 53.

64. Imperial Homes Corp. v. Lamont, 458 F.2d 895 (5th Cir. 1972); Scholz Homes, Inc. v. Maddox, 379 F.2d 84 (6th Cir. 1967); Demetriades v. Kaufmann, 680 F. Supp. 658 (S.D.N.Y. 1988). *But see* 17 U.S.C. § 120 (1988 & Supp. III 1991) (defining proprietary rights in architectural works, amendment effective Dec. 1, 1990); 17 U.S.C. § 101 (1988 & Supp. III 1991) (definition of "architectural work" includes a building, architectural plans or drawings, amendment effective Dec. 1, 1990).

65. *1979 House Hearings*, *supra* note 9, at 53.

66. *Id.*

67. *Id.*

68. *Id.* The assertion that a computer draws the layout of the chip is directly in conflict with other testimony on H.R. 1007. According to L. J. Sevin, circuit designers produce a schematic drawing which is a symbolic representation of the circuit and the interconnection of its components. *1979 House Hearings*, *supra* note 9, at 30 (statement of L. J. Sevin). Layout designers, in turn, use the schematic drawing to do the layout design. Layout design is done by hand and with repeated trial-and-error. *Id.*; H.R. REP. NO. 781, *supra* note 14, at 12, *reprinted in* 1984 U.S.C.C.A.N. at 5761. The goal of layout design is to draw the necessary circuit elements and to fit them into the minimum space. A computer is used as a tool to create and display the layout design. However,

masks used to manufacture the chip. The resulting mask is a computer-implemented design.[69] The mask is a useful article, so no copyright subsists in the mask. However, copyright protection exists for the computer programs and patent protection exists for the new, useful, and nonobvious manufacturing processes and products.[70]

The opponents of H.R. 1007 also noted that the bill would only affect U.S. companies and would afford no international protection.[71] Merely amending the definition of pictorial, graphic, and sculptural works in the Copyright Act would not prevent overseas chip piracy. Foreign pirates could still buy the chips of U.S. manufacturers and copy and sell the chips overseas with impunity.[72] Only infringing copying in the U.S. would be hindered by the amendment.

The strongest opposition to the bill to amend the Copyright Act, however, was on the issue of reverse engineering and what constitutes "fair use" of integrated circuits.[73] Much of the growth of the semiconductor industry has been due to second sourcing.[74] Competing manufacturers regularly share circuit designs, mask sets, and documentation necessary to bring a product to the marketplace in order to assure their customers of an alternate source for the product.[75] Where technology and information are not voluntarily shared, they are obtained by reverse engineering. Reverse engineering involves examining competing chips in great detail in order

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it is no more than a tool. *Id.*; *see 1979 House Hearings*, *supra* note 9, at 26 (statement of L. J. Sevin that "[l]ayout design is a skill that has successfully resisted 12 years of attempts at computerization. It requires a level of human ingenuity that will not be computerized for at least another 25 years, in my opinion, maybe longer—maybe never."). In light of this, any claim that a computer draws the layout of the chip seems disingenuous.

69. *Id.* at 54.

70. *Id.*; *see* 35 U.S.C. §§ 101-103 (1988) (defining statutory requirements for patentability).

71. *1979 House Hearings*, *supra* note 9, at 54 (statement of John Finch).

72. *Id.*

73. *Id.* at 54. *See* 17 U.S.C. § 107 (1988 & Supp. III 1991) (defining the fair use of a copyrighted work).

74. *See supra* text accompanying note 10; *supra* note 61.

75. *1979 House Hearings*, *supra* note 9, at 68 (statement of James M. Early).

to use the information obtained in improved designs.[76] Reverse engineering is recognized by all as a legitimate activity that should not be penalized.[77]

Fair use began as a judicially created defense to a suit for copyright infringement. The doctrine of fair use allows the use of a copyrighted work in a reasonable manner without the consent of the owner of the copyright. The doctrine allows courts to avoid the rigid application of the copyright law when that rigidity would stifle the very creativity which the law is designed to foster.[78] Section 107 of the Copyright Act of 1976 codifies fair use.[79]

Opponents of the bill to amend the Copyright Act to include integrated circuits questioned to what extent reverse engineering would constitute a fair use.[80] They believed that reverse engineering, as legitimate copying, should be protected. However, the bill did not include reverse engineering in the definition of fair use. From the perspective of a manufacturer contemplating reverse engineering, copying a competitor's chip before judicial determination of the scope of fair use as applied to reverse engineering would be risky. On the other hand, to wait for a favorable judicial ruling could force the manufacturer out of business due to his inability to compete successfully.. Each manufacturer who sought to produce a particular chip would have to "reinvent the wheel," expensively duplicating the research and development efforts embodied in the chip.[81] This threatened to stagnate competitive growth of the industry.[82]

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76. *Id.* at 69 (statement of John Finch).

77. H.R. REP. NO. 781, *supra* note 14, at 21-22, *reprinted in* 1984 U.S.C.C.A.N. at 5770-71; S. REP. NO. 833, 98th Cong., 2d Sess. 21 (1984). However, the distinction between legitimate reverse engineering and forbidden piracy is slim. *See infra* notes 173-186 and accompanying text.

78. Iowa State Univ. Research Found., Inc. v. American Broadcasting Co., 621 F.2d 57, 60 (2d Cir. 1980).

79. 17 U.S.C. § 107 (1988 & Supp. III 1991).

80. *1979 House Hearings*, *supra* note 9, at 54.

81. *Id.*

82. *Id.*

D. The Need for a Compromise

In 1979, opponents of chip protection predicted the decline of the semiconductor industry if the chip protection bill was passed. According to them, by not providing for legitimate reverse engineering, the bill would impede the flow of technical information within the industry. On the other hand, supporters of chip protection predicted the decline of the semiconductor industry if the bill was not passed to protect their investment and innovation. Congressional sponsors of the bill drew the conclusion that protection for integrated circuit designs was needed, but with a provision for legitimate reverse engineering. In 1979, H.R. 1007, the bill to amend the Copyright Act, died without further action.

In 1983, alternative legislation was proposed in both houses of Congress. The 1983 Senate bill,[83] like H.R. 1007 in 1979, was to amend the current Copyright Act to accommodate integrated circuits. The 1983 House bill,[84] on the other hand, was a sui generis bill creating a wholly new protection for integrated circuits, independent of the Copyright Act. In H.R. 5525, the legislation that was ultimately passed as the Semiconductor Chip Protection Act of 1984,[85] Congress opted for the sui generis approach.

Congress preferred sui generis protection for integrated circuits to distinguish the protection given integrated circuits from the protection given books.[86] The existing Copyright Act created an "author's copyright" for books and other literary and artistic works. Integrated circuits, unlike literary and artistic works, are essentially utilitarian and form an integral part of a machine. Integrated circuits thus conflict with the useful articles doctrine of copyright law. Therefore, Congress created an independent "industrial copyright" for integrated circuits.[87]

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83. S. 1201, 98th Cong., 1st Sess. (1983).

84. H.R. 1028, 98th Cong., 1st Sess. (1983). H.R. 5525, 98th Cong., 1st Sess. (1983), was a substitute amendment for H.R. 1028 in the House Judiciary Subcommittee on Courts, Civil Liberties and the Administration of Justice.

85. 17 U.S.C. §§ 901-914 (1988 & Supp. III 1991).

86. H.R. REP. NO. 781, *supra* note 14, at 6, *reprinted in* 1984 U.S.C.C.A.N. at 5755.

87. *Id.*; *see also* David I. Wilson & James A. LaBarre, *The Semiconductor Chip Protection Act of 1984: A Preliminary Analysis*, 67 J. PAT. & TRADEMARK OFF. SOC'Y

II. WHAT CONGRESS GAVE THE SEMICONDUCTOR INDUSTRY

The goal of Congress in passing the Chip Act was the protection of the proprietary rights in semiconductor chips. Congress concluded the best way to accomplish this was to protect the layers which form the chips, rather than just the masks from which the chips are made.

A. *What Is Protected*

Accordingly, the protection afforded by the Chip Act extends to a "mask work" fixed in a semiconductor chip product.[88] Under the Chip Act, a mask work is any series of related images which represent the three-dimensional pattern of metallic, insulating, or semiconductor material of a semiconductor chip product.[89] Each image in the series of images which forms the mask work must have the pattern of the surface of the semiconductor chip product.[90]

A semiconductor chip product is defined as any product with two or more layers of metal, insulating or semiconducting material arranged on a semiconducting substrate "in accordance with a predetermined pattern."[91] Additionally, the product must be "intended to perform electronic circuitry functions."[92]

Mask work protection begins when a mask work is fixed in a semiconductor chip product.[93] Fixation of a mask work in a semiconductor chip product occurs when the embodiment of the mask

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57, 66-70 (1985) (detailing opposition to the copyright approach, S. 1201, by the copyright bar and the Copyright Office).

88. 17 U.S.C. § 902(a)(1) (1988).

89. 17 U.S.C. § 901(a)(2)(A) (1988).

90. 17 U.S.C. § 901(a)(2)(B) (1988).

91. 17 U.S.C. § 901(a)(1)(A). The Chip Act's protection is limited to semiconductor chips and does not extend to other products such as printed circuit boards or magnetic media. H.R. REP. NO. 781, *supra* note 14, at 16, *reprinted in* 1984 U.S.C.C.A.N. at 5765.

92. 17 U.S.C. § 901(a)(1)(B). Thus, micro-machined products made using semiconductor processing techniques that do not include electronic circuitry are outside the statute.

93. *Cf.* 17 U.S.C. § 102(a) (1988 & Supp. III 1991) (for literary and artistic works, copyright protection subsists whenever a work of authorship is fixed in any tangible medium of expression).

work is more than transitory.[94] Thus, fixation occurs only in an actual semiconductor chip product, not in just a drawing on paper or an image on a computer screen.[95] Fixation in an actual chip brings the mask work within the protection of § 902.[96] However, the exclusive rights granted by the Chip Act[97] extend to other types of fixation, such as a database tape containing the coordinates of the geometries of the mask work.[98]

The Chip Act includes an originality requirement. The Chip Act does not cover a mask work which is not original or which embodies "designs that are staple, commonplace, or familiar in the semiconductor industry."[99] Thus, some minimal level of creativity is required.[100] Additionally, Congress determined that public domain works, those which are "staple, commonplace or familiar," may not be turned into proprietary rights via the Chip Act.[101] The requirement of originality under the Chip Act is constitutionally mandated and is analogous to originality for copyright in literary and artistic works.[102]

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94. 17 U.S.C. § 901(a)(3) (1988).

95. H.R. REP. NO. 781, *supra* note 14, at 16, *reprinted in* 1984 U.S.C.C.A.N. at 5765.

96. *See* 17 U.S.C. § 902 (1988) (providing protection for owners of mask works under treaty obligations).

97. *See* 17 U.S.C. § 905 (1988) (creating exclusive rights in mask works).

98. H.R. REP. NO. 781, *supra* note 14, at 17, *reprinted in* 1984 U.S.C.C.A.N. at 5766.

99. 17 U.S.C. § 902(b).

100. H.R. REP. NO. 781, *supra* note 14, at 19, *reprinted in* 1984 U.S.C.C.A.N. at 5768.

101. *Id.*

102. "Congress shall have the power . . . To secure to Authors and Inventors for limited Times the exclusive Rights to their Writings and Inventions." U.S. CONST. art. I, § 8, cl. 8. The copyright originality requirement requires only that the "author" contributed to "a writing" something more than a trivial variation. Alfred Bell & Co., v. Catalda Fine Arts Inc., 191 F.2d 99, 102-03 (2d Cir. 1951) (citing Chamberlin v. Uris Sales Corp., 150 F.2d 512 (2d Cir. 1945)). Section 901(4) of the Chip Act "adopts the essence of the customary copyright law concept of originality and applies it to mask works . . . ." H.R. REP. NO. 781, *supra* note 14, at 17, *reprinted in* 1984 U.S.C.C.A.N. at 5766.

B. The Protection Provided

Rights under the act belong to the owner of the mask work.[103] The owner is generally the creator of the mask work. For a mask work created within the scope of a person's employment, the owner of the mask work is the employer of the person who created the mask work.[104] The owner of rights in a mask work may transfer or license any of those rights.[105] Transfer must be by signed written instrument which may be recorded in the Copyright Office.[106] Ownership of mask works is similar to ownership of literary and artistic works under the Copyright Act.[107]

The Chip Act provides the owner of a mask work three exclusive rights.[108] First is the right to reproduce the mask work in whole or in part.[109] In an infringement action, the standard for infringement is substantial similarity.[110] A party who produces a mask work that is substantially similar to a previously registered mask work[111] under the Chip Act is liable for infringement of the exclusive reproduction right of § 905. Even reproduction of a part

103. 17 U.S.C. § 903(a) (1988).

104. 17 U.S.C. § 901(a)(6) (1988). Creation of mask works by employees acting within the scope of their employment as engineers or mask layout designers is doubtless the most common occurrence within the semiconductor industry.

105. 17 U.S.C. § 903(b) (1988). The provisions for transfer of mask work rights are generally similar to provisions for transfer of copyright and patent rights. H.R. REP. NO. 781, *supra* note 14, at 19-20, *reprinted in* 1984 U.S.C.C.A.N. at 5768-69. *See* 17 U.S.C. § 201(d) (1988) (transfer of copyright rights); 35 U.S.C. § 261 (1988) (transfer of patent rights).

106. 17 U.S.C. § 903 (1988).

107. H.R. REP. NO. 781, *supra* note 14, at 17, *reprinted in* 1984 U.S.C.C.A.N. at 5766. *See, e.g.*, 17 U.S.C. § 101 (1988 & Supp. III 1991) (defining a literary or artistic work made for hire); Community for Creative Non-Violence v. Reid, 490 U.S. 730 (1989) ("employee" under § 101 of the Copyright Act to be understood in light of the general common law of agency).

108. 17 U.S.C. § 905 (1988).

109. 17 U.S.C. § 905(1); H.R. REP. NO. 781, *supra* note 14, at 20, *reprinted in* 1984 U.S.C.C.A.N. at 5769. *See also* 17 U.S.C. § 106(1) (1988) (reproduction right for copyright in literary and artistic works).

110. H.R. REP. NO. 781, *supra* note 14, at 20, *reprinted in* 1984 U.S.C.C.A.N. at 5769 ("if this was otherwise, an infringer could immunize himself by adding a mistake to a mask work copied in its entirety").

111. Registration is a prerequisite to a suit for infringement. 17 U.S.C. § 910(b)(1) (1988).

of a mask work is infringement of the reproduction right if that part is material.[112] The Chip Act does not prohibit independent production of a mask work;[113] it only prohibits reproduction of another's mask work.

The second exclusive right under the Chip Act is the distribution right.[114] Distribution includes any transfer of a semiconductor chip product embodying the mask work.[115] Distribution of a product which incorporates a chip, such as a computer, is also distribution of the chip within the Chip Act.[116] The distribution right includes the right to import chips embodying the mask work.[117]

The third exclusive right under the Chip Act prohibits contributory infringement.[118] Only the owner of a mask work may "induce or knowingly cause another person" to reproduce or distribute a mask work or chip embodying a mask work.[119] No similar provision exists for copyright in literary and artistic works.[120]

Before any of the exclusive rights under the Chip Act attach, the owner of the mask work must register the work with the Copyright Office.[121] Unlike copyright in artistic and literary works where copyright registration is voluntary,[122] the Chip Act requires registration within a reasonable time at the risk of forfeiture of rights.[123] If the owner does not register within two years of the

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112. Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555, 1564 (Fed. Cir. 1992).

113. Brooktree Corp. v. Advanced Micro Devices, Inc., 705 F. Supp. 491, 494 (S.D. Cal. 1988).

114. 17 U.S.C. § 905(2); *see also* 17 U.S.C. § 106(3) (1988) (distribution right of copyright in artistic and literary works).

115. 17 U.S.C. § 901(a)(4) (1988).

116. 17 U.S.C. § 901(b) (1988).

117. 17 U.S.C. § 905; *see also* 17 U.S.C. § 602(a) (1988) (importation right of copyright of literary and artistic works).

118. 17 U.S.C. § 905.

119. *Id.*

120. H.R. REP. NO. 781, *supra* note 14, at 21, *reprinted in* 1984 U.S.C.C.A.N. at 5770. *But see* 35 U.S.C. § 271(c) (1988) (defining contributory infringement of patent rights).

121. 17 U.S.C. § 908 (1988).

122. *See* 17 U.S.C. § 408(a) (1988) ("such registration is not a condition of copyright protection").

123. *See* H.R. REP. NO. 781, *supra* note 14, at 24, *reprinted in* 1984 U.S.C.C.A.N. at 5773. (Congress's rationale is greater certainty of rights for both the public and the

date of first commercial exploitation, the mask work falls into the public domain.[124] Registration requires application via a form prescribed by the Register of Copyrights and deposit of four chips embodying the mask work along with plots or photographs of each layer of the work.[125] The Copyright Office examines the form and deposited materials only to ensure the claim is facially in compliance with the statute and regulations.[126] The Copyright Office does not examine the prior art as under the patent laws.[127]

The owner of the mask work may affix notice to the mask work and to any masks and chips made therefrom.[128] Notice may consist of the letter "M" in a circle, the symbol *M*, or "the words 'mask force,'"[129] along with the name of the owner of the mask work. While optional, provision of notice constitutes prima facie evidence of notice to others that the mask work is protected.[130]

Protection under the Chip Act extends for a term of ten years.[131]

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owners of the mask works).

124. 17 U.S.C. § 908(a).

125. 37 C.F.R. §§ 211.4, 211.5 (1992).

126. H.R. REP. NO. 781, *supra* note 14, at 25, *reprinted in* 1984 U.S.C.C.A.N. at 5774.

127. *See* Graham v. John Deere Co., 383 U.S. 1, 12 (1966) (defining the appropriate examination of a patent application with respect to prior art under 35 U.S.C. § 103).

128. 17 U.S.C. § 909(a) (1988).

129. 17 U.S.C. § 909 (b)(1) (1988). The "mask force" form of notice is clearly a typographical error in the statute, Pub. L. No. 98-620, Title III, § 302, 98 Stat. 3352 (1984), and should be "mask work." The Copyright Office regulations correctly list this form of notice as "mask work." 37 C.F.R. § 211.6(b)(1) (1992). However, because area on the surface of integrated circuits is so precious, it is likely that the creator of a mask work would choose one of the other, shorter, forms of notice. Therefore, this error should not be of consequence to mask work registrants.

130. H.R. REP. NO. 781, *supra* note 14, at 25, *reprinted in* 1984 U.S.C.C.A.N. at 5774.

131. 17 U.S.C. § 904 (1988). Protection under the 1979 amendment to the Copyright Act, H.R. 1007, 96th Cong., 1st Sess. (1979), would have been the same as protection for literary and artistic works—generally 75 to 100 years. *See* 17 U.S.C. § 302 (1988) (duration of copyright). This lengthy term of protection, relative to rapidly changing technology, was cited by opponents of H.R. 1007. *1979 House Hearings*, *supra* note 9, at 54. The strongest supporter of protection for semiconductor chips, Dr. Andrew S. Grove, President of Intel Corp. and a representative of the American Electronics Association, admitted that a 75 year term of protection was not necessary and suggested a term of 7 to 15 years was adequate protection. *Id.* at 41.

Protection begins on the date of a mask work's first commercial exploitation, or the date of registration of the mask work, which ever occurs first.[132]

Registration is a prerequisite to a suit for infringement of any of the exclusive rights in a mask work.[133] Remedies for infringement include temporary restraining orders, preliminary injunctions, and permanent injunctions.[134] The court may order the impoundment of infringing chips, masks, or database tapes.[135] If infringement is found, the court may order destruction of infringing products.[136] The court may award actual damages as well as the infringer's profits.[137] Alternatively, the court may award statutory damages up to $250,000.[138] Lastly, the court may award costs and attorneys' fees to the prevailing party.[139] The Chip Act includes a three-year statute of limitations.[140]

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132. 17 U.S.C. § 904.

133. 17 U.S.C. § 910(b)(1) (1988). Congress intended that the concept of infringement of mask work rights be the same as infringement of an author's rights under copyright. Concepts of copyright law relative to infringement are to apply to actions under the Chip Act. H.R. REP. NO. 781, *supra* note 14, at 26, *reprinted in* 1984 U.S.C.C.A.N. at 5775. These include substantial similarity as the standard for infringement, see, e.g., Arnstein v. Porter, 154 F.2d 464 (2d Cir. 1946) (establishing a bifurcated test of substantial similarity); the idea-expression dichotomy, see Baker v. Selden, 101 U.S. 99 (1879) (copyright does not extend to any idea); and merger of idea and expression when an idea can be expressed in only a limited number of ways, see Morrissey v. Procter & Gamble Co., 379 F.2d 675 (1st Cir. 1967).

134. 17 U.S.C. § 911(a) (1988).

135. 17 U.S.C. § 911(e)(1) (1988).

136. 17 U.S.C. § 911(e)(2) (1988).

137. 17 U.S.C. § 911(b) (1988).

138. 17 U.S.C. § 911(c) (1988). *But see* 17 U.S.C. § 504(c) (1988) (statutory damages for copyright violation limited to $20,000 unless the infringement was willful in which case the court may increase the award to not more than $100,000); *see* H.R. REP. NO. 781, *supra* note 14, at 27, *reprinted in* 1984 U.S.C.C.A.N. at 5776 (the difference in statutory damages reflects the substantial front-end costs of chip creation, the impact of disincentives to create new technology, and the absence of criminal sanctions).

139. 17 U.S.C. § 911(f) (1988); *see* Brooktree Corp. v. Advanced Micro Devices, Inc., 757 F. Supp. 1088, 1099 (S.D. Cal. 1990) (as with other copyright litigation, the award of costs and fees should be the rule rather than the exception), *aff'd*, 977 F.2d 1555 (Fed. Cir. 1992).

140. 17 U.S.C. § 911(d) (1988).

C. Limitations on Protection

While the penalties for infringement are stiff, they include significant limitations that may restrict the effectiveness of protection. As demanded by the opponents of protection in 1979,[141] reverse engineering is a defense to a charge of mask work infringement.[142] Specifically, a competitor or other person may legitimately reproduce a mask work for the purpose of "teaching, analyzing, or evaluating the concepts or techniques" employed in the mask work.[143] That person may then reproduce what he learns in another mask work for sale.[144] A competitor may thus legitimately appropriate a registered mask work if he employs "substantial study and analysis" of a chip, not mere copying.[145] The competitor may demonstrate such study and analysis by showing a paper trail of documentation.[146] One who reverse engineers, rather than copies, is not an infringer.[147]

A second limitation on the protection provided by the Chip Act is the First Sale Doctrine.[148] This doctrine is a carryover from traditional copyright law.[149] The doctrine limits control by the owner of mask work rights over a particular semiconductor chip once the chip has left the owner's hands. A purchaser of the chip can use or transfer the chip as he sees fit. He need not have authority of the owner of the mask work rights that subsist in that chip. The purchaser may not reproduce the chip, however.[150] The rationale of the First Sale Doctrine is to prevent the owner of mask

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141. *See supra* notes 73-82 and accompanying text.

142. 17 U.S.C. § 906(a) (1988).

143. 17 U.S.C. § 906(a)(1).

144. 17 U.S.C. § 906(a)(2).

145. H.R. REP. NO. 781, *supra* note 14, at 22, *reprinted in* 1984 U.S.C.C.A.N. at 5771.

146. Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555, 1570 (Fed. Cir. 1992); *see* H.R. REP. NO. 781, *supra* note 14, at 21, *reprinted in* 1984 U.S.C.C.A.N. at 5770 ("paper trail" of legitimate reverse engineering distinguishes it from chip piracy).

147. On the distinction between copying and reverse engineering, *see infra* Part III.

148. 17 U.S.C. § 906(b) (1988).

149. H.R. REP. NO. 781, *supra* note 14, at 23, *reprinted in* 1984 U.S.C.C.A.N. at 5772. *See* 17 U.S.C. § 109(a) (1988) (Copyright Act codification of the First Sale Doctrine).

150. 17 U.S.C. § 906(b).

work rights from limiting the free alienability of the goods of the bona fide purchaser. Out of respect for this principle, the Chip Act limits the extent to which the creator of a mask work can control his product.

The final significant limitation on the exclusive rights of mask work owners protects innocent infringers. An innocent infringer is one who buys and uses a chip in good faith and without notice of the protection afforded the mask work.[151] The innocent infringer is not liable at all for sale or distribution of infringing chips before he has notice that the chips are protected by the Chip Act.[152] After receiving notice, the innocent infringer[153] is liable only for a reasonable royalty on infringing chips he sells.[154] His immunity extends to his customers for those chips or products incorporating those chips.[155]

Thus, in the Chip Act, Congress reached a compromise. Congress gave both the supporters and opponents of protection for integrated circuits what they wanted. Supporters of chip protection sought a remedy for chip piracy, since the literal copying of their products threatened continued competitiveness. They insisted protection was vital. Opponents of chip protection demanded a limitation on their liability. They believed reverse engineering was a practice as old as the industry and fundamental to continued competitiveness. They, too, insisted limitation was vital. In the Chip Act, Congress provided severe penalties upon a finding of infringement. However, infringement under the Act may be difficult to find.

III. WHAT'S WRONG WITH WHAT CONGRESS GAVE THE SEMICONDUCTOR INDUSTRY?

The Semiconductor Chip Protection Act of 1984 was drafted in response to industrial problems of the 1970s. However, the Chip

151. 17 U.S.C. § 901(a)(7) (1988).
152. 17 U.S.C. § 907(a)(1) (1988).
153. Perhaps "formerly innocent infringer" is more accurate.
154. 17 U.S.C. § 907(a)(2) (1988).
155. 17 U.S.C. § 907(c) (1988).

Act provided a huge hole in its coverage by exempting reverse engineering from liability. In addition, the semiconductor industry and the technology it relies on have changed, mooting the Chip Act. The opportunities for and benefits from piracy no longer exist.

A. Technology and the Industry Have Changed

For chip piracy to work, the pirate must have access to the same manufacturing technology used by the legitimate manufacturer.[156] The pirate copies a legitimate design to produce a set of masks, each containing the geometries for a particular layer of the chip. The pirated masks must be compatible with the pirate's manufacturing process to be of any use to the pirate.

In 1979, when semiconductor chip protection was first proposed, processing technology among semiconductor manufacturers was alike from company to company.[157] Technology used by Intel was very similar to technology used by Intersil and others. Each firm used substantially the same mask layers along with substantially the same processing steps. A manufacturer could copy another firm's chip only because it could use the copied masks on its own processing line.[158] A pirate could copy a chip, make masks and contract with a legitimate manufacturer to produce new chips from the masks. In 1979, standardized technology made piracy feasible.

By 1992, processing technology has advanced and diverged within the industry. Changing technology and shrinking geometries have required additional mask layers.[159] These developments have led to fabrication procedures which require different or additional

156. *See* Risberg, *supra* note 48, at 256.

157. *1979 House Hearings*, *supra* note 9, at 38 (statement of Dr. Andrew S. Grove that, despite minor differences, processing technology is common among manufacturers); *id.* at 42 (statement of Roger Borovoy of Intel Corp., confirming this). *But see id.* at 69-70 (statement of John Finch that manufacturing processes are not identical from company to company).

158. Duplication of a patented process would be patent infringement. The small differences between processes might be sufficient to defeat such a claim.

159. *See supra* note 25 and accompanying text.

masks for chip manufacturing. While some layers remain common to technologies used by many firms, many other layers are different. In 1979, a typical process required 8 masks. In 1992, a typical process requires 16 masks. Current processes are much more complex than past processes.[160]

This complexity scuttles the pirate. He can no longer reproduce each layer of a chip and produce a knock-off in three months.[161] The manufacturing technology used by the legitimate manufacturer is unique to that manufacturer. The pirate has no production source for his copied chips. The masks he makes are useless except with the process used by the manufacturer whose chip he copied.[162] Changes in technology have left the pirate dead in the water.

Other changes in the semiconductor industry have also reduced piracy. Formerly, the bulk of sales by U.S. semiconductor manufacturers was in small logic chips that were relatively inexpensive to design, readily mass produced, and had to be pin-compatible among many manufacturers. Today, advanced technology has allowed higher levels of integration and more complex functionality for integrated circuits.[163] Semiconductor manufacturers today focus their efforts on big chips such as microprocessors, application specific integrated circuits ("ASICs") or digital signal processors ("DSPs"). These big chips realize the benefits of very large scale integration. These individual chips may be part of a family of interrelated chips.[164] Also, microprocessors, ASICs, and DSPs require more from a vendor than just circuit design and manufacturing expertise. They also require software, development tools, market development, and extensive, expensive customer support.[165]

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160. The differences in process technology are analogous to differences in computer software. Software written for an IBM personal computer, circa 1979, will not run on an Apple personal computer, circa 1991. *See* Risberg, *supra* note 48, at 256 n.71.

161. *See supra* notes 33-37 and accompanying text.

162. *But see* Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555, 1564 (Fed. Cir. 1992) (copying just two mask layers, active area and polysilicon, is sufficient for violation of the Chip Act); *see also* Brooktree Corp. v. Advanced Micro Devices, Inc., 705 F. Supp. 491, 495 (S.D. Cal. 1988).

163. *See supra* notes 24-32 and accompanying text.

164. *See supra* notes 27-32 and accompanying text.

165. *See supra* note 32 and accompanying text.

These chips are part of proprietary systems, each system unique to its manufacturer. For the manufacturer, the mask layout expense of such a chip is now relatively small. For the pirate, who is not interested in supporting what he sells, the value of copying such a chip is also small. There's no incentive to copy these large proprietary chips.

One type of chip remains susceptible to piracy—the DRAM. DRAMs are the type of high-volume, low-support, pin-compatible chips the semiconductor industry of the 1970s was built on. They are ideally suited for pirating.[166] However, pirating is no longer an issue even for DRAMs. Technology and industry have changed; there is no longer an incentive to pirate DRAMS. In the mid-1980s, the American semiconductor industry completely abandoned the DRAM market to the Japanese. U.S. DRAM producers fell behind their Japanese competitors, who invested heavily in DRAM research and development and production capacity. By 1986, the leading Japanese electronics companies controlled eighty percent of the world market for DRAMs and had gained technological leadership over virtually all U.S. producers.[167] Because they trail technologically, U.S. manufacturers could not successfully pirate Japanese DRAMs even if they wanted to.[168]

The expense of new technology and fierce competition has also changed the semiconductor industry. Barriers to entry into semiconductor manufacturing are high. In 1992, technology required investment of $200 million to $1 billion in manufacturing process development, and $250 million to $400 million for each manufacturing line.[169] To avoid these costs, many American semiconductor

166. *See supra* note 38 and accompanying text (Intel presented photographic evidence of copying of its 4127 DRAM by Toshiba).

167. Charles S. Ferguson, *Computers and the Coming of the U.S. Keiretsu*, HARV. BUS. REV., July-Aug. 1990, at 55.

168. Clearly, the Americans have no desire to compete with the Japanese in the DRAM market. World DRAM sales rose from $1.5 billion in 1986 to more than $9 billion in 1989. At no time did American chip makers attempt to get back into the DRAM market. IBM even offered to share its advanced DRAM technology with American chip makers, but found no takers. *Id.*

169. *Id. See* D. Lammers & R. Boyd-Merritt, *TI To Build Singapore DRAM Fab*, ELECTRONIC ENGINEERING TIMES, Apr. 15, 1991, at 1 ($320 million cost of manufactur-

start-up companies opted to contract for manufacturing services from domestic and foreign "foundries," manufacturers with excess capacity.[170] The result has been continued net migration of semiconductor manufacturing expertise overseas. Also, the number of semiconductor firms with manufacturing expertise has declined.[171] Today, six manufacturers hold forty percent of the world market. Four of the six are Japanese.[172] The industry, along with its technology, has changed and eliminated the incentive for piracy.

B. Reverse Engineering

In addition to the industrial and technological changes which made the Chip Act irrelevant, the Chip Act itself provides only weak protection against pirates. The Chip Act permits reverse engineering as an affirmative defense to a charge of infringement. Permissible reverse engineering includes legitimate practices employed in the semiconductor industry before passage of the Chip Act. Thus, the vast majority of chip copying is outside the coverage of the Chip Act. This result is at odds with the policies of intellectual property law.

The most important limitation of the Chip Act is the defense of reverse engineering.[173] Under the Chip Act, it is not an infringe-

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ing line to be shared among Texas Instruments, Inc., Hewlett-Packard Co., Canon, Inc., and the Singapore Economic Development Board). *But see* E. Sack, *Exploding the Fabless Myth: A Little Fab Can Go a Long Way*, ELECTRONIC ENGINEERING TIMES, Apr. 22, 1991, at 35 (Chairman of Zilog, Inc., maintaining that smaller, cheaper fabs can be competitive and suggesting that stories about $400 million production lines are circulated to discourage investment).

170. Sean Silverthorne, *Fabless Chip Companies Thrive Without Making Chips*, INVESTOR'S DAILY, June 5, 1990, at 35. *But see* E. Sack, *supra* note 169, at 35 (Chairman of Zilog, Inc., maintains that the market will not support two profits, one for the designer and one for the manufacturer).

171. Among the companies presenting testimony to Congress on protection for semiconductor chips were Mostek Corp., Fairchild Camera and Instrument Corp., National Semiconductor Corp., and Intersil, Inc. Mostek was bought by the French firm Thompson. National bought Fairchild. Intersil was already a division of General Electric; it was merged with RCA's semiconductor operations when GE and RCA merged; Harris Corp. later bought the combined GE-RCA operation.

172. Ferguson, *supra* note 167, at 55.

173. 17 U.S.C. § 906(a) (1988); *see supra* notes 142-146 and accompanying text.

ment of rights granted by the Act to reproduce the mask work for the purpose of teaching, analyzing, or evaluating concepts or techniques embodied in the mask work.[174] Also, it is not an infringement for a person who performs this analysis or evaluation to incorporate the results in an original mask work.[175] Thus, reverse engineering a chip, even for sale in competition with the original chip, is a complete defense to a charge of infringement. Unfortunately, the Chip Act and its legislative history do not define what acts are permissible as reverse engineering nor what differences in a chip design render it "original."

The report that accompanied the bill which became the Chip Act in the House of Representatives noted that § 906 codified "the established industry practice" of reverse engineering.[176] According to witnesses, copying in the semiconductor industry fell into two polar categories—piracy and reverse engineering. Piracy was marked by photographic reproduction of a first chip and direct incorporation into a second chip.[177] Reverse engineering, on the other hand, was marked by making improvements to an existing chip by incorporating substantial parts of its design into the second chip."[178] The report noted that § 906 was intended to permit and encourage the practice of reverse engineering.[179] It follows then that the scope of legitimate reverse engineering prior to the Chip Act, as presented by the industry to Congress, defines the scope of permissible reverse engineering under the Chip Act.[180]

In hearings before Congress, semiconductor industry representatives defined the acts they understood to be embraced by the term reverse engineering. A representative of National Semiconductor stated that "[w]e certainly reverse engineer, as do all of our com-

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174. 17 U.S.C. § 906(a)(1).

175. 17 U.S.C. § 906(a)(2).

176. H.R. REP. NO. 781, *supra* note 14, at 21, *reprinted in* 1984 U.S.C.C.A.N. at 5770.

177. H.R. REP. NO. 781, *supra* note 14, at 22, *reprinted in* 1984 U.S.C.C.A.N. at 5771.

178. *Id.*

179. *Id.*

180. M. Fisher, *Beyond Fair Use: Reverse Engineering and the Semiconductor Chip Protection Act of 1984*, COMPUTER LAW., Apr. 1986, at 11.

petitors, which is defined as looking in great detail at competitive chips and utilizing either in future designs or improved designs, the things we learn from those chips. It is standard industry practice."[181] A representative of Fairchild Camera and Instrument provided more detail:

> When a competitor brings out a new product, companies in the business buy the product, electrically test the product and usually pull the package apart to look at the chip. The chip is studied under a microscope to determine whether or not any new engineering procedures are incorporated in the chip. Photographs are taken of portions of the chip. These photographs are blown up and dimensions are obtained from the photographs in an attempt to characterize the structure of the chip. If the structure appears unique, then this unique structure might be incorporated by a competitor in its chip. Alternatively, this unique structure might be further improved by the competitor and incorporated in a new product.[182]

A representative of Intel provided further clarification, noting that under the reverse engineering provision, a person would have the right to analyze and understand the chip and determine the schematic diagram for the circuit embodied in the chip.[183] The desirable advantages of reverse engineering are cost reduction and performance enhancement. In that regard, "[i]t is the type of thing that even the original designer is going to do. It is ongoing engineering, which is perfectly allowable."[184]

Another Intel representative provided the definitive explanation of reverse engineering.

> When a company decides to become a second source for a chip already on the market, it will probably want it to be

181. *1979 House Hearings*, *supra* note 9, at 69 (statement of John Finch).

182. *Id.* at 57 (statement of James M. Early).

183. *The Semiconductor Chip Protection Act of 1983: Hearings on S. 1201 Before the Subcomm. on Patents, Copyrights and Trademarks of the Senate Comm. on the Judiciary*, 98th Cong., 1st Sess. 65 (1984) (statement of F. Thomas Dunlap, Jr.).

184. *Id.* at 66.

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 this can be documented with reference to the firm's ordinary business records. A pirate has no such papers, for the pirate does none of this work.[185]

This point was driven home in further testimony on behalf of Intel. Intel's Corporate Counsel responded to a question by Representative Frank.

Mr. Dunlap. Mr. Frank, you have hit it exactly on the head. When there is a legitimate job of reverse engineering, there is a very big paper trail, there's computer simulations, there's all kinds of time records, people who have spent an enormous amount of time understanding and figuring out how to make the design.

Mr. Frank. It is not the extent of the change, but the extent to which the work can be documented and the corrections can be documented.

Mr. Dunlap. Correct, whenever there is a reverse engineering job, there is a very big paper trail that cannot readi-

185. *Id.* at 146 (submitted statement of Leslie Vadasz, Senior Vice President, Intel Corp.).

ly be fabricated.[186]

Successful assertion of reverse engineering as a defense turns on production at trial of a paper trail of supporting documents.

Thus, representatives of the industry painted for Congress a picture of legitimate reverse engineering. According to this picture, reverse engineering has two steps. First, the reverse engineer examines and analyzes the first chip. Analysis includes electrical testing, visual inspection and photography, and measurement of the first chip's geometries. Second, the reverse engineer designs the second chip. This includes preparation of logic and circuit diagrams based on the analysis of the first chip, computer simulations of the circuit described in the logic and circuit diagrams, and trial layouts of new mask works based on the first chip. Both steps of reverse engineering leave a paper trail.

The evidentiary paper trail of the reverse engineering effort includes recorded test results, photos of the first chip, the trial layouts and computer printouts of logic and circuit diagrams, simulation results for the second chip, and the work records of the employees who performed this analysis. The picture of reverse engineering drawn by industry representatives stresses ample evidence of a legitimate practice. The question is: What is wrong with this picture?

Reverse engineering, as presented by the semiconductor industry to Congress, has both evidentiary and conceptual problems. A legitimate reverse engineer is given freedom to appropriate the intellectual property of another. The legitimate reverse engineer may leave no paper trail, while the pirate can readily invent one.

The paper trail described in hearings before Congress simply may not exist. Given current integrated circuit design methodology, even a legitimate reverse engineering job may not produce a paper trail. Today, virtually all layout work is done on a graphics workstation because of the need to handle the large amounts of data that form the layout of an integrated circuit.[187] A chip design-

186. *1983 House Hearings, supra* note 6, at 36.

187. *1979 House Hearings, supra* note 9, at 25. This is in contrast to 1979 technolo-

er may generate plots of the graphics database for checking work, but she may not retain these after a working circuit is produced. She may send and receive interoffice memoranda related to the reverse engineering effort via electronic mail, with no permanent copy retained. Current technology allows schematic drawings and computer simulation files to be extracted directly from the layout database, without the intervening paper copies.[188]

Reliance on a paper trail as evidence of reverse engineering may be misleading. At the time of trial, there may be no existing paper trail because one was never created. The sole remaining evidence of the reverse engineering effort may be a computer database tape of the new layout.[189] This may be indistinguishable from the trail left by the pirate. On the other hand, the pirate who is intent on copying can create a suitable paper trail after the fact. This is particularly troubling since, at trial, establishment of the defense of reverse engineering will turn on the extent to which work and changes to the first chip can be documented. Evidence of reverse engineering is not as clear as Congress was led to believe.

Moreover, a defendant in a suit brought under the Chip Act may legitimately reverse engineer, as conceived by Congress, only to have a jury find infringement under the Act. Advanced Micro Devices ("AMD") sought to enter the market for Brooktree's color video display chips.[190] AMD sought to make its chip form-, fit-, and function-compatible with Brooktree's. Those who defined reverse engineering for Congress suggested this was the type of activity which embraced reverse engineering.[191] AMD presented evidence of a two-and-one-half-year reverse engineering effort at a

gy that involved cutting and pasting mylar strips.

188. *See* R. Laurie, *The First Year's Experience Under the Chip Protection Act, or "Where Are the Pirates Now That We Need Them?"*, COMPUTER LAW., Feb. 1986, at 21.

189. This is particularly true given the three year statute of limitations under the Chip Act. 17 U.S.C. § 911(d) (1988).

190. Brooktree Corp. v. Advanced Micro Devices, Inc., 977 F.2d 1555 (Fed. Cir. 1992).

191. *See supra* note 185 and accompanying text.

cost of three million dollars.[192] AMD did not produce a "slavish copy" but extensively analyzed Brooktree's chip. Despite differences which clearly showed AMD's design was not a direct, photographic copy of Brooktree's chip, the jury found AMD infringed Brooktree's mask work rights.[193] Brooktree was awarded damages in excess of $25 million for mask work and patent infringement.

The conceptual basis of reverse engineering is inconsistent with other forms of intellectual property. Reverse engineering, as originally conceived, was analogous to fair use of a copyrighted work.[194] Fair use is limited to purposes such as criticism, comment, news reporting and teaching.[195] Commercial uses of a copyrighted work, in direct competition with the work itself, are presumptively unfair. Section 906(a)(1) of the Chip Act reflects a similar understanding of reverse engineering. Only the noncommercial activities of teaching, analysis, and evaluation of a mask work are recognized as legitimate reverse engineering under § 906(a)(1).[196]

Section 906(a)(2) of the Chip Act goes an additional step, however. Section 906(a)(2) allows the commercial exploitation of the results of the reverse engineering effort. The new chip may even be marketed directly in competition with the original chip. The industry understanding of reverse engineering presented to Congress included use of unique structures found in the original chip.[197] The legitimate reverse engineer, practicing ongoing engineering to improve cost and performance, may properly copy such unique structures and sell them in his own chip under § 906(a)(2).[198]

Such a provision is unique to U.S. intellectual property law. As noted, copyright law permits only non-competing fair use. Patent law contains no similar privilege. Rather, anyone who manufac-

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192. *Brooktree Corp.*, 977 F.2d at 1567.

193. *Id.* at 1561.

194. 124 CONG. REC. 37,192 (1978) (statement of Rep. Edwards introducing the precursor bill to H.R. 1007, to amend the Copyright Act of 1976 to protect integrated circuit layouts).

195. 17 U.S.C. § 107 (1988 & Supp. III 1991).

196. 17 U.S.C. § 906(a)(1) (1988).

197. *See supra* note 182 and accompanying text.

198. *See supra* note 184 and accompanying text.

tures, uses or sells a patented article is liable for infringement.[199] The reverse engineering provision of the Semiconductor Chip Protection Act allows the free appropriation of property clearly protected by the exclusive rights of the statute. Thus, reverse engineering destroys the incentives created by the Chip Act.

The broad rationale of the Chip Act, as well as of patents and copyrights, is to encourage innovation.[200] By giving the innovator exclusive rights for a limited time, these statutes create an incentive to create. The innovator knows he will have an opportunity to extract value from his creation. The competitor also receives an incentive from such protection. Because the competitor is excluded from use of the protected work, the competitor must innovate a new solution to the same problem. By this means, the level of technology is advanced.

Reverse engineering halts this advancement. The competitor is free to reverse engineer the first chip. The competitor thus lacks an incentive to develop a new solution. So long as the competitor can create a paper trail, the competitor is free to use the unique structures of the first chip. The innovator, knowing in advance that his new design is likely to be appropriated, will discontinue innovative work. The return on investment can no longer be realized when the result is free for the taking.[201]

Based on the legislative history of the reverse engineering defense contained in § 906 of the Chip Act, most copying which does occur is protected by the affirmative defense. Protected acts include those which the industry understood to be legitimate reverse engineering in 1983. The only prohibited act is photographic copying of one mask work to produce another. As discussed above however, such copying is technically feasible only where the pirate employs process technology identical to that of the legitimate manufacturer. Given the reverse engineering defense, the protection provided by the Chip Act is narrow indeed.

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199. 35 U.S.C. § 271(a) (1988).

200. U.S. CONST. art. I, § 8, cl. 8.

201. *See supra* notes 42-51 and accompanying text.

CONCLUSION

In 1979, some of the leaders of the semiconductor industry went to Congress with the problem of chip piracy. They insisted that the future growth of their industry turned on the incentives provided by protection of their proprietary rights. At the same time, other leaders of the industry insisted that such protection would cut off access to innovation within the industry and stifle competition. These two views precisely describe the dilemma of all intellectual property law. The incentive to one person's creativity conflicts with access by another to the fruits of that creativity.

In 1983, the industry presented new legislation that permitted access to new developments by other manufacturers. The industry was ostensibly unanimous in its support of this legislation. The Semiconductor Chip Protection Act of 1984 included provisions such as the reverse engineering defense that kept technology mobile. The net effect of those provisions was to wipe out any incentives to innovation the Chip Act might have created. The resulting protection created by the Chip Act was very narrow in scope.

The utility of the Chip Act is limited because the Act straddles the issues of access and incentives. The Act tries to create incentives by granting exclusive rights. At the same time, the Act tries to maintain access to innovation by exempting copying in the form of reverse engineering. A 1977 Federal Trade Commission report cited rapid copying as being very important to the semiconductor industry's rapid rate of innovation.[202] Perhaps unintentionally, Congress retained this important advantage in the Semiconductor Chip Protection Act by tightly limiting the scope of the Act.

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202. *See supra* note 10 and accompanying text.