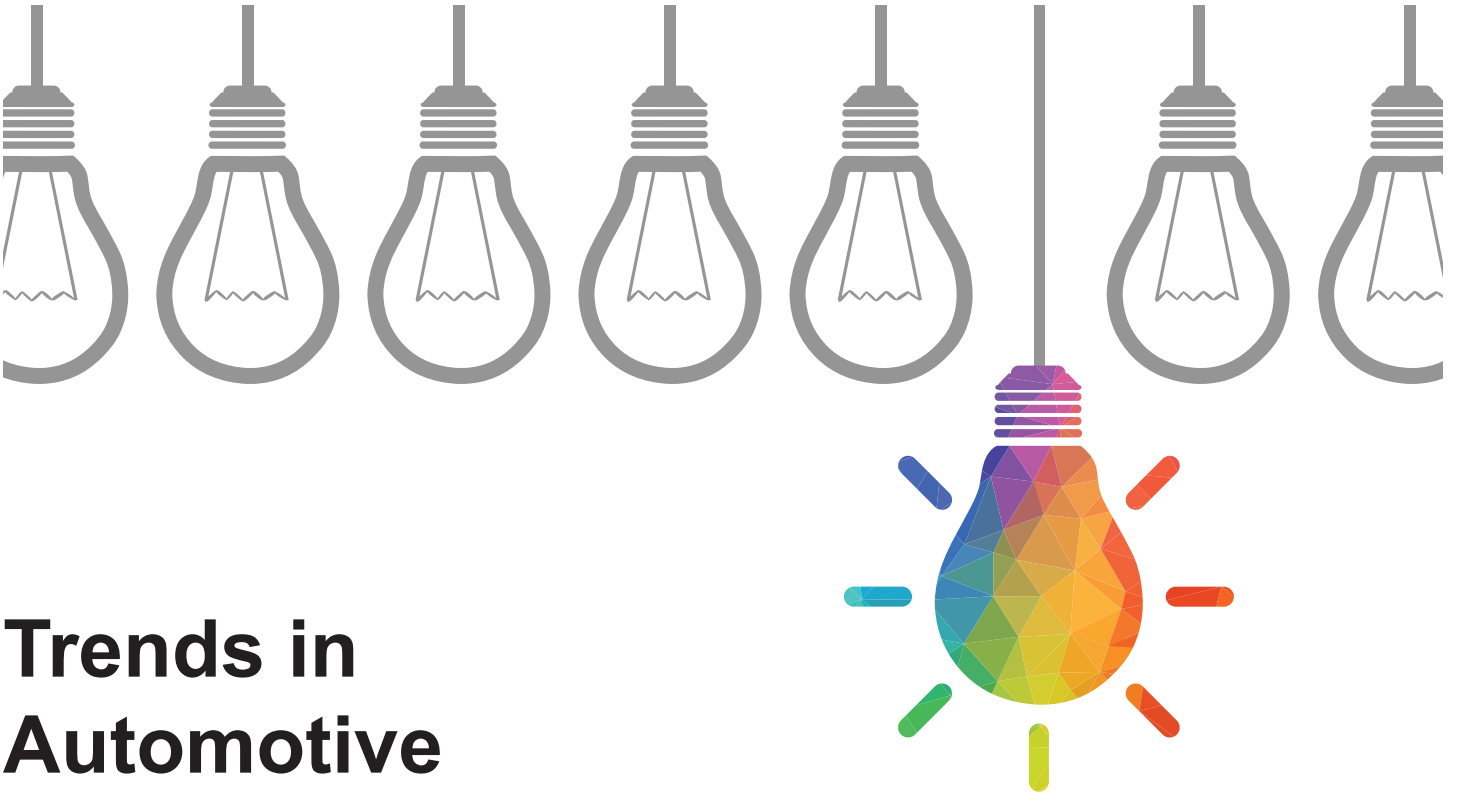


Trends in Automotive

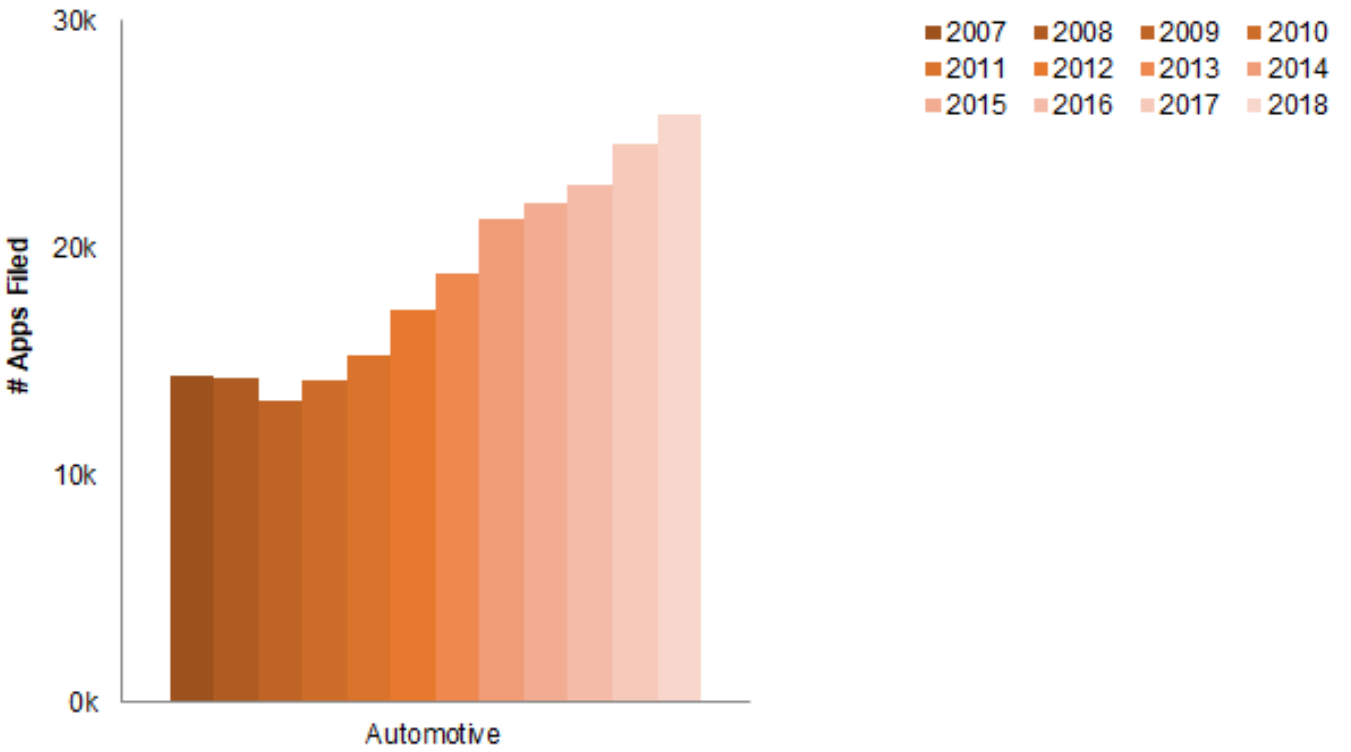
Consumers are increasingly prioritizing in-car technological innovations over brand loyalty. The decrease in brand loyalty means an increasingly competitive field, in which patent dominance can provide a significant advantage.

The last decade has seen huge changes in the automotive industry. New competitors have entered the market, electric motors and hybrid drivetrains have become viable alternatives to the internal combustion engine, which continues to evolve toward higher efficiency. Driver-assist features are offered on many cars today with brands working toward more autonomous driving technology. This wave of innovation is reflected in the steep rise in the number of patent filings by the automotive industry. To better understand the trends of patenting automotive innovation, we have investigated the following technology clusters within the general automotive industry:

Automotive - Level I Clusters	Level II Clusters
AI-Integrated Vehicles	Autonomous Vehicles
	Connected Vehicles
Ancillary Vehicle Systems	-
Battery	Lead Based Battery
	Lithium Based Battery
	Other Aspects (Battery Management System/Packs)
Electric Vehicle	Battery Electric Vehicles
	Fuel Cell Based Vehicles
	Hybrid Electric Vehicles
Vehicle Controlling System	-
Vehicle Design	-
Vehicle Navigation System	-
Vehicle Propulsion System	Electric Motor
	Internal Combustion Engine (Ice)
Vehicle Safety System	-

Taxonomies and expanded definitions of these clusters are included in appendix A.

Since the Great Recession, automotive patent filings have been on a steep uptrend



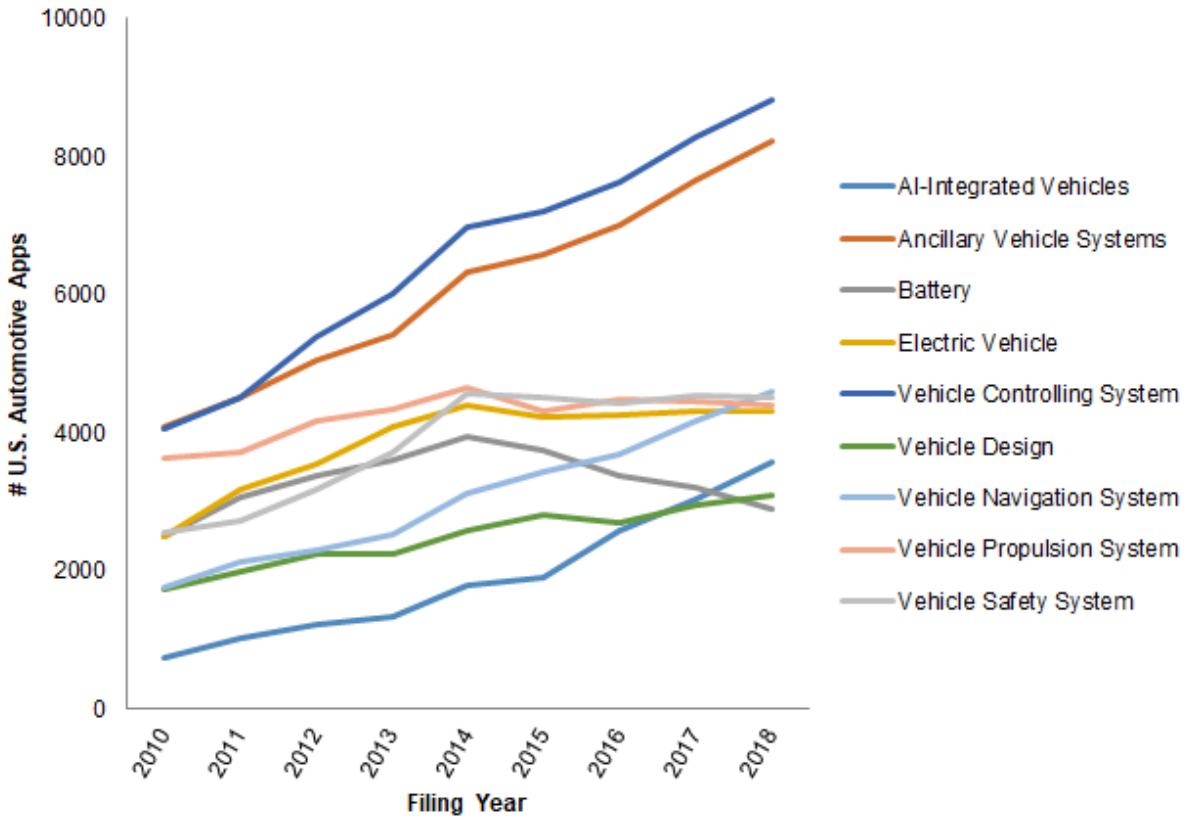
The automotive industry is heavily dependent on the availability of credit (both to its consumers and to manufacturers), so it was hit especially hard by the credit crunch of 2008. The situation was so dire that the U.S. government had to step in and bail out the big three American car manufacturers - General Motors, Ford and Chrysler. Predictably, R&D took a hit during that time,[23] and the number of patent filings reflect that downturn.

As the credit markets began to recover, so did the fortunes of the automotive industry and its R&D programs. Indeed, increasing their R&D efforts to produce energy-efficient vehicles was one of the promises that the bailed-out car companies made in order to receive government money.[24]

Other factors made the recent push for innovation imperative in the automotive industry. First, traditional car companies now have to compete with new entrants who focus on simpler electric propulsion without the burden of the combustion engine, and they see even more potential competition on the horizon from Big Tech powerhouses developing autonomous vehicle technology. Second, consumer tastes are evolving, and there is evidence that they are prioritizing in-car technological innovations over brand loyalty.[25] The decrease in brand loyalty means an increasingly competitive field, in which patent dominance can provide a significant advantage. The boom in innovation and in competition is reflected in the steep uptrend we found in patent filings from the automotive industry.

[23] https://newatlas.com/worlds-top-20-corporate-rd-spenders/13406/
[24] https://www.treasury.gov/press-center/press-releases/Pages/tg31.aspx
[25] https://www.prnewswire.com/news-releases/autotrader-study-finds-48-percent-of-car-buyers-prioritize-in-vehicle-technology-over-brand-or-body-style-300387862.html

The steepest innovation trend is around the Vehicle Control Systems cluster



Vehicle control systems are the subject of significant R&D efforts, which are resulting in increasing patent filings. Innovation in vehicle control systems relates to several areas, including fuel efficiency, cybersecurity, safety, and emissions control.[26] All of these areas are likely to continue to be significant hotbeds of innovation - and of patent filings - for years to come.

[26] https://www.marketresearchfuture.com/reports/automotive-electronic-control-unit-market-4835; http://www.ti.com/lit/wp/sszy009a/sszy009a.pdf; https://www.nhtsa.gov/technology-innovation/vehicle-cybersecurity

The number of fuel cell-related patent filings is small, but fuel cell cars are a strong bet for at least one industry leader.

Our study indicates that only approximately 5% of patent applications in the Hybrid/Electric Vehicles cluster are related to fuel cells. One reason why this may be the case is that the manufacturing process is more complicated for fuel cell vehicles as compared to electric and hybrid vehicles. Another factor may be the lagging development of infrastructure, such as fueling stations, to accommodate fuel cell vehicles.[27] Yet a third consideration is the cost of clean-source (not from natural gas) hydrogen, which is still significantly more expensive than traditional fuels and needs innovation to be more competitive.[28]

However, despite the obstacles, Toyota is selling a fuel cell car, the Mirai,[29] which currently comes with three years of free hydrogen to soften the blow of fueling costs.[30] One of its considerations may be that fuel cells for automotive applications is an emerging technology where innovation does not face as much prior art.

The race for market share in electric cars is heating up

Car manufacturers are putting great R&D resources into electric cars, indicating that they see this technology dominating the automotive industry of tomorrow. Toyota, Ford, and Hyundai are all competing in this space and filing hundreds of patents related to this technology cluster. Although not on the patenting leaderboard, Volkswagen is in this race, too. It has recently unveiled its new electric car platform, called Modular Electric Toolkit ("MEB"), which it is willing to share with other car manufacturers.[31] Volkswagen's path to an electric car appears to be through partnerships with other innovators. For example, it recently invested $100 M in a solid-state battery company[32] and is looking for partners to adopt their MEB platform for vehicles from competing brands. Other brands are developing their own platforms for their affiliate brands as volume is required to develop the economies of scale that will allow continued relevance as the internal combustion engine era fades.

The patenting space for electric cars also includes component manufacturers who are innovating and filing for patent protection in this technology cluster. This trend has been noticed by Investors who are betting that component manufacturers will be the early winners in the shift to electric.[33]

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[27] https://www.japantimes.co.jp/news/2017/12/22/business/infrastructure-needs-put-drag-fuel-cell-vehicle-popularity/#.XHrfcFNKi9Y
[28] https://www.theicct.org/publications/developing-hydrogen-fueling-infrastructure-fuel-cell-vehicles-status-update
[29] https://www.ft.com/content/328df346-10cb-11e7-a88c-50ba212dce4d
[30] https://ssl.toyota.com/mirai/ownership-experience.html
[31] https://www.volkswagenag.com/en/news/stories/2019/01/volkswagen-offers-electric-cooperations.html
[32] https://www.cnet.com/roadshow/news/2018-volkswagen-quantumscape-solid-state-battery-technology/
[33] https://www.reuters.com/article/us-autos-ev-investors/investors-bet-on-component-makers-in-electric-car-shift-idUSKCN1GJ1IE

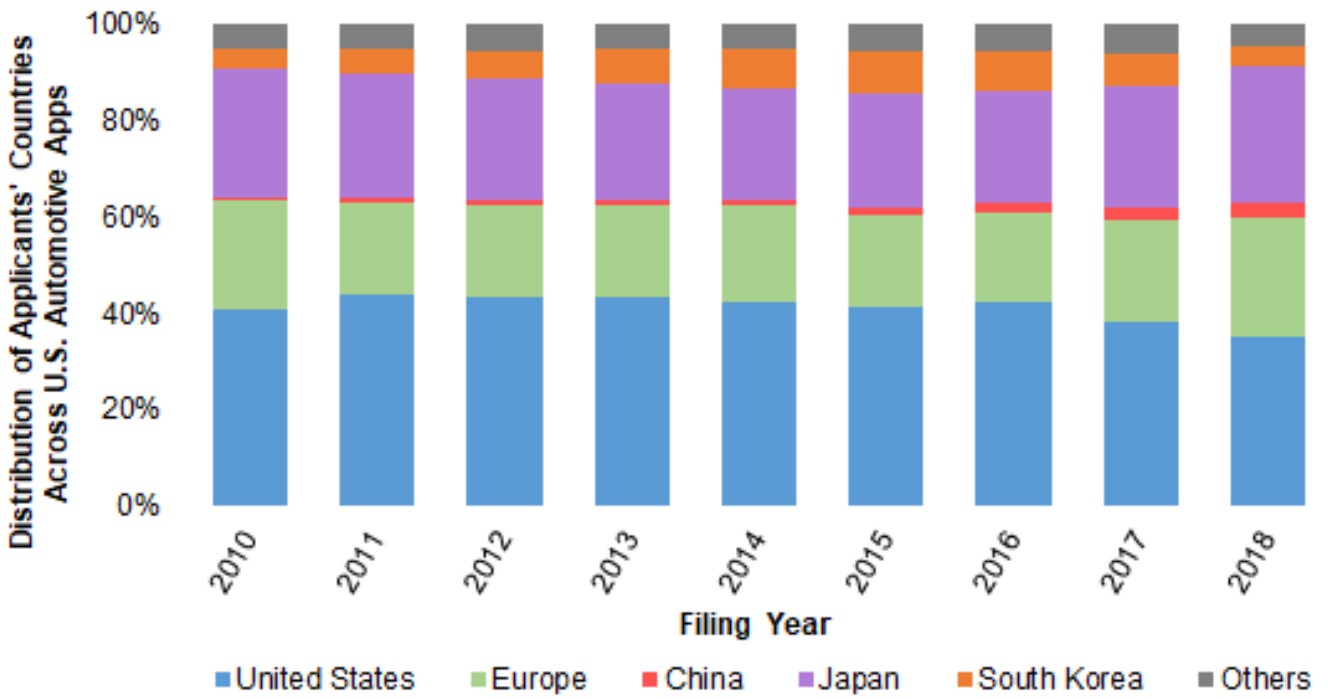
Toyota, Ford, Hyundai, and General Motors are the top filers in most technology clusters

Automotive leaders like Toyota, Ford, Hyundai, and General Motors, continue to patent broadly across all technology clusters, signaling their intent to maintain their leadership in automotive technology.

USING 2016 DATA:		
		Most Families Flied by
		(Applicants In alphabetical order)
Automotive		Ford, General Motors, Honda, Hyundai, Toyota
Level I		
AI Integrated Vehicle		Ford, General Motors, Honda, Hyundai, Toyota
Ancillary Vehicle Systems		Ford, General Motors, Honda, Hyundai, Toyota
Battery		Ford, Honda, Hyundai, Samsung, Toyota
Electric/Hybrid Vehicles		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Controlling System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Design		Bridgestone, Ford, General Motors, Goodyear, Honda
Vehicle Navigation System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle propulsion System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Safety System		Ford, General Motors, Honda, Hyundai, Toyota
Level I	**Level II**	
AI Integrated Vehicle	Autonomous Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
	Connected Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
Battery	Lead Based Battery	Ford, Hyundai, Johnson Controls Tech, Co., LG, Toshiba Corporation and affiliates
	Lithium based battery	Ford, Gs Yuasa International Hyundai, Ltd., Hyundai Toshiba Corporation and affiliates, Toyota
	Other Aspects {Battery Management System/Pads)	Ford, Honda, Hyundai, Samsung, Toyota
Electric/Hybrid Vehicles	Battery Electric Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
	Fuel Cell Based Vehicles	Ford, Honda, Hyundai, Toyota, Volkswagen
	Hybrid Electric Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Propulsion System	Electric Motor	Ford, General Motors, Honda, Hyundai, Toyota
	Internal Combustion Engine (Ice)	Ford, General Motors, Honda, Hyundai, Toyota

Other manufacturers, however, appear to be focusing their patenting efforts on vehicle design. Notable examples of this trend are Fiat Chrysler, Ferrari, and Daimler AG - the parent company of Mercedes Benz.

European and Japanese companies are filing a higher percentage of automotive industry patent applications

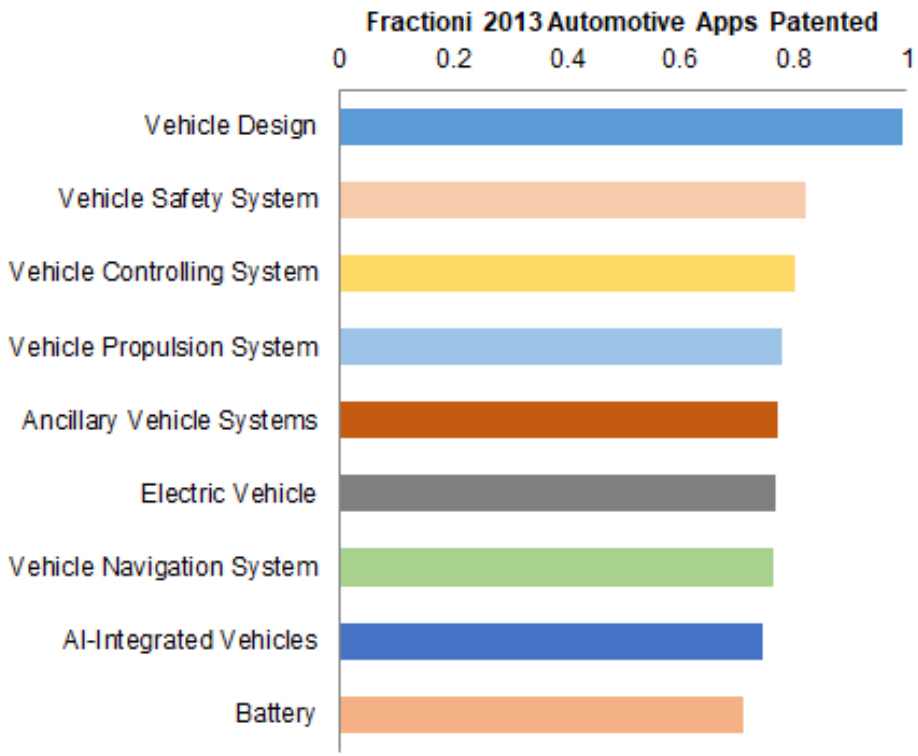


In the past 5 years, U.S.-based companies have been filing less than 45% of patent applications in the USPTO, and that percentage appears to be falling. The decrease is especially noticeable since 2017 when the present U.S. presidential administration began its tenure. This administration has rolled back a number of regulations that impact the automotive industry, potentially reducing the urgency of some R&D initiatives.

On the flipside of this trend, European and Japanese companies are filing a higher percentage of patent applications. It is likely that the uptrend in European and Japanese patenting activity relates at least in part to the more stringent regulatory environment in those markets, including much higher mandated fuel efficiency standards.[34]

[34] https://www.nytimes.com/interactive/2018/04/03/climate/us-fuel-economy.html

The majority of Automotive Industry patent applications are granted allowances



An automotive Industry patent application filed in the USPTO has a better than 75% chance of being granted allowance, which exceeds the average of the U.S. patent office. Vehicle design patents, in particular, are virtually guaranteed to be allowed, in line with industrial designs generally. The USPTO grants allowances on more than 95% of design patent applications as can be seen in the Industrial Design Industry section of this study.

KILPATRICK TOWNSEND

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