Automatic Kitchen Fire Suppression

Ivan Garcia
Connor Sutton

October 19, 2018

Contents

Chapter 1

Research

1.1 Brainstorm Possible Problems

The beginning of this year long journey started with a simple brainstorm. As all successful engineers do, we individually brainstormed everyday occurrences that were a nuisance. Because of the trivial nature of our complaints, every single statement started with the iconic phrase, "I hate it when". Below are some highlights of our many, many, many "I hate it when" statements.

Connor	Ivan
3D Printer Head Uncalibrated	Phone screen not bright enough
Dogs getting into trash	Seat belt burning hot in summer
Clean marker w/out damaging paint	Changing high lightbulb
Breakfast muffins go stale	Hand having pencil marks
Camera stabilizer sounds in recording	Falling asleep after alarm goes off
Sorting bolts	Hot grease jumps up from stove

1.2 Develop Problem Statement

Through a process of narrowing, us partners had to decide on three problems to pursue further. For each problem, we had to write a "business problem statement" encompassed the attack paths, statistics, location, and particularities of each endeavor. Presented next are the three problem statements we decided to pursue.

One of the most common culprits for workplace injuries may be

> hiding in plain sight. Typing on keyboards is a catalyst for a repetitive stress injury. Repetitive Stress Injuries (RSIs) are injuries that result from repeated motions over long intervals of time. In 2012, RSI injuries resulted in 3 incidents per 10,000 workers in the United States. A big culprit behind these injuries is computer use. Everything is repetitive, from typing on keyboards, looking at the screen, and clicking on the mouse. RSIs can take 23 days to recover from, 14 more days than other workplace injuries. The most common RSI is Carpal Tunnel Syndrome, currently affecting more than 8 million Americans and with a median time off of 31 days. RSIs such as Carpal Tunnel Syndrome stem from repeated micro movements of the hand such as to type on a keyboard. RSI treatment procedures are characterized by their 50% fail rate and are chronic.

Following is one of the more outlandish ideas to cross our minds.

> Wind turbines are among the top causes of bird mortality, killing between 140,000 to 328,000 annually in North America alone. The growing use of wind as an alternative energy source means that this number will continue to rise, yet there is still no go-to solution. Those killed by wind turbines tend to be larger and more endangered species. As incentive for a solution, the US Government signed into law the Migratory Bird Act, making the killing of all sorts of birds illegal whether purposeful or not. There's conflicting evidence as to if current solutions work, and many require the shutdown of entire windfarms. The only effective method is to sight birds at a far enough distance (which is often difficult) and shut down the blades in a process that takes up to 45 minutes. Depending on the scale of the windfarm, a full shutdown can cost energy companies hundreds of thousands of dollars.

Following is the final problem statement that we wrote. Ultimately, this is the problem we chose to pursue for the remainder of the year. What attracted us was the potential for life saving solutions. We noticed that deaths and injuries fell over time for home fires. However, when the scope narrowed to household kitchen fires, there was no progress. The potential benefit was immense.

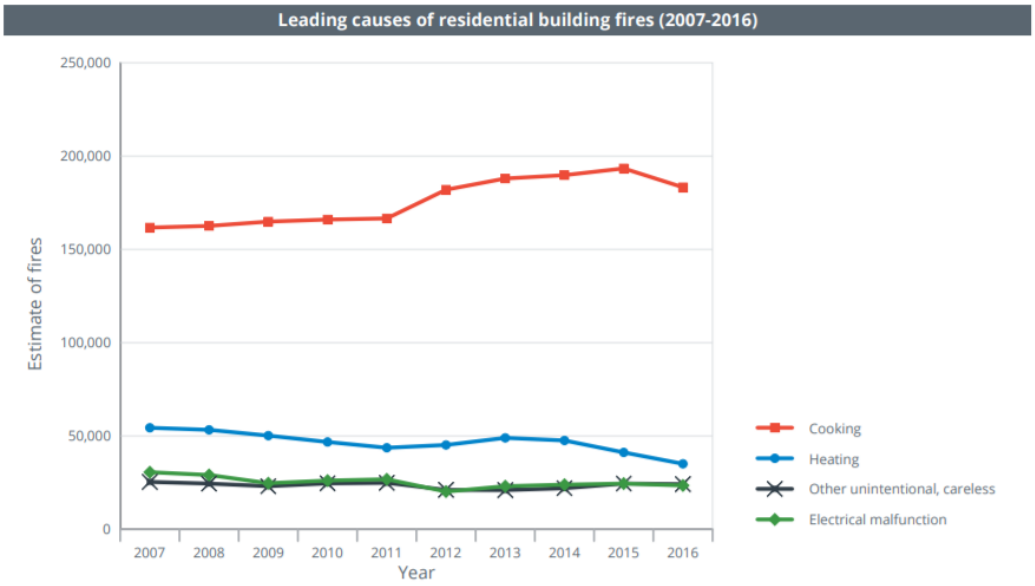
Kitchen equipment can facilitate the process of cooking as well as the process of burning. Every year in the US, fire departments respond to an average of 166,000 household fires stemming from household kitchen equipment. Kitchen equipment accounted for 50% of all household fires. These kitchen caused fires cause about 500 deaths and 5,500 injuries per year. The cost of total yearly property damage surmounts $1.1 billion. Two thirds of these fires resulted from a direct flame and one third resulted from leaving equipment unattended. Current home systems alert the homeowner of smoke or carbon monoxide but can't detect or combat a live fire. Also, many homeowners unknowingly place dangerous kitchen equipment close to flammable substances. Civilian lives as well as property is at stake with equipment we use everyday.

1.3 Identify Stakeholders

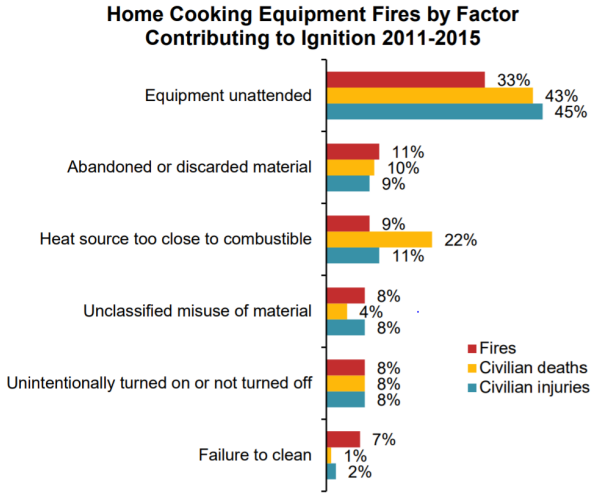
Placeholder Text

1.4 Justify Problem

Kitchens are the staple feature of any American household. Families congregate around their kitchens to laugh, prepare meals, and bond as a family. It's a communal space that serves a purpose greater than just preparing food. However, as happy an atmosphere kitchens may provide, they are also the greatest source of danger in residential spaces. Open flames from gas-burning stoves, unattended appliances, and toast that is just too burnt all cause one thing: kitchen fires. Among all causes of residential fires, kitchen fires rank number one by a substantial margin.



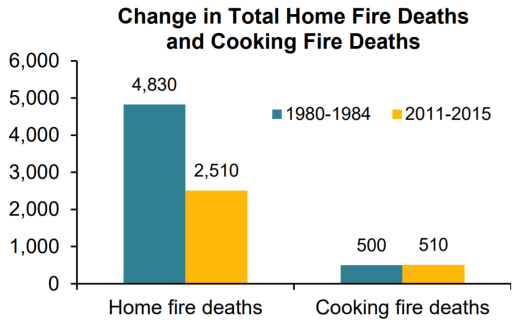
This chart from the US Fire Administration shows just how much more frequently cooking fires occur compared to other leading causes. The source of a residential fire is roughly 3.5x more likely to stem from a cooking related incident than the next most significant cause. Therefore, the area of concentration with the greatest potential for benefit is cooking fires. Development and money geared towards other causes are unlikely to produce a high yield as their occurrence is much lower.



Being the leading cause of residential fires, it makes sense that kitchen fires can start in a multitude of ways. Unattended equipment is typically

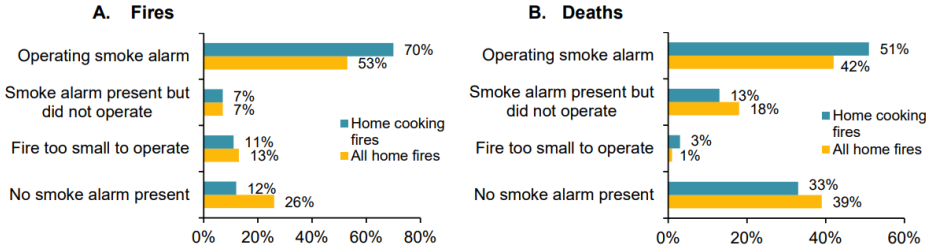
the prime culprit for these incidents. Discarded cooking materials are also a large contributor, and moving heat sources to close to combustibles are the second highest cause of injuries/death. Misuse or user error make up the rest of these causes. Also important to note is the fact that electric ranges have a higher risk of fires and losses than gas ranges. This seems counter intuitive as gas ranges have an open flame and therefore an average person would attribute them to higher safety. However, this points to a possibility of overconfidence of their safety which results in more fires. On the other hand, people may be more attentive to the open flame present in gas ranges thus minimizing their risk.

Staying attentive in the kitchen helps immensely when trying to minimize these risk, but oftentimes that isn't an option. Though never leaving an open flame unattended is common sense, it's a bit more gray with things like ovens, or pressure cookers, or toasters, or almost any other appliance. Each of these exist with some points of failure that carry with them the risk of fire. For these kinds of fires, being attentive or even being present isn't often an option. This is especially the case when the fires are large enough to cause injuries or bodily harm. A whopping 55% of civilians injured in home fires relating to cooking equipment were injured in the process of fighting the fire itself. The risks are manifested even more when the civilian is over the age of 65 or under 5 years old (NFPA).



As much as fire prevention in American households has improved, the home cooking sector seems to be lacking. Other fire safety prevention techniques or household technologies make up for the reduction in overall home fire deaths, but obviously, the pattern does not follow suit in home cooking fire deaths. Home fire deaths decreased from 4,830 to 2,510 from the 1980's to the 2010's. However, the home cooking fire deaths increased from 500 to 510. This points to a gaping hole in home kitchen fire prevention. It is this hole that we seek to close.

Figure 1.7 Smoke Alarm Status in Reported Home Cooking Fires and All Home Fires 2011-2015



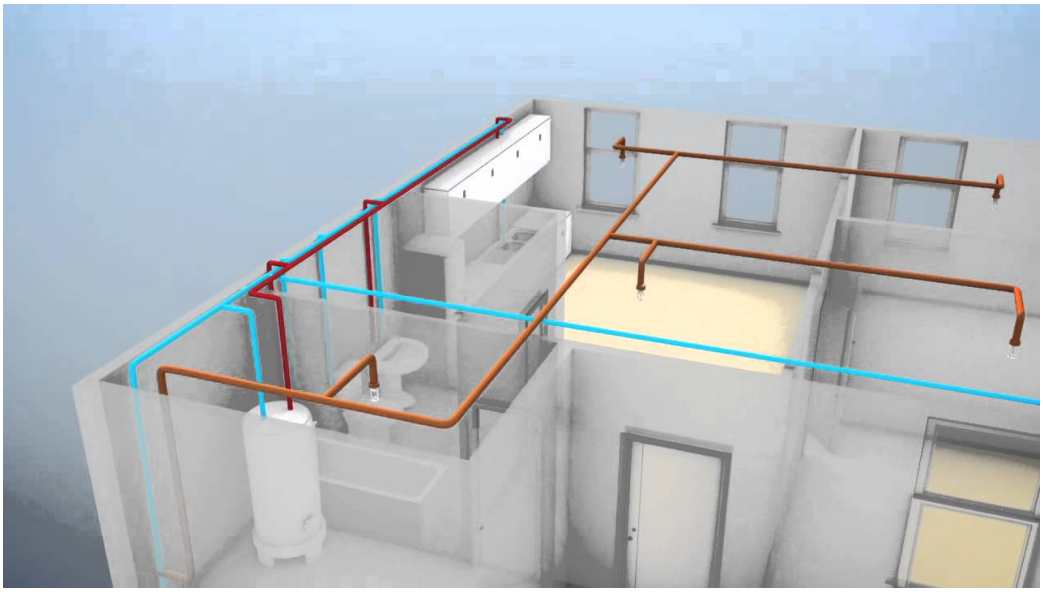
As evident from the chart, home cooking fires resulting in deaths have an operating smoke alarm 51% of the time. This is a high percentage for fires that result in death. This suggests that rather than evacuating at first notice, people may delay and harm their chances of survival. It is also important to note that non-death fires reported a higher percentage of operating smoke alarms demonstrating that increased awareness of fires is associated with survival.

1.5 Analyzing Prior Solution Attempts

There have been many solutions targeted at solving kitchen fires and this element will serve to analyze those previous solutions, target their strengths, and point out their weaknesses.

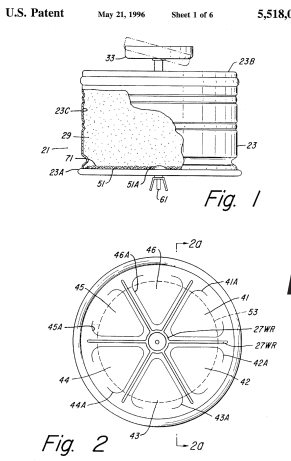
1.5.1 Residential Sprinkler System

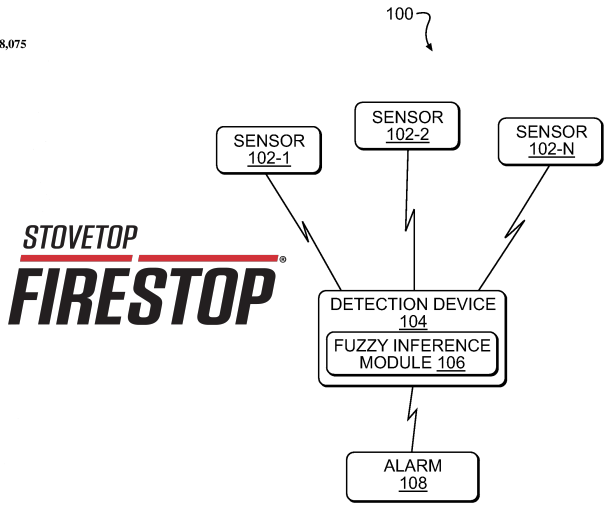
The first and most obvious solution is a kitchen sprinkler system. These are systems of sprinklers that are installed into the ceiling of a residential building, mostly along areas of high fire risk such as kitchens or high heat spaces. There is absolutely no doubt that these systems are incredibly effective. According to the NFPA, the civilian death rate was 81% lower in homes with sprinkler systems vs homes without them. More than that, the firefighter death rate was also lower by a similar margin. Also, when fires did present themselves, they were kept in their room of origin 97% of the time. That means that a fire that starts in the kitchen would stay in the kitchen, minimizing the risk of injury and death for all those in the household. The NFPA aggressively promotes fire sprinklers, to the point of having their own advertising initiative.



The main drawback to sprinklers is their cost. In order to be the most cost effective, sprinklers have to be installed at the time when the house is built. Homeowners and buyers of pre-built houses would have to pursue installation in pre-existing home layouts. That includes re-doing all ceilings, running water lines, and possibly leaving the home while the project takes place. A conservative estimate is a cost of $4 per square foot in a pre-existing home. This cost is just to get the system in place without consideration for extensive modifications and home repairs. Installation in an average pre-existing American home costs about $16,000. Other costs include the plumbing, pumps, stored water sources, regular inspections, and possible failures. These sprinklers can also be triggered by stray objects like ball, resulting in extensive property damage.

1.5.2 StoveTop FireStop





Patent No. US5518075A

Date of Patent May 21, 1996

Price $75-200

Abstract

The fire extinguisher particularly useful on a cooking stove, is formed by a container having a fire extinguishing powder, an explosive charge and a heat sensitive fuse. The fuse actuator the charge for forming an opening in the container through which the powder passes. A screen is located across the opening formed to meter the flow of fire extinguishing powder. A vent is provided to release the pressure in the container resulting form actuation of the explosive charge. A tilt-able hanging assembly is provided as well as an extension fuse. For use on a gas stove, a system including an acoustic detector and circuity is provided for turning off the gas upon detection of the sound produced upon actuation of the explosive charge.

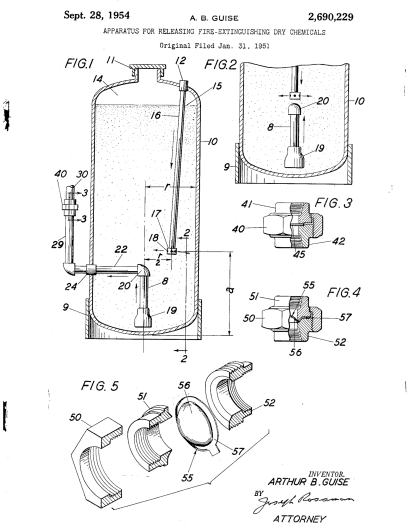
The StoveTop FireStop is a current consumer solution for automatic kitchen fire suppression.

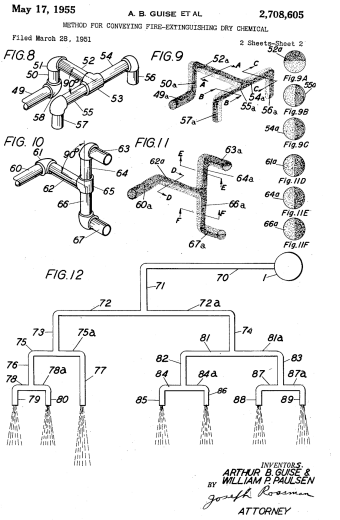
Features

- Automatically puts out unattended cooking fires
- Stylish new design
- Simple, magnet-based installation
- No maintenance or inspections needed
- 6-year effective life
- One pair protects a typical 4-burner stove

Pros	Cons
Automatic	Only designed for stove top
Stylish	Needs refilling after use
Simple Installation	Is that a secure installation?

1.5.3 Ansul R102





Patent No. US2690229A and US2708605A

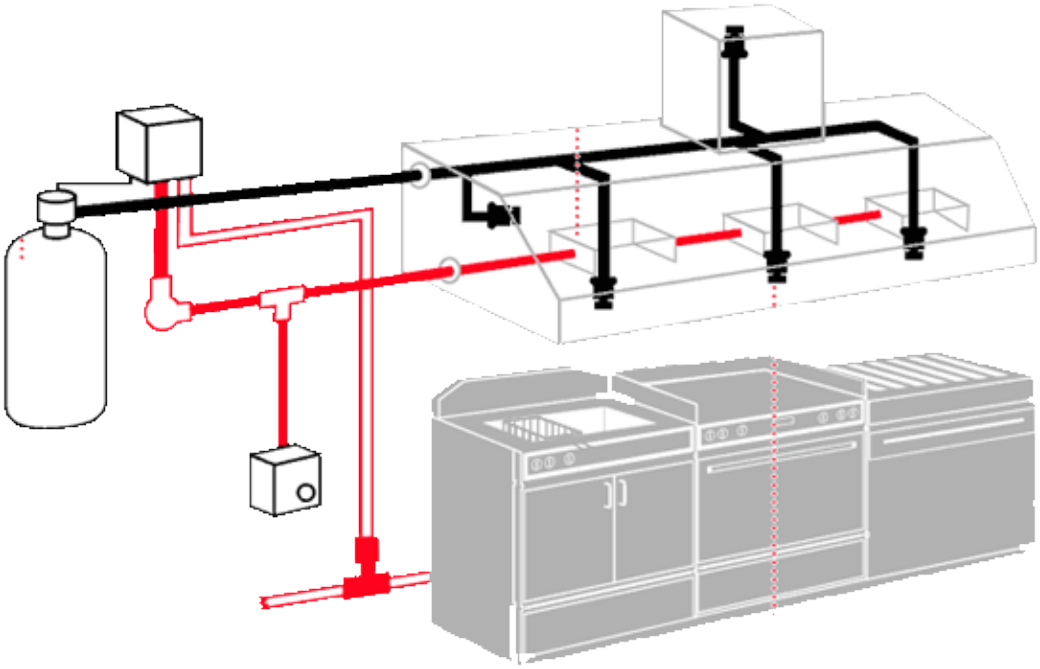
Date of Patent September 28, 1954 and May 17, 1955

Price Unknown [TODO: This]

Abstract

This invention relates. to an apparatus for con trolling the release of dry chemical powder from fire-extinguishing apparatus to obtain greater fire-extinguishing effectiveness.

The Ansul R102 system has remained the industry standard in automatic cooking fire suppression for the past 60 years. Variations of this time-tested system can be found in restaurants all over the world. However, this solution is not fit for a residential scenario.



Features

- Low pH Agent
- Proven Design
- Reliable Gas Cartridge Operation
- Aesthetically Appealing
- UL Listed – UL 300
- ULC Listed – ULC/ORD-C1254.6
- CE Marked

Pros	Cons
Automatic	Regular maintenance & inspection
Aesthetically pleasing	Very high initial price point
Very proven design	
Versatile	

1.5.4 Sonic Fire Suppression

Another more innovative and targeted solution is a system that stops fires with sound waves. 2 students at George Mason University developed a system that stops fires by emitting sound waves between 30 and 60 Hz. Their solution focuses the sound waves through a small opening and when points at fires, extinguishes them. The sound waves effectively create a vacuum around the fire, starving it of oxygen and eventually putting it out. Because all fires require oxygen for continual burning, this method works for all types of fires including heat, grease, paper, and electrical.

Bibliography

[1]