Independence Day for the United States usually means eating a plethora of hot dogs then watching an elaborate and beautiful firework show. However, even though the Fourth of July, along with New Year's Eve, baseball games, and amusement parks may be the most popular places and events for sparklers, firecrackers, and fireworks, the fiery entertainment began nearly 2,000 years ago in China.

The earliest fireworks, also known as *pao chuk*, or "bursting bamboo", consisted of burning only green bamboo, which would crackle and explode. However, these started changing when the Chinese discovered black powder around 9th century AD, and they began packing it inside the bamboo for louder and more powerful explosions.

Today's firecrackers consist of gunpowder (or black powder), or a similar powder like flash powder, in a tight paper or cardboard tube that is lit by a fuse.

Gunpowder consists of carbon, potassium nitrate, and sulfur. The carbon (typically charcoal or sugar) acts as the fuel, the potassium nitrate is an oxidizer with the ability to set off the chemical reaction the carbon needs to burn. Sulfur then moderates the chemical reaction. To brighten the explosion, some firecrackers have an addition of aluminum.

When the fuse is lit, the heat starts the chemical reaction between the three components. As everything starts to rapidly expand, an explosion is formed that blow apart the wrapper and creates the trademark bang.

Looking for something with a little less bang, and a little more *wow*? Then, sparklers are right up your ally! The handheld firework is able to burn for up to a minute and produces exceptional bright and showery light. The framework of a sparkler includes a strong stick or wire consisting of a chemical compound, that much like the firecracker, requires a fuel and

an oxidizer, but not usually a moderator, along with a heat source to set off the chemical reaction.

The fuel is typically a powdered metal, such as aluminum, iron, zinc, or magnesium, while the oxidizer is, like firecrackers, generally potassium nitrate. With an added binder of either sugar or starch, the chemical compounds are mixed with water and coated on a wire or poured into a tube.

Once a heat source finds the powdered metal mixture, it creates the mesmerizing shimmering sparks as it heats up. For more special effects, such as colors or pops, additional metals may be added. The fuel and oxidizer are proportioned, along with the other chemicals, so that the sparkler burns slowly, rather than exploding like a firecracker.

To create the huge display of magnificent color, explosions, and even images that are launched into the night sky, there is a little more science behind it.

Aerial fireworks are normally formed as a shell that consists of four parts:

Container: Usually a wrapping of paper or cardboard into a cylinder that holds the rest of the shell.

Stars: The sparkler-like material that is formed into cubes, spheres, or other shapes.

Bursting Charge: A firecracker-like explosive in the center of the shell.

Fuse: This provides the heat necessary for the chemical reaction, as well as a delay, so that the firework explodes at the desired altitude.

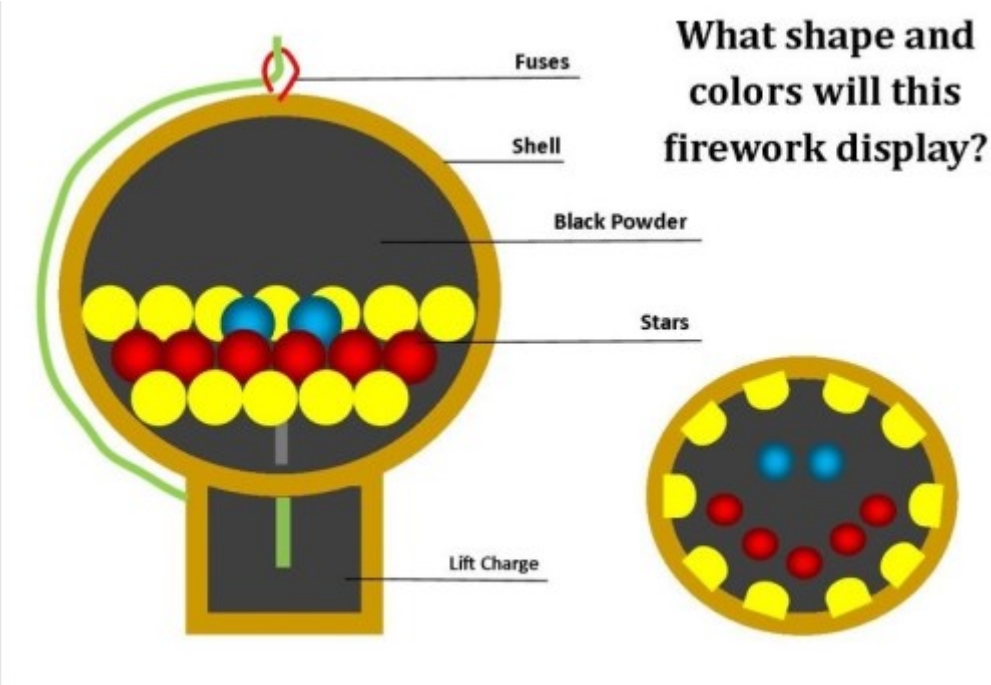

image via loc.gov

The shell is launched from a motor, which might be a short, steel pipe with a lifting charge of black powder that explodes in the pipe to launch the shell. When the lifting charge launches the shell, it also lights the shell's fuse. The fuse burns while the shell rises to the predetermined correct altitude.

When the fuse burns all the way down, the bursting charge explodes, igniting the stars and sending them flying in all directions. The way the stars are arranged inside the container determines the pattern of the explosion. For example, if they are arranged in a circle around the bursting charge, the result will be a circular firework pattern. So, however the shell is packed, be it a star, happy face, or square, they maintain that shape in the sky as they are thrown from the shell.

For a more complicated design, they use what is known as multi-break shells. Instead of a

single bursting charge, multi-break shells contain multiple break charges that separate different sections of the shell. The break charges are designed so that each charge lights the next, creating a series of explosions. Each section of the shell contains different stars of assorted colors and/or patterns, and sometimes additional explosive for more desired effects.

But what gives firework shows that extra pop of color?

The color is determined by the metal salts that are present in them (much like firecrackers and sparklers). When the metal salts react with heat, it excites the metal atoms to a higher energy state, and when the atoms relax back to their more stable state, they emit colors.

The wavelength of the light that is emitted when these atoms relax, are characteristic of specific atoms. For example, strontium glows red, calcium salts burn orange, barium burns green, and sodium recreates a brilliant gold. Other colors can be created by mixing these metal salts, which is called “painting” in the fireworks trade.

The most difficult and dangerous firework color to recreate is surprisingly blue. This is because the copper salt needs a very precise temperature to be excited to the energy state that is required to emit blue light. If it burns too hot or too cool, the color gets washed out to a lighter blue hue.

Even though they are more complex, aerial fireworks were built off the simple foundation of sparklers and firecrackers. It is nothing more than a chemical reaction initiated by heat, which just a tad more artsy and technical showmanship.

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