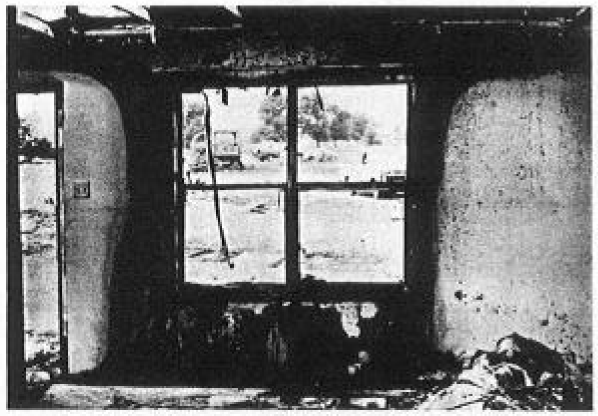
Misconceptions About "V" Patterns

By Carter D. Roberts

"V" patterns are probably one of the most discussed concepts by Fire Investigators attempting to determine the origin and cause of fires. Although understanding the causes of "V" patterns is not difficult, Fire Investigators often misinterpret these indicators.

Sometimes the most simplistic concept can easily be misinterpreted and result in incorrect conclusions because the causes are so simple one wants to make the issue more complicated than it really is.



An hour glass thermal column was the end result of gasoline being poured on the floor of a house under construction. After the accelerant had been consumed, available combustible materials ignited resulting in normal convection processes causing the fire to burn upward and outward. The resultant char pattern was an hour glass shape.

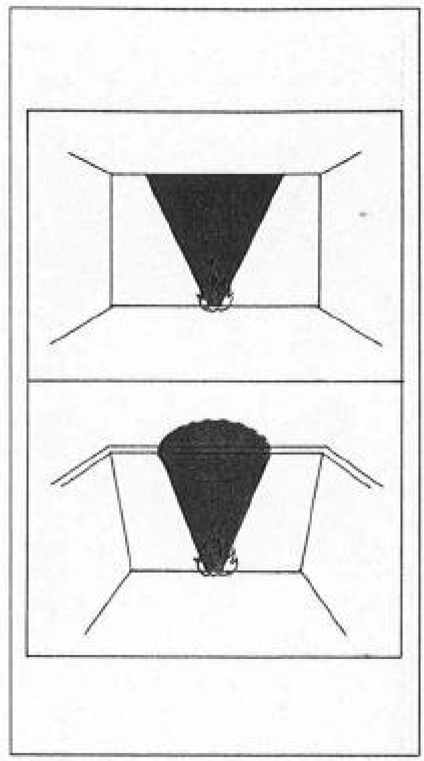
In order to understand why misconceptions arise in the meaning of "V" patterns, we must first examine what causes them to occur. In order to do this, we must first review some basic physics and chemistry of fire. All matter in the universe exists in one of three physical states: solid, liquid, or gas. Solids and liquids will not burn until they are transformed into a gas or vapor, and this process takes some kind of heat. We call this thermal decomposition of a substance into a gas or vapor pyrolysis.

Almost all combustible substances in our world contain the chemical elements hydrogen or carbon or both. Once these elements have been vaporized, they can easily mix with oxygen, which, along with more heat, is necessary for ignition. After ignition occurs, the combustion or oxidation of the hydrogen and carbon in turn produces heat. This combustion is called an exothermic reaction because it produces rather than takes up heat, and it is self-sustaining as long as there is an adequate amount of fuel and oxygen. Once ignition has occurred, the fire will normally continue until all the available fuel or oxygen has been consumed or until the flame is extinguished by water or by some other means of reducing the number of excited molecules.

The flame part of this reaction occurs in the gas or vapor above the solid or liquid and is primarily restricted by the supply of fuel and oxygen.

The burning rate is restricted by the supply of fuel and oxygen rather than the basic chemical reaction within the flames. The basic gas phase combustion process occurs in regions reaching fuel vapor enriched with oxygen. Fuel and oxygen combine to produce combustion products and heat. The opposite type of reaction in which substances absorb heat is called an endothermic reaction. For our purposes, the Fire Investigator is mostly concerned with exothermic reactions where the ordinary oxidation or combustion of substances gives off heat and energy.

When pyrolysis occurs, the chemical composition of the product being heated changes and a char formation develops. We must remember the "Law of Conservation of Matter and Energy" which states matter and energy in all ordinary transformations are neither created nor destroyed but are merely changed in form. This presents quite a problem for the Fire Investigator because although evidence of the material is often still at the fire scene when he arrives, usually the form of the material has been changed by its thermal decomposition.



A "V" pattern is the visual result of a thermal column that has manifested itself by the thermal decomposition of the surrounding materials. In reality, the "V" pattern is a cone and is three dimensional.

The char pattern left is usually dependent upon the type of combustible substance at the fire scene. The most plentiful and most frequently encountered substances are organic substances such as wood, paper, or cellulose materials containing carbon and hydrogen in varying proportions. Petroleum hydrocarbons such as gasoline, are the most common gaseous carbon-hydrogen compounds. Each type of combustible substance has its own peculiar reaction when exposed to heat. In most fires, the conditions surrounding the combustible materials will vary in many ways and consequently will result in various kinds of heat and char patterns.

In general, bulky fuels such as thick wood, books, and heavy furniture give off flammable vapors very slowly. As a rule, the amount of heat given off during the combustion process of most organic material is proportional to the material's weight. The rate at which the heat is given off, however, depends on how quickly the substances approach the gaseous state and also upon temperature balance. This in turn affects how fast oxygen mixes with the flammable vapor. Solid lumber is slow to pyrolyze compared to wood shavings which burn at a very rapid rate because they have such a large surface area in relation to their mass. Not all substances that are combustible give off the same amount of heat during this oxidation. For example, oak wood gives off 7,180 BTU's per pound while gasoline gives off 20,100 BTU's per pound.

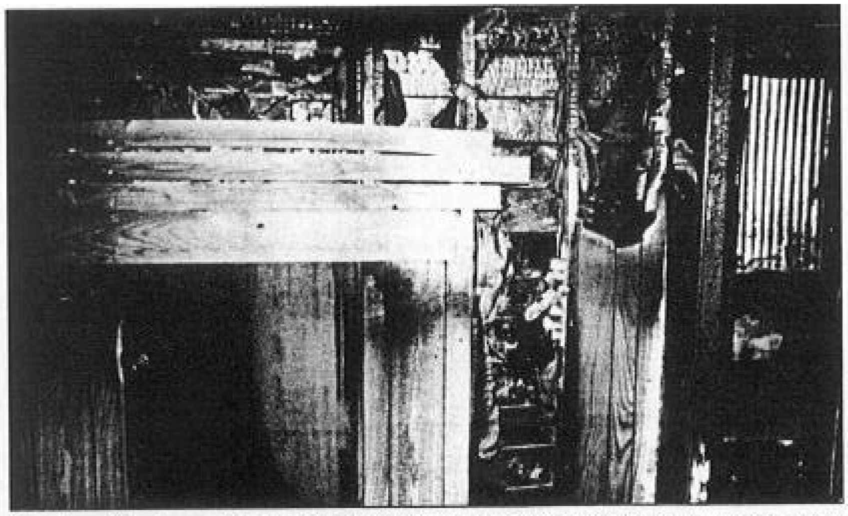
Another factor that affects the heat of fires is the material's ability to conduct heat. When a substance is heated, heat is conducted in all directions away from the point of heating and materials vary in their rate of heat conduction. This thermal conductivity of material is often called the "K Factor", which measures the material's thermal conductivity coefficient. If a fire plume impinges heat on metal, the metal will quickly transmit the effects of the heat to its surroundings, thus increasing the scope of the fire. Copper, for example, will conduct heat about 2,000 times faster than wood.

Liquid accelerant poured on the floor often forms an inverted "V" pattern. The hinge pins can easily be removed and the door taken down so the Investigator can document by photographs, the thermal decomposition on the underside of the door.

Heat is transferred in any of three ways: conduction, radiation, and convection. Some Fire Investigators refer to direct impingement as a form of heat transfer; however, this method is so closely associated with convection that it is impossible for anyone other than a scientist to separate the two. Heat that is transferred by direct contact from one body to another is conductive heat. Although when heat is generated, it flows in all directions. Substances differ in their ability to accomplish this conduction. Gaseous substances like air conduct heat very slowly because their molecules are so far apart. The reason a down jacket keeps you warm is that there is air trapped in the feathers. Heat conduction cannot be completely stopped and is the reason a vacuum bottle will not keep its contents hot indefinitely. The thermal conductivity of a material may take on great importance when heat is transferred through conduction. For example, a copper pipe may be heated to a very high temperature when a joint for an air conditioner or a heater is sweated in and may cause a fire within the wall when the heat is transferred to the flammable materials inside the wall.

Radiation is the transfer of heat from one area to another by infrared rays. It is not necessary for particles to come in contact with each other for heat to be transferred by radiation. Radiation energy travels in straight lines and at the same speed in a vacuum as the speed of light. Heat from the sun is a good example of radiated heat transfer.

Radiated heat is very important in the combustion process but is seldom considered by Fire Investigators. Everyone knows it is very difficult to burn one large piece of wood by itself. One reason for this is that there is no radiated heat to assist in maintaining a high temperature. The geometry of a building greatly affects the radiated heat in a fire, and this in turn greatly affects temperature and char patterns. For example, radiated heat in an attic will usually cause low burning on the cross beam and the uninitiated Investigator may interpret this phenomenon as a flammable liquid burn pattern. In my opinion, the failure to recognize the effects of radiated heat causes the misinterpretation of a very large number of fires.



The shape of the thermal column is determined in part by the flammability of the material burning and may range from a wide cone to a vertical cylinder. The vertical column on the right was the result of burning an open container of gasoline. The burning of shredded paper on the left also resulted in rapid thermal decomposition of the wall panelling.

Convection and/or direct flame impingement are the most frequently observed methods of heat transfer in the propagation of fires. Convection involves the specific gravity of a vapor in relation to surrounding gases, such as air. Accordingly, the heat transfer by convection involves the earth's gravity. Hot gases and vapors rise by convection, and the cooler, heavier air moves in to sustain the oxidation and combustion processes. The burning gases travel upward in all directions, and this process continues until the entire fuel load has been consumed. The upward draft of the flame will continue with varying strength depending on the temperature and fuel available at the time.

Heat transfer by convection is very familiar to us all and is the reason warm air inside a hot air balloon will cause the balloon to rise. It is the same reason that most air-conditioning ducts are at the upper levels in a room since the cold air is heavier than warm air, and a mixing process is desired.

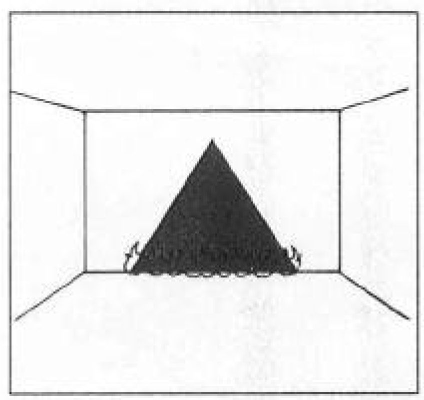
Most accidental fires are low-heat-source fires which occur at inception usually in a very small area. As the material is heated and the fire is initiated, convection causes the fire to burn upward and outward often resulting in a "V" shape char pattern on the surrounding materials. The fire will continue to burn upward and outward until it meets resistance, such as a ceiling. Once the fire cannot travel vertically, then it will extend horizontally until it meets further resistance. This is what causes the mushroom effect and sometimes causes a rolling motion of the fire once it hits a wall. Investigators' misconceptions of "V" patterns result from the fact that they tend to think in two dimensions rather than in three dimensions. We often speak in two dimensional terms of "V" patterns; when in reality, heat is radiated upward and outward in all directions thus creating a cone.

The “V” pattern, simply put, is nothing more than the result of a thermal column that has manifested itself by the thermal decomposition of the surrounding materials. The shape of the thermal column is determined in part by the flammability of the material burning and may range from a wide cone to a vertical cylinder. For example, a bucket or a container of shredded paper will burn very rapidly and will produce a thermal column shaped like a cylinder. A slow burning glow fire in a wall socket will burn slowly and will usually produce a cone with a very wide angle. Although the thermal column is three dimensional, the evidence that it leaves on a wall after the fire is out is usually a two dimensional “V” pattern.

Sometimes when a flammable liquid is poured on the floor, the “V” pattern will be inverted, particularly in areas where the fuel load is not sufficient to establish rapid burning away from the accelerant. After the accelerant has been consumed, if there are available combustible materials, normal convection processes will cause the fire to burn upward and outward resulting in the normal “V” pattern or thermal column. The resultant char pattern will either be an inverted “V”, which occurs only when the accelerant has been consumed, or an hour glass shape when the accelerant has burned long enough to ignite other combustible materials.

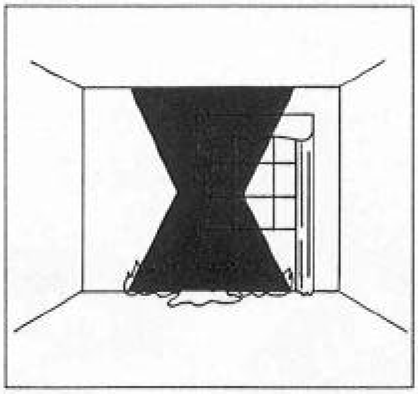
In the case of a low heat source accidental fire, such as a glow fire in a wall outlet or a coffee maker, the fire will burn upward and outward until it reaches the ceiling and then will travel horizontally. Sometimes the progression of the fire will ignite flammable materials, such as curtains and plastics, which will drop and will continue to burn. The material that has dropped to the floor level and has continued to burn will also cause a “V” pattern and will burn upward and outward.

The “V” pattern or thermal column is often below where the fire originated, and this causes misinterpretation as to the origin of the fire by new Investigators or Investigators who have failed to check such things as depth of char and thermal decomposition. If the fire continues to burn, it may travel to many parts of the structure causing material to drop and form many “V” patterns or thermal columns within the structure. I have seen accidental fires where these many naturally occurring thermal columns or “V” patterns were interpreted to be separate and unconnected origins. An accidental fire originating in one spot and burning slowly should create many separate and different “V” patterns throughout the structure if the fire is not quickly extinguished. Unfortunately, this very natural phenomenon is often interpreted as arson because the Fire Investigator failed to understand fully the char patterns, fire language, and fire path. In arson fires where copious amounts of accelerants are used, one does not normally find many “V” patterns since the flammable liquid generally causes pyrolysis to occur very rapidly and evenly throughout the room.



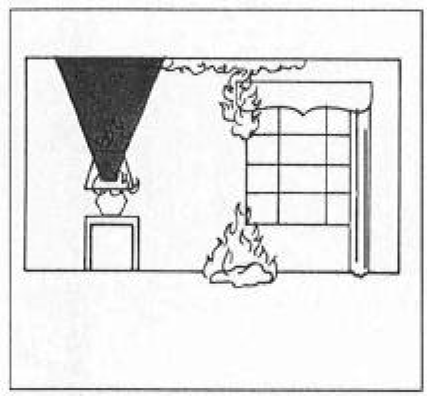
When a flammable is poured on the floor, the “V” pattern will be inverted, particularly in areas where the fuel load is not sufficient to establish rapid burning away from the accelerant.

As the fire continues to burn, the hot gases will rise; and as the temperature reaches somewhere around 900 degrees, the vapors in the top portion of the structure will ignite all at once. This is commonly referred to as flash over. Flash over is a problem for Fire Investigators in that the flash over causes the heat factor to increase very rapidly sometimes masking and hiding many of the "V" patterns and other indicators used to determine the origin of the fire. If suppression never occurs, then the material continues to be consumed further destroying many of the Investigator's indicators as to the origin and cause of the fire. That is why it is normally much easier to determine the origin and cause of a fire if fire suppression occurs rapidly and without delay.



After the accelerant has been consumed, if there are available combustible materials, normal convection processes will cause the fire to burn upward and outward resulting in the normal "V" pattern or thermal column. The resultant char pattern will be either an inverted "V" or an hour glass shape when the accelerant has burned long enough to ignite other combustible materials.

One must remember that the determination of the origin and cause of the fire is nothing but one's opinion based upon facts. The Fire Investigator must approach all fires as being accidental in nature and arrive at the fire scene with that point in mind. If the fire is arson, then the Investigator must have a sufficient number of facts to support his opinion and not rely upon only one phenomenon, such as several "V" patterns within the structure which are often misinterpreted as separate and unconnected points of origin. "V" patterns, so what! In an accidental fire, and even in arson fires, they help only to interpret the language of the fire and to assist the Investigator in identifying the origin. At the origin the Investigator can start looking for a cause, and that cause and opinion should be predicated upon fact. As stated in the **Scandal in Bohemia, The Adventures of Sherlock Holmes**, "It is a capital mistake to theorize before one has data. Insensibly, one begins to twist facts to suit theories instead of theories to suit facts."



Fire will burn upward and outward until it reaches the ceiling and then will travel horizontally. The progression of the fire can ignite flammable materials away from the point of origin, which can drop and will continue to burn. The material that has dropped to the floor level and has continued to burn will also causes a "V" pattern and sometimes Investigators mistakeingly interpret this phenomenon as a separate and unconnected origin of the fire.