Professional Perspective

Trends in Patenting Vehicle Motive Technology

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Improvements in automotive vehicle technology have been reflected in the steady growth of patent grants for over a century. Until very recently, the increase in the storehouse of vehicle technology was propelled in large part by improvements in the internal combustion engine (ICE).

Today, conventional engine technology is giving way to technologies aligned with electric vehicles. Traditional engine design and production businesses are finding themselves in patent competition with companies operating in advanced, computer-related technologies, many of them small- or medium-sized companies.

The days of simply focusing on typically incremental mechanical improvements in the vehicle's platform directed to the fossil fuel engine and its related drivetrain components are behind us. Taking their place is a focus on new and, for most OEMs (original equipment manufacturers), unfamiliar technologies related to the electric vehicle itself (primarily battery technology) as well as to EV support systems, such as recharging stations.

But this is not as simple as one door closing and another opening—for a variety of reasons, some technical, some practical, some political, the ICE will be with us for many years to come, thereby forcing OEMs to continue improving both efficiency and durability of fossil fuel engines. Not only do traditional auto manufacturers need to adopt new technologies to survive but they must also refashion their traditional and comfortable patent filing strategies both at home and abroad to protect this new world.

Internal Combustion Engine & Related Technologies

Improvements in ICE technology focused on increases in thermal energy use with the resulting increase in fuel efficiency without compromising output. Cylinder deactivation, improvements in ignition systems to improve combustion efficiency, variable compression ratio engines, and better turbocharging and supercharging arrangements are examples of ICE technologies which result in a combination of leaner fuel consumption and maintained or improved horsepower. The ICE has long demonstrated a wide power range made possible in party by its light weight. Nonetheless, improvements continued to be directed to increasing power density and reductions in both driveline power loss and vehicle weight.

Positive developments in the overall efficiency of the ICE and its related components continued to be represented by a general increase in patent filings until peaking in 2014-2015, and the numbers continue to fall. Recent World Intellectual Property Organization statistics show that year-over-year reductions in the number of patent applications for ICE and supporting technologies by mid-2021 had fallen by almost 25,000.

But U.S. numbers for this time period are likely skewed as U.S. companies filed, overall, about 4% fewer patent applications in 2020 as compared with 2021. Some auto makers, such as Audi and Mercedes, decided not to further invest in new ICEs but instead to adapt existing technologies to emission guidelines and standards.

The Electric Vehicle & Related Technologies

The shift of developments in motive technologies is clearly from the ICE to the EV. Enabled largely by new developments in storage battery capacities, governments, particularly China and in the EU, are implementing future restrictions on vehicles that rely on the ICE for power. Less than two years ago, the U.K. announced that the sale of ICE-powered vehicles would be banned by 2030, becoming the first G7 nation to do so.

Perhaps recognizing the writing on the wall, a number of auto manufacturers, including Ford, GM, Volvo, and Mercedes-Benz signed a pledge to phase out ICE-powered vehicles by 2040 around the world. Neither Toyota nor Volkswagen signed the pledge.

The dramatic shift in national and corporate perspectives and strategies on the ICE resulted in an unprecedented level of attention to electric vehicles with headlines about both great successes and perhaps predictable failures. A cooling-off of new patent applications being filed on the ICE-related technologies and particularly on the engine itself is being offset by an increase in patent application filings not only directly related to EV systems—such as traction battery technology, controllers, thermal management technology and the traction motor itself—but also for charging new types of charging

stations such as U.S. Patent No. 10,518,657 directed to an energized streetlamp for curbside charging. Some EV technologies are entirely new and have no place in the ICE world, such as Ford's "Battery Charging by Towed Regenerative Braking" patent application, which provides a method of recharging an EV while being towed.

The shift in re-thinking ICE technology and embracing EV science has also resulted in the creation of opportunities for existing companies not normally thought of as auto companies entering the market. Recent filings by unlikely participants in the auto market include Huawei which filed patent applications for drive systems for electric vehicles.

Propelled largely by government pressure and enabled by new battery technologies, electric vehicles appear to be here to stay. Arguably the greatest technical challenge to public acceptance of the EV was its limited range, a problem which was solved by the discovery of the lithium-ion battery in the early 1970's. U.S. Patent No. 4,084,046 for a rechargeable electrochemical cell comprising a lithium metal anode and electrolyte containing lithium perchlorate is an early example of such a battery.

This patent, together with other related patents, were the first in what has become a virtual avalanche of patent applications and issued patents directed to improvements in battery technology. There were 212 battery-related patent applications filed with the U.S. Patent & Trademark Office in 2000, this number being expanded to 7,843 in 2019, the latest year application filing numbers are available for the entire year due to delayed publication.

Both OEMs and suppliers are responding to the new environment by moving aggressively in developing and protecting EV-related technologies. Given the growth of partnerships between the OEMs and component suppliers, both OEMs and high-tech suppliers such as Waymo, Uber, and even IBM became major assignees of patents. Traditional auto makers have little experience with the development and protection of many of the technologies related to the EV and will likely have to choose between developing expensive in-house capabilities or taking licenses from those companies which were created specifically to develop the EV platform.

The top three applicants for international patent application filings on battery technology—Samsung, Panasonic, and LG Electronics—are not traditional auto companies. Smaller, purpose-created companies, such as silicon lithium-ion battery company Enevate Corporation, which claims to have 100 issued patents around the world with almost 400 patent applications pending, are becoming well-positioned as battery technology licensors. The World Intellectual Property Organization statistics show that while patent applications for ICE technologies dropped almost 20%, year-over-year increases in the number of patent applications for electric vehicle technology were almost 60%.

Recognizing the challenges of encouraging consumers to simply switch over from their familiar ICE-powered vehicle to an electric version, some manufacturers are taking steps to bridge the two worlds, even if artificially. A patent application published in early 2022 and assigned to Toyota allows the operator to manually shift "gears" in a manner similar to the conventional, manual ICE vehicle. Taking the traditional experience a step further, both Hyundai and Kia seek patent protection on an invention which mimics the vibration of an ICE—in an EV. Figures included in a Ferrari patent application show a battery pack mounted in the middle of the car in an apparent effort to continue the company's mid-engine tradition.

Not all elements of EV patent filings are increasing numerically at the same pace. The electric vehicle requires a broad platform of components, so it is only natural that patent filings are uneven, such as the number of filings directed to braking, steering, and suspension systems as well as battery, electronic, and propulsion positioning. For the last decade, most patent applications on these ancillary technologies focused on braking systems followed by one or the other of chassis systems and steering systems depending on the year.

The numbers notwithstanding, a caveat is necessary in any quantitative analysis of inventing related to ICEs and EVs. One-on-one or in-kind comparisons between the patenting of ICE technology and that of EV technology cannot be linear, because EVs are technically less complex than the ICE and its related systems. Some have argued that patent filings on EV technology will flatten out in the not-too-distant future for this very reason, although it is recognized that there will be continuing improvements in, for example, battery efficiency and durability for some time to come thereby warranting new patent filings. But simpler technologies naturally warrant less inventing.

Existing Technologies Useful

Despite transitioning from ICE technology to EV technology, certain aspects of the automotive vehicle will likely not see much change if any change at all. These technologies include braking and steering systems, safety systems, lighting, and high technology "smart" windshields. Developments in these areas will continue to see the addition of new patent protection. And regardless of the method of power, the overall shape of the vehicle as well as individual components such as headlights, fenders, and bumper assemblies will continue to require protection by way of design patents.

End of the Road for the Gas Engine?

The shift away from the development of the internal combustion engine toward electric vehicle technology does not mean in all likelihood that the gas engine and the demand for improvements in gas engine technology are over. It would be difficult to imagine certain industries without gas powered engines. Propulsion systems for aircraft or aero engines comprise either piston engines or gas turbines. While electric drive systems may be attractive for earth-bound transportation, it is unlikely that an immediate application for airplane use is on the imminent horizon. The internal combustion engine will also likely dominate the emergency vehicle world for some time to come as well by providing flexibility and predictable availability regardless of access to a power grid. The same holds true for military applications including tanks and support vehicles.

And while the OEMs may be ceasing development of new ICEs, research into improving performance of the basic ICE knowledgebase continues. Recognizing that battery ranges are still limiting particularly in cold weather environments, that the needed-recharging infrastructure for wide-scale use of EVs is not in place and that problems related to lithium batteries exist, it is clear that for both practical and economic reasons, the OEMs will need to nurse existing ICE technology while EVs become the vehicle of choice for the consumer. Technical improvements such as high pressure electric boosting and variable valve timing and compression ratio engine configurations will continue to be made.

Technologies that allow the use of alternative fuels such as hydrogen and biodiesel in an otherwise conventional ICE continue to be developed. Even new engines continue to be developed by some companies, such as Mazda's supercharged two-stroke ICE, which was disclosed in a patent application published earlier this year. Non-traditional, entirely new engine designs such as the three cylinder, six opposed piston ICE being developed by Achates Power for the U.S. Army are still being advanced.

While the trajectory for development of electric vehicle technology is clearly on the upswing as represented by increased patent filings and grants, the trajectory is not mutually exclusive relative to non-electric vehicle technologies. But no matter the outcome, the growing mix of electric and gas technologies is fascinating at multiple levels.

But it isn't necessarily surprising that the ICE has resilience and will continue to do so for some time to come, as it will take 20 to 30 years to replace existing ICE-powered vehicles with an all-electric fleet. Unlike approaches to patenting EV and related technologies, which appear to be steady and unrelenting, customer acceptance of EVs as a replacement to the tried-and-true ICE-powered vehicle has been uneven.

While acceptance is likely to increase as vehicle range and battery life increase, according to a 2021 Pew Research Center report, about 40% of Americans stated that they would "seriously consider an electric" when looking at their next vehicle, while 14% stated they were "not too or at all likely to do so." The same report found that just 7% of U.S. adults owned either an electric or hybrid vehicle.

It is assumed that as speed of charging, vehicle range, durability of batteries, and cost improve, the interest of Americans in electric vehicles will increase and the patenting of related technology to protect developments will continue. One of the most visible changes of attitude occurred with the introduction of Ford's 2021 Mustang Mach-E. Purists initially balked at the concept, but demonstrations of the vehicle's tire-burning quickness helped to win them over.

While this next chapter of EVs and the patenting of EV technology is off to a good start, much needs to be done to convince consumers and improve technology. In many ways this shift has moved the OEMs into unexplored and unfamiliar territory. The year 2030 may be a goal for suspended sales in some countries, but conversion of the global driving population from ICE dependency to electric vehicles is far more complex than just flipping a switch or turning an ignition key.