

Legal Aspects of Protecting

Intellectual Property in Additive Manufacturing

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Abstract

Additive manufacturing (AM) emerges as a transformative manufacturing technology that will play a significant role in the future. Also broadly known as 3D printing, AM describes the process of fabrication when 3D objects are created incrementally by synthesis of successive material layers. Where traditional manufacturers require materials as well as customized components, molds, and machinery; additive manufacturers merely require materials and a 3D printer. Without the need for expansive customization, entrance barriers for manufacturers drastically lower. Relying on 3D printers reduces the high fixed overhead and expensive maintenance costs, allowing for smaller, more flexible business models to become competitive. Less reliant on economies of scale, AM has begun to reflect a service industry as manufacturers have greater freedom to fabricate to customer specifics. With greater market diversity, however, comes greater market adversity. The ready availability of 3D printers for a consumer market creates a broad spread of independent manufacturers. But, a decentralized market for production is also a decentralized market for piracy. In traditional manufacturing, the copying of a design in a manufacturing process could be readily traced to a source as an infringer would require both infrastructure for fabrication and a marketing platform for profitability. In a decentralized manufacturing environment, there is neither a need for specific infrastructure nor a marketing platform. This research focuses on legal solutions available to the intellectual property (IP) owners in the United States for blueprints, objects, and processes used in AM. By establishing a baseline for the current environment for federal protections, this research outlines issues encountered when protecting these intellectual properties.

1. Introduction

Advances in technology have led the manufacturing industry through several transformative states—from manual formative processes to automated factories. Though made easier through the proliferation of computers to orchestrate construction and assembly, traditional manufacturing is hindered by its inherent requirement of specifically designed infrastructure to fabricate a limited set of products. Due to the expense of the machine array and high operational overhead, traditional manufacturers remain profitable via economies of scale.

Resolving many of the existing difficulties in traditional manufacturing, the widespread adoption of 3D printing technology heralds the arrival of additive manufacturing (AM). Where traditional manufacturers rely on multiple machines to generate relatively few products, additive manufacturers can create a variety of articles employing a single 3D printer. Enhancing flexibility and scalability within the supply chain, the propagation of 3D printers reduces startup capital for operations, which lowers entrance barriers into the market [1]. While not a problem by itself, broader market participation creates its own hurdles for the industry.

A major obstacle for industry progress concerns the protection of intellectual property (IP) rights in an age of decentralized manufacturing [2]. Software-driven supply chains coupled with the commoditization of 3D printers have eroded many of the former barriers to IP infringement for proprietary designs and products. In a traditional manufacturing process, for protected IP rights to be violated, the infringer must possess specialized infrastructure to create the products. The advent of 3D printing technology, however, requires only a printer and a digitally replicated blueprint for an individual to infringe. Lacking the constraints of an expensive central process, the manufacturing industry becomes exposed to the threat of piracy [2] and external attacks [3].

Additive manufacturing is not the first industry to face degradation of IP protections. Prior to

the introduction of the printing press, copying a printed work was such an expensive and arduous process that a published work was protected by nature against copying [4]. Peer-to-peer file sharing and website distribution give the public the necessary tools to copy electronic documents and digital media files [5]. Growing parallels between copyright infringement for digital media and IP infringement for 3D printing prompt concern for the blueprint designers. Where an audio file can be executed by a media player to listen to a copyrighted song, 3D printers can construct a protected object from a digital design file. Ubiquitous accessibility of high quality printing capability renders it both difficult and expensive to prevent unauthorized replications. Federal privacy protections preserve the anonymity of individual infringers by transforming their homes into veritable safe houses. Without probable cause, the Fourth Amendment prevents state agents from surveillance activities that would reveal cases of infringement.

The arrival of 3D printers pushes the fabrication industry into a similar age experienced by digital media companies when first battling file sharing of digital copyrighted material. Existing United States intellectual property safeguards are antiquated when considering the full protection of IP right holders involved in AM. Under the current statutory framework, the lack of patent protection on a blueprint renders infringement claims impractical, and inherent limitations to copyright and trademark protections on protectable designs and symbols can be exploited to completely prevent recovery in some circumstances. This research focuses on legal solutions available to the IP owners in the United States for blueprints, objects, and processes used in AM. By establishing a baseline for the current environment for federal protections, this research outlines issues to be addressed in a future work.

2. Related Works

The existing body of literature concerning how IP protections in 3D printing have a

predominate focus on difficulties encountered for patents to provide effective recovery to IP owners. To complement these works, this research analyses diverse protection mechanisms and considers their applicability for secure outsourcing in AM. Yampolskiy et al. [6] discusses an outsourcing model as represented by the relationships among three parties: the designer of the object printed, the manufacturer printing the object, and the experts responsible for tuning the manufacturing process. After assessing the risks to actors in the model, the authors propose a series of protection goals for outsourcing activities in AM but do not consider limitations to IP protection offered by the federal government.

Resai and Magliocca [5] provide an overview of IP protections within the arena of 3D printing. Using personal computers for product fabrication allows consumers to customize products or to generate replacement parts. The article discusses patents, copyrights, and trademarks in general application to 3D printing. Depoorter [2] describes changes in the manufacturing industry exposing it to decentralized piracy. The author cites practical and societal sources for complications arising when enforcing IP rights.

Doherty [7] identifies difficulties in applying patent protections to 3D printed objects. Because patents guarantee rights to an object or a design, potential legal arbitrage around patent limitations can eliminate the practical effects of having a patent. The author suggests modernizing patent laws to prevent unenforceability of existing protections. Likewise, Brean [8] surveys possible theories to patent protections for 3D printed inventions. After discussing the flaws in each approach, the paper considers the applicability of copyright law for effective protection. Holbrook and Osborn [9] concur in the inappropriate fit of patents for enforcing against infringers using 3D printers. The authors propose nontraditional theories for inferring direct infringement that would attach greater significance to the blueprint file for creating the

patented object. Holbrook [10] discusses the scope of patent infringement with respect to intangible products. The author argues that, by protecting against the offer to sell inventions, not all patent infringements required a tangible manifestation. He asserts that the statutory language should be construed broadly to provide more effective protections.

While considerable literature exists to describe how patents pertain to additive manufacturing, the research does not address other forms of protection. Furthermore, the existing literature available is primarily concerned with protection of the object itself and does not address protection for the blueprint, design, and process.

3. IP Risks in AM

To secure outsourcing activities in additive manufacturing, intellectual property must be protected at each level. In the model proposed by Yampolskiy et al. [6], this means taking precautions against the unauthorized use of a design by the tuning expert or by the manufacturer. Likewise, protections must be in place to preserve the usage restrictions for the process tuned by the expert [6]. Taking these two forms of IP into consideration, there are four types of property to be protected in AM: (1) the blueprint with the design schema, (2) the manufacturing process used during production of the design, (3) the printed object, and (4) creative and original designs present on the object.

Additive manufacturing presents a new arena for IP in that possession of a blueprint allows any party with a printer to create the underlying object. Disclosure of a blueprint file is tantamount to enabling another party to infringe a patent by printing the object. As such, object designers are charged with protecting their object through stalwart monitoring of any party in possession of the file. Furthermore, because the manufacturing process is made privy to the diverse multitude of designers, as opposed to a relatively small set of traditional manufacturers,

the advent of AM increases risk for process experts.

With blueprint and process, a manufacturer or some adverse party can fabricate a protected invention or design. Depending on the properties of the printed object, patent or copyright protections may apply. If the object possesses original designs separable from the function of the object, those may be independently protected as well. However, the decentralized environment of AM can lead to enforcement problems under the current legal framework.

4. Federal Protections

The United States Code (U.S.C.) details the forms of protectable intellectual property: patents (Title 35), copyrights (Title 17), and trademarks (Chapter 22 of Title 15). Upon application, a **patent** can be granted to novel and nonobvious inventions or discoveries. Section 145 of Title 35 guarantees patent holders with the right of exclusion for the "making, using, offering for sale, or selling" the protected invention for a period of 20 years from the application date. Under section 101 of Title 17, **copyright** automatically protects "original works of authorship fixed in any tangible medium of expression" which can be communicated. Furthermore, copyright protection extends to compilations and derivative works pursuant to section 102. Sections 107 through 122 grant right holders exclusive authority to reproduce works, create derivative works, or distribute copies. The term of protection persists until 70 years after the date of the death of the last surviving author. **Trademarks** can be granted to "any word, name, symbol, or device" to be used in commerce. Section 1058 gives 10 years of protections, and right holders can renew trademark registration indefinitely upon demonstrating that the mark is still being used.

While federal provisions afford robust protections, the respective statute must be applicable for enforcement to be considered. In 3D printing, the form of protection available to a blueprint owner depends upon the nature and use of the design. When extended to the AM process, right

holders have a business relationship with manufacturers, but activity which directly infringes may emanate from unrelated third parties rather than from the manufacturer. In terms of a decentralized environment of anonymous infringement, inadequate attribution and enforcement mechanisms remove many of the teeth present in existing IP law. Table 1 provides a summary of the various forms of federal IP protections available and some of their specific differences.

Table 1: Federal Protections

	Protects	Needed for Protection	Trigger for Protection	Duration
Patent	Invention	Novel and Nonobvious	Applied-for Protection	20 Years
Copyright	Expression	Originality	Automatic Protection	Life of Author + 70 Years
Trademark	Symbol	Use in Commerce	Applied-for Protection	10 Years + Renewals

4.1 Patents

The patent system was designed to promote the "creation and disclosure" of technological advances by awarding an exclusive right to the use of the invention for 20 years [11]. But, there is a counterbalance. Pursuant to sections 111 and 112 of Title 35, in exchange for federal protections, inventors must disclose the data necessary for others "skilled in the art" to create the invention. By protecting creators, thus encouraging innovation, Congress intended to bring new designs into the public domain [12]. However, not every discovery can be protected by patent. According to Title 35 of the U.S.C., for a design to be patentable, the claimed subject matter must be both novel and nonobvious. The requirement for novelty is satisfied under section 102 when the discovery was filed prior to any other patent, description in a printed publication, or presence in public use or commerce. To be nonobvious, section 103 demands that the differences

between the invention to be patented and any previously existing similar designs must not be obvious "to a person having ordinary skill in the art."

Title 35 describes two primary forms of patents for manufactured objects: utility patents and design patents. Utility patents are only available for "new and useful" material compositions or improvements under section 101. These patents protect the function that an object performs. Design patents relate to appearance as opposed to utility, and section 171 makes patentable "any new, original and ornamental design." While similar to copyrights, design patents have a more limited applicability in that there is no prohibition on derivative works for patented subject matter.

The law provides patent holders with two primary forms of remedy for infringement. Section 284 entitles a right holder to monetary compensation for reasonable royalties for the unauthorized use of the patented invention. For patent holders wishing to enjoin a party from specific use of an invention, injunctive relief is made available by section 283. When determining whether to grant equitable relief, courts employ a balancing test to discern how the public interest is affected by the result. In *Apple Inc. v. Samsung Electronics Co., Ltd.* [13], the Federal Circuit denied Apple's attempt to prevent Samsung from selling its Galaxy S 4G, Infuse 4G, and Galaxy Tab 10.1 despite a jury finding of liability of infringing several Apple patents. The court reasoned that Apple and Samsung were the two primary players in the smartphone market for first-time users, and in deference to public interest, the balance of the equities did not favor granting a permanent injunction against the sale of the Samsung products.

Employing patents to protect printed objects may prove difficult for right holders. Any party with both infrastructure and a blueprint can manufacture patented designs. Printers for AM can be obtained more cheaply than the equipment array used in traditional manufacturing. No longer

needing to produce units in bulk to justify costs, third parties can more discretely print patented objects. Efficacious protection, therefore, hinges upon the ability of patent law to protect the blueprints. Once a party possesses a blueprint, infringement becomes trivial.

But, using patents to protect blueprints may not be possible in the current legal framework. Printed matter such as a blueprint does not satisfy the requirement for "new and useful" compositions. Though there are cases in which printed matter may be patentable, courts "look to the underlying invention" to determine whether legal protection should be afforded [14]. Consider *In re Beauregard* [15], in which the court found a computer program to be protectable under a patent for the process executed by the program instructions. The case does not offer good precedent for an inference of blueprint patentability as the underlying facts can be easily distinguished.

For a manufactured object, a patent holder obtains protection for the object—not the process by which the object was created. While an improvement to the 3D printing process would be patentable, a blueprint is merely a tool used in an existing process. The blueprints themselves are not novel [5]; only the underlying object being printed could be patentable [9]. For utility patents, the blueprint does not possess the protected function, and for design patents, the protected design is on the printed object as opposed to the blueprint.

Though an argument could be made that protection of the blueprint would be a reasonable proxy for more effective enforcement overall, there is no standing case law to support the proposition. Nevertheless, patent holders are not completely without recourse for enforcement of their rights. Title 35 details three distinct theories of patent infringement: direct, induced, and contributory.

4.1.1 Direct Infringement

Section 271(a) describes direct infringement as the making, using, offering to sell, or selling of a patented invention without authorization. For patented subject matter to be made within the understanding of section 271(a), courts determine whether the item in question had been operably assembled [16]. With respect to 3D printing, using a blueprint results in making the patented subject matter and directly infringes.

Printing objects from altered blueprints may also constitute infringement if the differences are "insubstantial" [17]. The doctrine of equivalents, codified in section 112(f), establishes infringement for altered designs provided that the patented function is being performed. An altered design that "performs substantially the same function in substantially the same way to obtain the same result" infringes under this doctrine [18].

Because a patent does not pertain to blueprints, the sale or distribution of the file does not directly infringe the patent for the underlying object. Holbrook and Osborn [9], however, argue that courts could apply the doctrine of equivalents through a proxy analysis on the printed objects, but the authors base their theory in public policy. While patent infringements do not necessarily require tangible embodiment [10], without supporting legal precedent, there is no basis for courts to infer patent protections on a blueprint file.

For AM, a theory of direct infringement is ill-fit to combat insider threats. Whether by maliciousness or negligence, if a blueprint is distributed by a licensed party, that manufacturer has not directly infringed. At no point does the distribution of the file result in the making, using, offering to sell, or selling of the printed product. Until a court infers that the sale of a blueprint carries the same effect as the sale of the patented invention, a direct infringement claim against the manufacturer would fail, but even that theory would not be applicable if the file was stolen or

freely given without obligation [19].

A theory of joint (or divided) infringement may present an alternative approach to hold a manufacturer liable for direct infringement. Joint infringement occurs when the actions of different parties taken together constitute direct infringement. To assert a successful claim, the right holder must show that a single party exerted "control or direction" over the infringing actions [20]. Therefore, to be liable, an additive manufacturer should be able to exercise authority of the third parties who print unauthorized units. Determining whether a manufacturer controls or directs the actions of a third party compels a court to consider the nature and extent of the relationship between the parties [20]. Without lasting engagements or mutual benefits, the inference of a relationship giving rise to joint activity has tenuous prospects. In *Limelight Networks, Inc. v. Akamai Technologies, Inc.* [21], the defendant had performed some steps outlined in the underlying patent before encouraging its customers to complete the remaining steps. The Supreme Court found the level of control and direction employed by Limelight was insufficient to establish joint infringement—although the act of encouragement was sufficient to find inducement [21].

Other challenges may exist when pursuing a joint direct infringement claim. With respect to AM, the claim presumes that the distribution of a blueprint file partially infringes the patent of the underlying invention. The assumption attaches properties of patent protection to the blueprint file itself, but as with direct infringement, the lack of case precedent in this matter may prevent pursuit via this avenue of recourse.

4.1.2 Induced Infringement

If the success of a direct infringement claim against a manufacturer seems unlikely, a claim under section 271(b) that the manufacturer actively induced a third party to directly infringe may

be easier to establish. While demonstrating inducement appears trivial, the Supreme Court recently determined that proving induced infringement "requires knowledge that the induced acts constitute patent infringement" [22]. A defendant can be liable for induced infringement only if he is found to have known that his conduct induced another to directly infringe [16]. Inducement without intent does not constitute a valid claim under this doctrine.

Nonetheless, a manufacturer will be unsuccessful in an attempt to refute inducement on the basis of a good faith belief in the invalidity of the underlying patent [23]. An infringement inquiry should not be conflated with an inquiry to determine validity [23]. Rather, the assertion of a belief that a patent is invalid presumes knowledge of the patent itself. Cognizance of a patent's existence connotes an understanding of acts that infringe the patent—regardless of the document's presumed validity.

Manufacturers cannot deliberately shield themselves from direct knowledge of infringing activities by way of willful blindness [22]. The Supreme Court limits the scope of the doctrine with a two-step analysis: the manufacturer "must subjectively believe that there is a high probability that a fact exists" and the manufacturer "must take deliberate actions to avoid learning that fact" [22]. For additive manufacturers licensed to print a patented invention, knowledge of the underlying patent has already been established. Because a blueprint's only purpose is to print a design, it seems straightforward to conclude that a contracted manufacturer would appreciate the high probability that unauthorized distribution of the file would result in infringement. Even online file distributors can be liable for induced infringement; particularly if the product is marked with a United States patent number [8].

The final hurdle for a right holder to show induced infringement is to prove that the inducement resulted in a violation of section 271(a) [16]. A defendant cannot be held liable for

induced infringement "when no one has directly infringed the patent" [21]. Recall that direct infringement in the context of AM requires the making, using, offering to sell, or selling of the patented object, not the blueprint file. Possessing, copying, or distributing the file is not direct infringement but merely potential evidence to demonstrate inducement.

As a matter of practicality, this distinction may construct an insurmountable hurdle for properly asserting induced infringement in the general case. Internet anonymity coupled with an environment encouraging a decentralized collection of private infringers significantly threatens patent enforcement [7]. Ease of accessibility to resources can give rise to numerous and diverse infringements. Finding each infringer may prove difficult enough without even considering the impracticality of prosecuting in all instances. Digital copyright owners have struggled to counteract internet piracy for nearly twenty years [24]. Whereas digital copyright infringement can occur after a blueprint is downloaded, patent infringement does not occur until the digital file is used to print the protected design. For actors printing patented inventions within the privacy of their homes, the Fourth Amendment prevents investigators from searching key locations for evidence of infringement without a warrant. Effective enforcement against all instances of private patent infringement for 3D printed inventions is not possible without diminishing the strength of constitutional privacy protections [25].

4.1.3 Contributory Infringement

Outlined in section 271(c) of Title 35, the third form of patent infringement, known as contributory infringement, holds liable anyone who offers to sell, sells, or imports a material component of a patented invention with knowledge that the component was specially made or adapted for an infringing use. As with induced infringement, these actions must have culminated in an act of direct infringement [16]. Likewise, the statutory language only pertains to sales or

offers, not thefts or gratuitous transfers [19].

Inherent properties of the 3D printing process may prevent remedy under this theory however. Additive manufacturing differs from traditional manufacturing in that it does not assemble an invention from component parts; rather it constructs an object by combining materials through additive layers. Even if the raw materials used by the printers were considered components of the printed invention, as long as there are non-infringing uses for those materials, a strictly definitional interpretation of contributory negligence can lead to a harsh outcome for right holders.

The issue becomes even more complicated when the infringement originates with a manufacturer who sells or offers to sell a blueprint. For a design owner to recover in such an instance, a court must find that the blueprint file is a component of the invention. Unfortunately for patent holders, a blueprint is not a combinable component of a device within the understanding of the statute [26]. But, because such a ruling would effectively barricade recovery via a contributory infringement claim for 3D blueprint creators, courts may be amenable to inferring a limited exception as a matter of policy.

In a recent case addressing whether software could be a component, the Supreme Court distinguished "software in the abstract" with a copy of the software on a medium [26]. Though the Court rejected the argument that software detached from any medium qualifies as a component, a copy of software encoded on a medium can potentially receive protection as a component [26]. However, the example of a suitable medium proffered in the case opinion was a CD-ROM [26]; there is an open question as to whether a digital file could be considered a medium in this regard.

If a litigant successfully argues for a blueprint to be judicially regarded as a component for a

product manufactured with a 3D printer, many of the remaining requirements can be satisfied. Materiality is trivial to establish, as a blueprint file is necessary to give instructions to the printer. Scientist is more easily found for contributory as opposed to induced infringement because the contributory infringer need only be aware that the component has no substantial non-infringing use [27]; the defendant does not have to have the intent to infringe. Notwithstanding the relative ease meeting these requirements for contributory infringement, practical barriers pertaining to proving that direct infringement had occurred can completely bar recovery under this doctrine.

4.2 Copyrights

Where patents offer a monopoly over an idea itself, copyrights exist to protect the expression of an idea. Section 102 of Title 17 grants rights to authors of original works expressed on a fixed tangible medium. Protected works can be communicated directly or with the aid of a device. Copyright holders gain exclusive rights under section 106 to produce copies, prepare derivative works, and distribute copies to the public. An implied right in section 1201(a)(1)(A) is the privilege to encrypt a work without destroying the underlying copyright. Attempts to circumvent the technological measure to control access qualify as infringement under section 501.

Originality is the hallmark of eligibility as a copyrightable design. According to the Supreme Court, "the requisite level of creativity is extremely low;" as long as the work possesses "some creative spark," it will receive Title 17 protection [28]. An author need only contribute more than a trivial distinction from an existing piece [29]. Nevertheless there are exceptions when determining whether a work is copyrightable. Section 113(b) withholds protections for useful articles which are defined in section 101 as having intrinsically utilitarian functionality beyond the mere portrayal of the creative work. For instance, a painting on a canvas is copyrightable even though the canvas has a purely utilitarian function. Because the purpose of the canvas is to

serve as a medium for the painting, section 113(b) does not exclude the work.

There are times when a copyrightable work may not receive protection. Arising from the dichotomy between idea and expression, the merger doctrine can be applied to deny copyright protection when an expression has merged with an idea [30]. If an idea can only be expressed in a limited or singular fashion, the expression will receive little to no copyright protection lest the author receive a monopoly on the underlying idea itself [31].

Infringement of a valid copyright occurs when a third party uses the rights exclusive to the holder without authorization. The threshold for stating an infringement claim is set relatively low; the rights holder need only indirect evidence demonstrating that the alleged infringer had access to a protected work and produced something substantially similar [32].

Articulating a second theory of infringement, the Supreme Court brought the claim for inducement from patent to copyright [27]. A manufacturer can be liable to a designer if the manufacturer had taken "active steps" to encourage direct infringement [33]. However, proving this claim presents a challenge. Mere knowledge of the potential for infringement is insufficient to validate a claim [34]. If a manufacturer is negligent in safeguarding a copyrighted file or design, there is insufficient basis to establish intent.

Even if a manufacturer were actively distributing files, there are three probative elements of intent to induce copyright infringement [27]. The manufacturer must have an unlawful objective which promoted infringement, neglected to diminish the potential for infringement, and implemented a business model dependent on third party infringement [27]. These requirements imply that a manufacturer must profit from encouraging third parties to directly infringe.

Nonetheless, there are several avenues for a copyright to provide a remedy for designers of 3D printed works: when the printed object is copyrightable in its entirety, when a design on the

printed object is copyrightable, and for the 3D blueprint. The application of copyright subtly differs depending on the subject matter protected.

4.2.1 Printed Creative Works

A straightforward application of copyright for 3D printed objects pertains to a printed object being entirely protected. An original expression, the work cannot be printed without authorization, but the merger doctrine may provide a small loophole for would-be infringers. If a third party constructs a design whose similarity primarily relates to the abstracted ideas that gave rise to the design, infringement will not have occurred [35].

Like with patents, because the protected subject matter is the object being printed, distribution of the blueprint file does not constitute infringement on the copyright of the resultant work. As this form of piracy gains prominence, barriers of practicality diminish the likelihood of effective enforcement.

4.2.2 Designs on Printed Objects

Copyrights can also be used for a decorative design or ornamentation present on the end product. If a useful article contains original works of authorship independent of the functional components of the article, the original work may be independently copyrightable under Title 17, section 101. Not intending to protect utilitarian products that appear "aesthetically satisfying and valuable" by serendipity, Congress made the cornerstone for the determination hinge on whether the design is "physically or conceptually" severable [36].

To distinguish between "applied art" and "industrial design" [37], courts question whether the work reflects "independent, artistic judgment" [38]. Answered in the affirmative, the design is deserving of copyright as being conceptually separable from the function of the object. Conversely, if the design appears to have been motivated by "utilitarian pressures" as much as by

"aesthetic choices," copyright protection is properly denied [39]. Phrased differently, the primary role of the design must independently lie in its artistry and not its industrial necessity.

Note that, in these circumstances, if a copyright protects a design as an original work of authorship but not the printed object, only the design is protected. To circumvent this form of protection in AM, a blueprint need only be modified to remove the copyrighted design. Then, the object could be printed without risk of infringement. Without additional forms of protection, a designer who outsources the printing process risks much of the work product without legal recourse.

4.2.3 Blueprint Files

Section 102(a)(5) protects "pictorial, graphic, and sculptural works" which include "technical drawings" within its definition in section 101. Despite the artistic value of a technical drawing likely being predominated by its utilitarian function, blueprints used in 3D printing are protectable subject matter [40]. A blueprint meets the definitional requirements of the statute as it is a fixed tangible means of expression perceived with the aid of a machine to construct an object. Not all blueprints are copyrightable however. Though the threshold for originality is low, digital models created with three-dimensional scans are not sufficiently original to give rise to protection [41].

Having a copyrightable blueprint does not guarantee full protection for right holders. Instead, copyrighting a blueprint supplements other forms of protection. Because the subject matter of the copyright is the blueprint, the rights are attached to the file, not to the products made when the file is executed. Infringement of a copyright on a blueprint occurs when the blueprint file is copied or altered without authorization. Actually printing objects using the file does not violate the copyright. Lacking a contract stating otherwise, a party with an authorized blueprint can print

an unlimited number of times without infringing the blueprint's copyright.

Further troubling for right holders is the potential for using a blueprint's information without violating copyright. In defining protections available for technical drawings, section 101 states that protection applies to the form of the works, not their utility. Consider a scenario in which an adversary has captured the instructions sent to a 3D printer from the application which read the blueprint and uses those instructions to print the object again without recreating the blueprint. Because the specific form of expression has changed, courts could be hesitant to find that copyright has been infringed if those instructions were used to fabricate unauthorized copies of the printed object.

While the scenario described seems incredulous, it can be readily analogized to architectural works of construction. Prior to the enactment of the Architectural Works Copyright Protection Act in 1990, architectural blueprints received protection while the structures did not [42]. Cases leading to the statute's amendment held that a rights holder of a copyrighted blueprint does not have a protectable interest in the building depicted [43]. Additive manufacturers may find itself postured similarly when cases increase in frequency. Barring congressional mandate, courts may hesitate to extend copyright protection to encompass the printed article.

4.3 Trademarks

Differing significantly in purpose from other forms of protection for IP, trademarks exist to alleviate customer confusion regarding brands in the marketplace [44]. Consumers can rely on these marks as a "concise and unequivocal identifier" for product expectations and responsibilities [45]. Since assuring brand integrity for consumers pertains to events preceding a transaction, section 1114 of Title 15 protects a registered mark for use in commerce.

Given the underlying goal of trademarks, the strength afforded a specific mark varies with the

potential for commercial confusion [46]. For example, if a particular brand with a registered mark improves the scale and scope of business, the trademark will logically be more recognizable leading to more severe economic consequences if the mark is misused.

When protection is available, it can extend beyond a specific word or symbol. Trade dress, the visual characteristics of a product [47], is protected under section 1125. As a subsection of trademark law, trade dress receives relatively less protection, however. For one thing, trade dress must be nonfunctional [48]. Trade dress also cannot be distinctive intrinsically; the product's design must have achieved secondary meaning after having been suffused in the market [49].

4.3.1 Direct Infringement

Under section 1114(1)(b), the reproduction, counterfeiting, or copying of a registered mark is not at issue unless it is "intended to be used in commerce." Infringement occurs when products are sold bearing a design that resembles a registered mark [50]. To evaluate resemblance, courts question the likelihood that consumers will be confused by considering several factors such as the strength of the trademark, the degree of similarity, and the proximity of the markets for the products [51]. Note that, unlike with patents and copyrights, timing matters. If a product does not ever enter the stream of commerce, there is no trademark protection because consumer confusion is not at issue. As a result, an individual possessing a 3D printer can print an object bearing a trademark for personal use without actually infringing.

In AM, trademarks appearing on a printed product may not receive as robust protection as a rights holder may desire. As with copyrighted designs on printed objects, the trademark can be easily circumvented. If the trademark is removed prior to printing, there is no infringement. Likewise, as long as a printed object bearing an unauthorized trademark does not enter the stream of commerce, there is no violation. Even though a design may be stolen and a mark

copied, if there is no potential for consumer confusion, a rights holder cannot make a claim.

4.3.2 Indirect Infringement

Though the statutory text is silent as to alternative forms of trademark infringement, courts have judicially constructed two forms of indirect infringement: contributory and vicarious. A claim of contributory infringement is available when a party either induced the direct infringement by a third party or when a party should have known that his distribution of a product was infringing a mark [52]. Though called contributory infringement, the scienter requirement for knowing cooperation more closely resembles that required to establish induced patent infringement.

Conversely, vicarious infringement does not require intent, but instead evidence of cooperation. The claim arises when an enabler and the direct infringer have an apparent or actual partnership [53]. Web service owners whose services are used to distribute unauthorized products bearing trademarks may be found vicariously liable [54].

As with patents and copyrights, to file a successful claim of indirect trademark infringement, a plaintiff must show evidence that the mark was directly infringed by a third party. If a manufacturer distributes or makes available a blueprint of an object bearing a registered mark, even though the acts constituting indirect infringement are readily apparent, without evidence of direct infringement having taken place, right holders cannot find recourse through this mean.

5. Protection Limitations

While the United States Code provides robust protection for a variety of forms of intellectual property, the unique environment inherent in AM prevents effective enforcement. Table 2 illustrates shortcomings and caveats for forms of IP protection. The availability of multiple avenues of infringement reveals the multiple inadequacies in the existing legal framework.

Greater reliance on a blueprint as a means of facilitating piracy almost necessitates patent law to evolve in response. Until sufficient deterrents are in place to render internet piracy manageable, federal protections are insufficient to deter many forms of infringement.

Table 2: Limits of IP Protections for Additive Manufacturing

	Patent	Copyright	Trademark	Problems
Blueprint	N/A: Not novel; Uses preexisting tools and processes	Yes: Technical drawing; Scans not original	No: Unless blueprint possesses a trademark and is used in commerce	<i>Impractical enforcement against direct infringers</i>
Process	Yes: If novel and non-obvious	N/A: Not an expression	N/A: No registered mark present	<i>Impractical enforcement against direct infringers</i>
Printed Object	Yes: If novel and non-obvious	Yes: If an original expression	Yes: If the object possesses a trademark and is used in commerce	<i>Removable trademark; Impractical enforcement against direct infringers</i>
Design on Object	N/A: Form of expression	Yes: If original and separable from utilitarian function of object	Yes: If the design possesses a trademark and is used in commerce	<i>Removable design and/or trademark</i>

Legend: No Protection Not Applicable Protection Available

Where statutory limitations become apparent, however, private contracts in the form of licensing agreements may be used as a supplement. Right holders can negotiate with particular manufacturers regarding the treatment of their IP, can narrowly draft usage requirements, and can specify damages for manufacturer misconduct. Licensing agreements can even be drafted to not require proof of direct infringement but instead can impose contractual liability for

manufacturer negligence in safeguarding intellectual property.

While privatized agreements may seem to be a panacea for right holders, if a contract claim is challenged and proceeds to trial, there must be evidence of misconduct to support a claim. Without technical evidence amounting to factual proof of misconduct, a right holder has less hope for recourse. Technical adaptations may need to be implemented into the AM process to enhance the likelihood of positive attribution.

6. Conclusions and Future Work

The advent of 3D printers pushes manufacturing into a similar age experienced by digital media companies when first battling file sharing of digital copyrighted material. Existing United States intellectual property safeguards are inadequate to fully protect right holders for objects, designs, and processes involved in AM. Under the current statutory framework, the lack of patent protection on a blueprint renders infringement claims impractical. Inherent limitations to copyright and trademark protections on protectable designs and symbols can be exploited to completely prevent recovery in some circumstances.

Because each form of IP protection can be circumvented by an infringer, both legal and technical alternative solutions are required. However, until such mechanisms are in place, a right holder involved in 3D printing should be cognizant of the potential to not be able to pursue a claim of infringement. Rather, prudence and caution are advised as the fabrication industry adapts to a digital age.

Future works in this area will consider the effectiveness of private contracts to satisfy the needs of right holders identified in the current research. The research will also consider evidentiary requirements to prove an infringement claim or a breach of contract claim. Security attributes will be discussed to develop a working understanding of the needs to be satisfied

before exploring technical solutions to better ensure the applicability of existing legal protections. With better attribution mechanisms, IP rights enforcement procedures can be improved upon to provide right holders with their federally guaranteed protection.

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