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| **A Collection of Essays by Bill Ofca****REVIEW OF THE BASICS**A general review of basic safety considerations for fireworks makers is perhaps overdue. The new-comer amateur or pro can especially benefit from the safety facts of this pyro-chemical art and science. Years of hard earned experience, mistakes, and tragedy should not be relearned in bits and pieces. This only invites history to repeat its tragedies. Nor does space in AFN allow an in-depth and fair study of this vast subject. However, a look at some basics may inspire readers, with a thirst for more knowledge, and a desire for future existence to do research and ask questions.It must be borne in mind that any mixture of oxygen and fuel, under the right conditions, may explode if it ignites. It must be also remembered that fireworks mixtures are mixtures of chemically bound oxygen and fuels in solid form. It is therefore the responsibility and duty of all fireworks makers, from the hobby mixer to the industrialist pro, to take all steps to prevent accidental ignition. The second most important duty is to limit exposure by preventative means, should accidental ignition occur. This means limitation of quantities being worked on, and isolation of all other quantities of explosives. It also means to limit the number of workers on an operation to the bare minimum required, and to isolate the operation from accidental propagation to all other operations on the premises.Almost all the ingredients used in fireworks compositions are used as finely divided powders, which greatly increases their surface area in a given volume and/or density. For example, a charcoal dust cloud in air explodes violently when ignited. Therefore, all finely divided mixtures of materials should be handled with care. This is especially important with finely divided metals, which are hard enough to cause friction ignition. Finely divided metals present a hazard to violent explosion when ignited, and are susceptible to ignition by static electricity more easily than other mixtures due to their conductivity. Steel tools must be avoided in grinding, mixing, charging, pressing, tamping, ramming, or other similar loading operations. Steel tools create sparks when struck. The almost as hard bronze, may be used for certain purposes, but the much softer brass and lead are safer. Wood and aluminum tools, and mallets made of rawhide are also non-sparking safe.Potassium chlorate, in many ways one of the best fireworks ingredients, may under certain conditions of temperature and acidity, slowly break down giving chloric acid, or chlorine dioxide, both of which are more active oxidizing agents than potassium chlorate itself. When this happens, potassium chlorate mixtures are extremely hazardous, with disastrous results often occurring. Sensitivity to heat, shock, friction and impact are greatly enhanced with ignition occurring, in some cases, as little as a flick of the fingernail. Sulfates, sulfides, and sulfur itself may be slowly oxidized to form sulfuric acid, which can then break down the potassium chlorate into dangerously active chloric acid.Places where plain mixing is done containing sulfur, (but no potassium chlorate;), must be kept separate from the places where chlorates are mixed. This separation also applies to personnel, clothing, tools, and utensils, which should be thoroughly washed between operations. No chlorate should ever be used with ammonium salts because of the probability of forming ammonium chlorate, which violently explodes at the temperature of boiling water (212 degrees F). All the oxidizing agents, when mixed with finely divided metals, should be handled with extra care and respect.Carbon, (in the form of charcoal, lampblack, or carbon black), potassium nitrate, and sulfur mixtures, seem to be fairly safe to handle. Barium nitrate also seems fairly safe when mixed with sulfur, carbons, or finely divided metals. Finely powdered metals, in mixtures with barium and strontium nitrates and potassium perchlorate, even when sulfur is present, appear to be fairly stable mixtures. It is reported, the sensitivity of such mixtures is increased by the addition of powdered charcoal. There is no doubt charcoal does indeed speed-up the burning rate of some mixtures, and also lowers the surface ignition temperature of certain mixtures. There is some evidence that mixtures containing both potassium perchlorate and asphalt gums, cause the perchlorate to be changed into the chlorate, with disastrous results during storage. Asphalt gums should be avoided with perchlorates or chlorates because the asphalt gums contain sulfur and sulfur acids, which break down the chlorates to chloric acid.The smallest amounts as possible should be used when experimenting with new compositions, as the slightest incident can turn a mixture into an explosion.Magnesium metal powder should be avoided by the inexperienced pyrotechnician. This metal must be treated with special coatings to avoid spontaneous combustion before it can be safely mixed with oxidizers. Magnesium cannot form a protective metal oxide layer on its surface as aluminum can.Mixes of any type of aluminum powder, potassium nitrate and sodium oxalate, with water, will often heat;-up, and can result in spontaneous combustion. Atomized aluminum, because of its strong aluminum oxide outer layer, appears to be far less reactive than other aluminum powders in mixtures known to react with aluminum.Titanium seems to be relatively safe in regard to spontaneous ignition, and has not been reported to cause such problems. Finely divided titanium powder or dust, is a fire and explosion hazard by itself, when dry. For this reason titanium dust is packed wet (with water) in sealed drums for shipment. Titanium dust has no useful purpose in fireworks due to its hazardous nature. However, in granular form (sponge), it is used to make many beautiful sparking effects. Titanium is an extremely hard metal, and as such, poses a friction;-ignition hazard. It especially increases the sensitivity of mixtures containing chlorates or perchlorates. Extra care must be exercised when ramming devices such as whistles, gerbs, fountains, etc., that contain perchlorates and titanium. Ramming of devices containing potassium or barium chlorate should never be attempted, especially if titanium is an ingredient.During commercial manufacturing, the amount of chemical composition in a building at any one time should be kept as low as possible. The workers should wear non-sparking or conductive shoes. Floors should be conductive as outlined in the National Fire Protection Agency (NFPA) standard #99. Cotton clothing should be worn, and all metal machinery and moving parts should be well grounded electrically, to bleed off static electricity before it can build up a dangerous charge. No matches should be allowed in the manufacturing area. Change houses or areas where smoking is permitted will help keep the dangers of smoking under control. Safety training and periodic scheduled safety review meetings with employees are required by OSHA. Close supervision during work is essential to safety.- WO **ON CHEMICAL SENSITIVITY**Sensitivity of chemical mixes not only relates to how easy (or difficult) one can "strike fire" by friction or impact, but also involve other considerations. The level of heat energy required for combustion (ignition temperature), and whether the chemicals are susceptible to spontaneous combustion should also be considered. The choice of fuel and oxidizer may very well be compatible and free of the danger of spontaneous combustion when water dampened or wet mixed. However, in some instances, the choice of fuel and the ratio of fuel to oxidizer, can render the same mix sensitive to heat by having a low ignition temperature characteristic. The lower the ignition temperature, the easier a spark, (electrical or mechanical), can set it off.I have often heard pyros say, "Oh, that stuff is safe, its not sensitive, don't worry!" Compared to what? Everything we measure in life is relative compared to some standard. So how do we base our judgment on the "relative" sensitivity of fireworks chemical mixes? Unless you have access to a good explosives engineering library, a lot of money for special apparatus, a lot of time to set-up and conduct experiments, and a good education to interpret the data of your findings you can't make an accurate judgment on relative sensitivity.Attempts at establishing practical measurement standards are being made and that's good! (See AFN #15, Oct. '82, pp5 "Impact Sensitivity;" by L. S. Oglesby). However, the fireworks industry generally does not have any practical standards of sensitivity measurement other than government specs for military signals. For the most part, the work of professionals and amateurs alike has relied on the knowledge (or hearsay) of those who are experienced and willing to share their knowledge. Unfortunately, there are, and always will be, those who work in the "dark", without regard or ability to conduct controlled experiments for determining relative sensitivity.Be it a question of chemical compatibility or heat, friction, shock, and impact sensitivity;; we must presume an inherent and intrinsic danger exists by treating all chemical mixes with equal care. It can be dangerously misleading to use the words "never" and "always". However, when handling fireworks chemicals, we must never trust in the unknown and must always respect what is known.The following is a list of chemical combinations known to cause sensitivity problems. Next to each listing are letters to indicate the types of sensitivity. The code key is given as follows:F = FrictionHY = HygroscopicI = Impact or ShockSP = Spontaneous CombustionU = Unstable (poor shelf life, slow decomposition or unpredictable)**AVOID THESE COMBINATIONS OF CHEMICALS**1. Potassium Chlorate & Sulfur, Sulfides, or Sulfates - F, I, SP, U2. Barium Chlorate & Sulfur, Sulfides, or Sulfates - F, I, SP, U3. Potassium or Barium Chlorate & Ammonium Compounds - F, I, SP, U4. Potassium or Barium Chlorate & Calcium Carbonate - F, I, U5. Potassium or Barium Chlorate & Aluminum - F, I, U6. Barium or Potassium Nitrate & Aluminum (when wet) - U, SP7. Ammonium Perchlorate & most Nitrates - HY, U8. Untreated (coated) Magnesium & any Oxidizer - SP, U9. Barium Nitrate & Sodium Oxalate - HY, U10. Barium or Potassium Chlorate & Sodium Oxalate - HY, U, F, IReaders are invited to contribute additional chemical combinations known to cause any sensitivity problems (and the reasons) for future publication. Mail any comments to:Bill Ofcac/o B&C Associates66 Holt RoadHyde Park, NY 12538**THE PROFESSIONAL DISPLAY OPERATOR**What is a professional display operator;? (Hint: the emphasis here is on professional;). He is a person thoroughly familiar with the most important aspects of the responsibilities associated with the safe handling, transportation, and use of exhibition fireworks. He knows not only the how-to and rules, but the reasons why specific directives exist.A true sense of pride and accomplishment can be enjoyed through the proper handling and control of display fireworks. Likewise, when rules are ignored or broken, the consequences can be serious. Those who operate public fireworks displays belong to a rare and unique "brotherhood" of professionals. Again, the emphasis is on professional. The training and experience a display operator receives, when reflected in responsible attitude, behavior and actions on every display, allows the title to be fitting and deserved.The professional display operator will be respected as professional when his conduct and attitude shows he is a respectable person. Think about it! When a stranger approaches him on a display, is he polite and does he show any manners? That stranger might be the customer, a politician, a display committee member, etc. That stranger might also be a relative or close friend of any of the above. Does the display operator avoid the use of foul language in public? People nearby have ears and fireworks events are usually family type entertainment affairs. Even the common spectator tells stories, often exaggerated beyond the bounds of truth, to their friends and relatives.Are YOU a display operator;? During a display, the eye of the public is upon you! Ten thousand pairs of eyes are focusing in on you, off and on, as evening approaches. Giving someone the finger, or pulling a moon is definitely juvenile. Likewise, reckless horseplay and fighting among the display crew does not show maturity or professionalism. Smoking near the fireworks set-up also looks bad. You may know its safe (if it really is), but those watching will think you are a reckless menace. Drinking beer in public before a display is definitely forbidden. Not only does it look bad, it is bad. In many states, it is against the law for display operators to drink alcoholic beverages before or during a fireworks display. Local ordinances may include an open container law forbidding drinking in public. Many display sponsors post signs forbidding spectators from bringing beer to the displays. How outraged do you think the sponsor will be if you are spotted drinking a beer? It is grounds for charges of criminal negligence in the event of an accident, no matter what the cause. Do you show respect for the display sponsor and his committee workers?The display sponsors (customers) have the final authority when you are in their territory. They are paying big bucks for a good display, which includes your services. In other words, you are his paid servant and the spectators are guests. If you respect the relationship of this arrangement, customers will always treat you with dignity. After all, they understand you are the expert in your field, and they need your services to present the display. Likewise, the professional display operator is aware that repeat business depends on how the customer perceives him. - WO **WHOSE JOB IS DISPLAY PLANNING?**With July 4th, 1986 now history, it appears there were more tales of public display accidents than ever before. I wonder if that's true or only seems that way because of the heightened awareness of this year's insurance crunch. One thing is for sure: the accidents that did happen received intense media coverage, especially by newspapers. Most of the stories either mentioned or focused on the insurance situation while suggesting inevitable law suits. There is nothing like "fanning the flames" to make the industry look bad!Perhaps the reported public display accidents were not as many as the negative media reporting would lead one to believe. After all, there were tens of thousands of displays exhibited on July 4th across the nation. Yet one accident is one too many. Year after year, the fireworks industry has taken a "beating" from the news media. Accidents at public displays are preventable.When a serious accident occurs, it is usually the result of several safety rules, not just one, being ignored and broken. The errors may even be traced back to the factory at the assembly table, with everyone along the way sharing some of the responsibility. If the display sponsors and the shooters do their jobs, public injuries can be avoided, even if a bad shell is experienced. All of the rules of shooting are more or less premised on the assumption that fireworks are somewhat unpredictable and the next shell could be a bad one. From barricading the mortars to placement of the spectators, the set-up should consider public safety first, with those what-if situations thoroughly thought out. The consequences of every choice must be thought out. We are free to choose, but we are not free to avoid the consequence of a bad choice.Public safety is the responsibility of all parties involved, not just the shooters on display night. Jobbers, shooters, and manufacturers must insist on quality work from their production facilities. Cheap shells only invite accidents in the field. The customer must be educated by the salesman seeking a signature on the display contract. The salesman should be an experienced shooter and knowledgeable in all display set-up situations. A customer must be taught what his responsibilities are. Important safety concerns should be bound in the contract. For example, safe distances from the mortars to the spectators, parked cars, inhabited buildings, etc. Defining the responsibility for a rope line, crowd control, fire protection, police protection, auto parking, clean-up of the site after the display, etc., should all be detailed in the contract.The customer must be made to understand his cooperation is essential to the planning and success of the display because, after all, it is his display. If there is an accident that he could have helped avoid, it will come out in the trial. The customer will be sued along with anyone who had anything to do with producing the display. Lawyers name everyone. If the customer doesn't know what to do or how he can help, it won't get done.The display salesman, the shooter's crew chief, and the customer, should all meet at the display site a few weeks ahead to plan the display, check and measure distances, establish where the rope line will be, and discuss what to do about wind and wind direction, fall out ash, etc. A set of written rules and guidelines should be given to the customer. All the customer's crew men should get a copy of these safety rules and concerns. To take for granted the customer knows how to plan a successful safe display is a serious breach of responsibility. Every display site should be reviewed in person to assure conformity within the law, and common sense safety for the size of the display and the size of the crowd. - WO **SHELL SPIKING IMPROVES SAFETY**"Spiking" is the term used by shell makers for binding a cylinder shaped aerial shell with twine. The twine is usually wrapped around the shell from end to end vertically, and then spirals down the side to where it is tied with a clove hitch knot. Generally, most shells have at least eight or more equally spaced vertical spikes (or double spikes) of twine. The number of turns spiraling down the side of the shell varies with the type and size of the shell. Spiking is always applied before a shell is pasted-in.Spiking is the traditional method of "Italian" shell design. It comes from the days of making shells by first rolling a "bag" casing around a wooden former. Discs of cardboard or "chipboard" were inserted into the bag casing to form the casing ends, which were secured by folded down, over-lapping paper from the ends of the rolled cylinder. After the shells were loaded and the last discs (with fuse;) were inserted and secured, the shells were spiked with strong twine of cotton or flax. It is obvious the spiking adds strength to the shell and improves the burst spread, but how significant is shell spiking to safety?In recent years, most professional manufacturers have phased out laborious shell rolling in lieu of using inexpensive paper cans. The paper can walls are more ruggedly constructed than the rolled bag casing, and have impressed many shell makers to the point of producing "stringless" shells. Those who remember their trials of designing stringless shells will recall compromises that had to be made to preclude extensive instances of flower potting when the shells were fired. The lift charge had to be reduced or heavier paper had to be pasted-in, or internal as well as external discing, had to be introduced, etc. For light weight shells, the problem of flower potting may not have occurred. However, with heavier shells of more complex performance, the problem is pronounced. Some shell makers overcame this problem by introducing more and more turns of heavy kraft paper when rolling the shell casing or when pasting-in.During the 1983 display season, I witnessed approximately 600 four inch color with report shells perform flawlessly. Each shell was constructed identically using thin wall (.030") paper cans with: 1/8" thick chipboard discs on the ends, spiked with strong twine, pasted-in with 4 turns of 60# kraft paper, and lifted with 2-1/2 ounces of FFA black powder. The shells traveled high, had wide symmetrical bursts, and the reports ignited, then timed out, and detonated perfectly at a high altitude.As an experiment near the end of the season, twenty more shells were made identical to the first 600 with only one difference: the twine spiking was left out. Out of the 20 fired, 8 flower potted, 1 failed to ignite the salute after the aerial burst, and all had burst out the fuse end of the shell casing, driving the salute at high speed in the opposite direction, sometimes dangerously toward the ground.I have concluded the sudden occurrence of flower potting was caused by inertia of the shell contents and the weakened, unstrung shell ends. The shell is resting at zero velocity at the bottom of the mortar when, at the moment of ignition, it accelerates to 100+ feet per second muzzle velocity. The "g" forces of the shell contents act internally against the bottom of the shell casing causing it to separate from the shell walls. The shell casing tends to accelerate faster than its contents, and perhaps, if no lift flame were present, would exit the mortar empty, partially empty, or severely cracked. Without twine spiking, the shell would have to be "beefed-up" with extra pasted-in paper and/or have its lift charge reduced. While this would help get the shell successfully launched, it does not resolve the aerial burst and report ignition problem, especially when paper cans are used.The experiment left no doubt in my mind that shell spiking improves safety. This is not to say that all stringless shells are unsafe. There are many shell makers producing good quality stringless shells, and have overcome the problems mentioned here in their own peculiar ways. However, most of the stringless shells I have come across were usually lightweight, no larger than 4" diameter and no heavier than 1.5 lbs. unlifted. The more complex "stringless" shells I have seen had rather heavy wall paper cans or heavy wall rolled cans, heavy discing inside and out on both ends of the shell, and were pasted heavy with extra paper. They also used extra generous portions of commercial FFA black powder for bursting or used flash bags. All this extra work and material to make a performing "stringless" shell makes me wonder if any material cost or labor is saved at all. - WO**THE DREADED DUDPART 1**Anyone who has operated a public display and experienced the frightening embarrassment of seeing the tracer sparks of a fired shell die, knows the dread of a dud shell. Several thoughts race through one's mind: ...will it break low? (probably not if the fuse died), ...will it come down and hit someone? ME?, ...feet!, do your stuff!, ...shush! I wish the spectators would stop booing so I can hear where it lands, ...Oh God, I pray no one gets hit, ...here it comes, ...no car roofs please...THUMP! Phew! On the ground safely! ...Get another shell up quickly, ...find it at all costs later!, ...can't let anyone get it, especially children!Then after the show, you find the dud or maybe have to return at daybreak to search. All the time you are looking, new thoughts creep into your head: was it only an isolated shell or are there more? ...is it only this type of shell or will it happen randomly throughout the inventory? ...Why? ...What caused it?This subject has played on the minds of shell makers, professional and amateur alike, for as long as aerial fireworks have been made. Yet, very little has been written on the subject. Many have isolated the problems, and now avoid the causes with varying degrees of success, including this writer. Others are still perplexed and curious, maybe even desperate to solve their dud problems.In this continuing series on the subject, we will examine some of the apparent causes of the dreaded dud and what some shell makers are doing to avoid the problem. The purpose will be to present and share varied opinions objectively so that readers may form their own opinions and conclusions, or investigate this controversial subject further.If we broadly define a dud shell as the result of a malfunction that caused the shell to deviate from normal performance or intended design during lift (firing), than we can identify duds in four categories:1. The "flower pot;" effect2. Time delay fuse ignition failure3. Time delay fuse failure after ignition4. Shell burst ignition failure after time delay fuse burn throughIn subsequent issues of American Fireworks News (AFN), we will attempt to look at each of these categories objectively, while presenting some of the reported possible conditions that may create the dreaded dud. The subject is controversial because it addresses the heart of reasoning behind the decision of some professionals in areas of shell design such as: discing technique, shell pasting, time delay fuse orientation to the lift charge, and whether or not to cross match time delay fuse, etc. We will briefly state facts and present some design techniques and allow you to form your own conclusions. We hope to stimulate the thinking process. (To be continued ...)- WO**THE DREADED DUDPART 2**In part one of this continuing series, we can easily agree the dud aerial shell is a common safety concern of all shell makers, pros and amateurs alike. In broad definition of the dud, it was said we can place the phenomenon in four categories: (1) the flower pot shell, (2) time delay fuse ignition failure, (3) time delay fuse failure after ignition, and (4) internal shell ignition failure after fuse burn through.**The Flower Pot Shell**The flower pot shell gets its name from the visual effect of a giant flower bouquet. From the launching mortar, the observer sees a vertical blast of colors in a column in which the colors spread while ascending, to create a flower bouquet pattern. The cause was the shell exploding in the mortar or within a few feet of the mortar muzzle. If the shell was a salute or contained flash report effects, a real danger of the mortar exploding is a possible consequence. (A good practice of many experienced display operators is to shoot ordinary flash salutes (aerial maroons;) only from cardboard mortars. There have been observed, many factors, or perhaps combinations of factors, which are possible causes of the flower pot shell. Some of these conditions are as follows.1. Too much black powder lift charge can release excessive shearing forces around the shell that tear at the shell edges, exposing the shell contents to the lift flame. It has also been suggested, the rapid acceleration of the shell causes compression of the shell contents (.i.set back;) against the shell bottom, creating interior shear. Another possibility is set back compression of shell contents, friction, or impact, causing stars to collide and ignite, especially when potassium chlorate stars are present. This is an excellent reason why shells should have their contents packed tight during assembly, with no moving parts.2. Lift charge particle size may be too small. Generally, FFA grade commercial black powder is used to lift cylinder shaped shells. Smaller grain powders burn quicker and can create the same problems of too much lift charge.NOTE: Sphere shaped ball shells from the Orient are lifted with smaller grain powder than FFA but the sphere shape makes a much stronger shell casing than a cylinder. Ball shells can take the harder acceleration and pounding presented with small grain black powder.3. Paper and Paste: Not enough paper pasted around the shell, improper pasting technique, inferior paste, or wrong paper for ".i.pasting;-in", have all been suggested as possible causes of the flower pot shell. A shell of weak wall strength has flower pot potential.4. Inferior strength on the end of the shell exposed to lift. Most shell makers are using paper cans these days. With proper design, the paper can shell can be made with dignified performance. Some shell makers place a cardboard or chip board disc on both ends of the shell. Some disc only the lift end. Some place a disc inside and outside the paper cap of the can. Others disc only the outside, while still others disc only the inside. There are variations within each technique, such as disc thickness, double discing on the outside of the shell or combinations of discing with paper tape sealing or glue sealing. All of the above techniques are used extensively and successfully among shell makers. The key factor is to achieve the required strength and flame barrier seal, to withstand the lift forces when the shell is fired.5. Improperly sealed time delay fuse, especially if the fuse end of the shell is also the lift powder end (shell fired with fuse down). Some people use animal hide glue, some use Elmer's white glue, while still others use hot melt glue. Whatever the glue, the important factor is to seal around the fuse with a fillet that has no gaps of even the tiniest pin hole size. A pin hole leak can allow lift flame into the shell or be the weak spot to allow the lift blast to tear into the shell. Remember, the lift is encased usually in a "bag" rolled around the shell (.i.nosing paper;). Even with the time delay fuse on top, flame gasses from the lift are guided to, and encased around the time delay fuse by the nosing paper and blow-by space between the shell wall and mortar wall. One interesting observation is that the many shell makers who use animal hide glue exclusively to seal time delay fuses, also fire their shells with the time delay fuse up or opposite the lift charge end of the shell. This is because of the brittleness of hide glue and its tendency to crack after drying, especially during the blast of lift. Of course, Roman fuses or "spoolettes" are always fused up due to the tendency of the powder core to blow through from the lift pressure and blast.Proper shell design and close attention to details are necessary ingredients to eliminating the flower pot problem. Once design details have successfully overcome the flower pot problem, workers must develop consistent work habits (in a manufacturing situation) to assure the quality of each shell, thereby eliminating the random occurrence of the flower pot dud. - WO**THE DREADED DUDPART 3**In part one of this continuing series, we can easily agree the dud aerial shell is a common safety concern of all shell makers, pros and amateurs alike. In broad definition of the dud, it was said we can place the phenomenon in four categories: (1) the flower pot shell, (2) time delay fuse ignition failure, (3) time delay fuse failure after ignition, and (4) internal shell burst ignition failure after time delay fuse burn through.Time Delay Fuse Ignition FailureThis is perhaps the most controversial aspect of the dud shell phenomenon. It has been the cause of many heated debates among shell makers who profess their theories with strong conviction and authority to justify the way they make their shells. The question is: what's better, firing a shell with the time delay fuse up or time delay fuse down? It appears there is no right or wrong way to fire a shell in this regard, as it is many factors that determine the success or failure of shell performance. However, the shell design and construction overview may mandate one way or the other in regards to fuse orientation. For example, I believe most shell makers agree that shells made with spoolettes (rammed Roman fuse;) should be fired with the fuse up to avoid flower pots due to the fuse powder core blowing through under lift pressure and blast. Since the bulk of shells made today are made with the 1/4" diameter Japanese or Chinese time delay fuse, this discussion will focus on its use.Some shell makers cross match the time delay fuse on the outside of the shell, a short distance from the starting end of the fuse. This is done by piercing the side of the fuse and threading a short piece of black match or thermolite through the hole. When the shell is to be fired fuse up, a piece of quickmatch is used to transfer ignition fire from the time delay fuse cross match at the top of the shell, down alongside the shell to the lift powder charge at the bottom of the shell. This is called the "pass fire". The long quick match shell leader fuse is introduced into the nosing paper at the top of the shell, terminating at the time delay fuse cross match, and tied off within the gathered nosing paper at the top of the shell. This is surely a successful and reliable method when assembled properly, yet some disadvantages have been noted:1. There is a risk of the fuse leader pulling out of the nosing paper connection (top of the shell) when shells are handled. For example, when lowering a heavy shell into a mortar or when handling chained groups or bundles such as when loading flights (salvos) or finale mortars.2. Ignition failure can occur if the quickmatch leader only slips, nearly pulling out of the nosing, and the shell is then loaded into a mortar with the problem undetected. The shell leader burns and stops, failing to ignite the cross match, extension quickmatch pass-fire and lift charge. The result is a live shell hung up in the mortar.3. Time delay fuse ignition failure has occurred when a defective piece of black match was present in the cross match hole. During handling, sometimes the black powder coating on the match cracks, crumbles and falls out of the string. Misfires in this category are rare, but it has been known to happen upon examination of the recovered dud.4. Lift ignition failure has sometimes occurred when the time delay fuse cross match fired, but the quickmatch extension (pass-fire) to the lift charge didn't. This can be observed when a shell leader fires, with first a delay equal to the burn time delay fuse, then the shell flower pots or detonates in the mortar. Similarly, when the pass-fire does ignite, but for some reason delays lift charge ignition, low breaking shells have been observed. Again, a pause between the snap of the shell leader firing and the discharge of the shell from the mortar was observed, which leads one to suspect the time delay fuse was burning during the pause. Two conditions have been known to cause this. First, if string is tied around the time delay fuse and pass fire quickmatch, the pass fire can be choked if the string is too tight. This will definitely delay the quickmatch until fire burns through the choke. The second is similar to the first. If string is tied tight around the shell body to secure the pass-fire quickmatch, a choke delay is formed beneath, where the string pinches the quickmatch. If there are multiple chokes in the pass-fire, there will be multiple small delays that add up.Some shell makers cross match the time delay fuse and then fire the shell with the time delay fuse down, in contact with the lift charge. The shell quickmatch leader enters the nosing paper at the top of the shell and proceeds down along the side of the shell directly to the lift charge. The side of the shell in contact with the quickmatch paper piping is dabbed with pasted to prevent the leader from slipping during handling. The flame of the lift charge ignites the time delay fuse cross match. If the shell is made properly, and the time delay fuse sealed well, the risk of flower potting can be eliminated. The major weakness in this method of time delay fuse ignition is in the cross match. Dud shells have been examined and found to have the time delay fuse sheared off at the cross match hole. Apparently the piercing of the side wall of the time delay fuse (for the cross match;) weakens the wall strength, such that the lift blast tears off the end of the time delay fuse and cross match. This too is a rare occurrence but does happen under the right conditions. Some of the variables that can contribute to this happening can be: amount of lift charge, placement of the match hole from the end of the fuse, size of the cross match hole, thickness of the cross match, and how much force was used to insert the cross match, etc. This problem can be eliminated with using thermolite igniter cord as a cross matching material. The thermolite is thin and very reliable. Because it is thin, a much smaller hole can be punched in the time delay fuse. Caution must be exercised with using thermolite igniter cord;: it is friction, impact and heat sensitive. Medium speed thermolite seems to be less sensitive than fast speed thermolite. However, the same precautions need to be applied. Avoid sources of heat coming into contact with thermolite such as hot melt glue, etc. Avoid hitting, striking, scratching, stepping on, smashing, and rough handling, etc., of thermolite igniter cord.Some shell makers will split and prime the time delay fuse with a slurry of black powder. The slurry may be in combination with nitrocellulose lacquer or a dextrin and water mixture. Lacking any experience in this method, I have no pro or con evidence to convey. However, it should be noted that this is the method used extensively in the Orient to make Japanese and Chinese shells. The incidence of dud oriental shells due to the failure of the fuse primer to take fire is extremely rare, attesting to the success of this method.It should be clearly understood that there may be many other convincing factors, both pro and con, to each method of shell making detail, that are unknown to this writer. The "best" method is the method that successfully and reliably works for each shell maker. By all means, safety should be the criteria for judgment. - WO**THE DREADED DUDPART 4**In part one of this continuing series, we can easily agree the dud aerial shell is a common safety concern of all shell makers. In broad definition of the dud, it was said we can place the phenomenon in four categories: (1) the flower pot shell, (2) time delay fuse ignition failure, (3) time delay fuse failure after ignition, and (4) internal shell ignition failure after time delay fuse burn through.**Time Delay Fuse Failure After Ignition**The shell is loaded in the mortar, fuse lit, then "thump"! It's airborne with a healthy spark tracer from the 1/4" diameter Japanese time delay fuse. The shell is about half way along its flight to the apex when all of a sudden the time delay fuse tracer dies. The shell peaks and then falls with a heavy smack into the ground.Upon dissection and examination, more often the fuse quit burning at the point where it passes through the discs and sealing glue. One immediately suspects a defective fuse due to a break in the powder train. However, this is unlikely, as the hot burning gases will tend to flash over any small gap. Users of Japanese time delay shell fuse are generally satisfied with its reliability and quality. Its performance has established a high confidence level among shell makers.Another thought is the glue (perhaps white or similar types) penetrated the asphalt layer of the time delay fuse (under the outer paper wrap) and contaminated the powder core. Again, this too is unlikely. I have conducted my own tests in this regard by submerging several 12" long pieces of fuse in a gallon of Elmer's glue for 30 days, leaving only 1" of fuse on each end unsubmerged. After 30 days the container was opened, the fuse removed and test burned, all without failure. While it is possible an occasional "dead" spot may appear in the powder core or asphalt layer of Japanese time delay fuse, it is highly unlikely it would consistently occur at the point where the fuse passes through the shell end disc. I suspect I am not alone in experiencing this type of dud situation. (Please note, I am referring specifically to the use of Japanese time delay fuse, not Chinese. I have found Chinese fuse to be of inferior quality to the point of unreliable and unsafe. Most of the problem with Chinese or Taiwanese time delay fuse have been poor quality in the powder core, mainly due to the chemicals being too granulated and poorly mixed.)Some people who use hot melt glue to seal the Japanese time delay fuse and experience core burn out where the fuse passes through the hot melt glue and disc, will suspect the heat of the hot melt glue causing the asphalt layer of the fuse to melt and penetrate the fuse core. Not so. I submerged several long pieces of time delay fuse in our hot melt glue system hopper tank to test this theory. The molten glue was at 375 degrees F. After 30 minutes, I removed the fuse and it all performed flawlessly.Here is the real cause! On properly pasted shells, the paper will be thoroughly soaked with wheat paste which will be in intimate contact with the time delay fuse. Until the shell has dried, the water will saturate the outside layer of paper on the time delay fuse and travel within the paper fibers along the entire length of the fuse, much like the wick of a kerosene lamp. When the wetness reaches the inside cross match, (presumed black match;) the cotton string easily absorbs water and conducts it into the time delay fuse powder core. The powder core then migrates the water as far as the discs and perhaps further. As time passes and the shell dries, including the outside of the time delay fuse, a wet spot remains within the fuse core (you guessed it) at the point where the fuse passes through the discs. This progression of events was observed by taking apart shells at subsequent daily intervals after they were pasted and when not allowed to dry quickly. It was observed the stars also became wet and mushy in some shells around where they contacted the cross match. Remember, this does not happen to every shell, but to a percentage at random throughout the inventory. It was especially prevalent when shells were pasted on cloudy or rainy days and could not be quickly sun dried.The obvious answer to avoiding and eliminating this problem is to dry shells quickly. Sun drying of shells is not a perfectly reliable method in climates with high relative humidity or when rainy days can occur on a random, unpredictable basis. The best method is to dry shells in a safe building or room where hot air is ducted in and circulated, perhaps with the aid of a ceiling fan. Shells can be thoroughly dried to a crisp within 48 hours with this method. The air should not be recirculated or ducted back to the hot air furnace as it will be laden with moisture and only serve to increase the humidity of the drying room thus slowing the drying process. Fall, Winter and Spring are the best seasons for pasting and drying because the cooler the air temperature, the less moisture it can hold. Now, as the temperature of this air is increased, the capacity to hold moisture increases greatly. On a hot, humid summer day, the air would have to be heated 20 or 30 degrees F higher than the outside atmosphere to gain any drying benefit. Thus, the Summer months are not best for shell drying.If sun drying is the only available method, it is suggested at least 7 days of rain free drying be allowed for the best assurance against duds in this category. Remember, the longer a shell stays wet, the larger the dud risk. Also be aware, too little water in the paste can reduce the strength of the dried shell wall due to insufficient paste penetration into the paper. Skimping on the paste is not the answer, fast shell drying is. - WO**THE DREADED DUDPART 5**In Part 1 of this continuing series, we can easily agree that the dud aerial shell is a common safety concern of all shell makers. In broad definition of the dud, it was said we can place the phenomenon in four categories: (1) the flower pot shell, (2) time delay fuse ignition failure, (3) time delay fuse failure after ignition, and (4) internal shell ignition failure after time delay fuse burn through.**Internal Shell Ignition Failure After Time Delay Fuse Burn-Through**When a single break color shell (cylinder shaped) is fired it will usually spin at a high rate of RPMs as it ascends. When this type of shell is made with a spoolette or rammed Roman time delay fuse, shell internal ignition failure has been known to occur. Many shell makers believe the cause of failure is centrifugal force expelling the flame, sparks and perhaps a loose layer of fuse powder along the core train, as the shell is fiercely spinning. This is the only known defect of this kind for spoolettes, and indeed, rare.On one occasion I had a bad experience with flash bag shells and another time with salutes. Both involved failure to ignite flash powder. On both shells, I had used Japanese 1/4" diameter time delay fuse and decided an internal cross match was not necessary. Boy, was I wrong! When observing a piece of Japanese time delay fuse burning, one sees a hot flame burst of out the terminating end of the fuse. This misleads one to believe a cross match on the terminating end (inside a shell) is redundant. I especially didn't think so since the end of the fuse was nestled into flash powder. The result was an average of 5 out of 10 shells dudding (50%)! While the terminating spurt of flame out the end of the fuse is certainly hot enough to ignite flash, I now believe the duration of the flame is too short (at least 50% of the time) to raise the contacting flash powder to ignition temperature. It appears the temperature and duration of the flame spurt out the terminating end of the fuse are on the threshold of flash ignition, as the results of 60 shell firings was exactly 50% failure. In each case, the shells were disassembled and the fuses shown to have burned through. By following the rule of always cross matching the shell-internal end of the time delay fuse, I have not since experienced a dud of this nature in over 25,000 shells.In this series of articles on, "The Dreaded Dud", I have tried to remain objective in sharing many ideas and observations. I hope it has enlightened the thoughts of those who have been "in the dark", or perhaps has provoked ideas in others who may now investigate the phenomenon from a more exact and scientific study. Until then, the generalized ideas presented here will remain conjecture based on the observed evidence. Readers must form their own conclusions. - WO **CAUSES OF DISPLAY DEFECTSPART 1**Fireworks defects occurring during a display are defined here as anything that causes a deviation from a normal intended function. Malfunctions that have been experienced on occasion are often the fault of an operator such as a loading and firing mistake, equipment set-up error, or sloppy set piece or finale assembly work. There are also unpredictable malfunctions as a result of defective fireworks. The aim of this and future articles is to discuss the common malfunctions, causes, prevention, or action to take in their event. Both operator error and material defects will be discussed in the following categories: (1) low breaking shells, (2) the "flower pot" shell, (3) dud shells, (4) flight or salvo problems, (5) finale problems and (6) set piece problems. When these problems occur, it is a rare exception, not the norm.The intention of these articles is not to get into an in-depth study of assembly or functional detail, but to isolate common errors and causes of display problems.**Low Breaking Shells**A shell that breaks low causing colors to fall burning to the ground, or other effects such as reports to go off on the ground, is usually caused by insufficient lift pressure in the mortar from which the shell was fired. The most common reason (on hand fired displays) is, the operator placed the shell in the wrong size mortar pipe. For example, a 4" shell cannot be put in a 3" mortar but it can be placed in a 5" mortar by mistake. When this happens, the propellant lift charge gas pressure escapes around the outside of the shell instead of concentrating its driving energy underneath the shell. The result is the shell "puffs" out of the mortar, goes about 50 feet into the air, arches over and then falls toward the ground. The shell will burst low on its way to the ground scattering burning stars towards the ground. If the shell was a color with report or a multibreak shell, the remaining effects will continue to go off on the ground. If this should ever happen, it is imperative that all shell "ready" boxes or other such containers of live shells, be kept tightly closed or covered. Anyone on the crew who first notices this problem must quickly holler out and warn the others. The first sign of this type of problem-error will be the sound of the mortar at discharge. A "whoosh" or "foomp" sound should be an alarm signal. The normal discharge sound is a good cracking report - "thump!", which may sometimes ring the steel mortar pipe. Experience will teach the new operator the proper sound, and a low break will definitely sound different and grab attention. Other causes of a low break shell are a cracked mortar pipe, or too little lift charge when a shell was manufactured. These causes are very rare, however, and even a shell with reduced lift charge, when fired from the proper size mortar, will still achieve a fairly safe altitude when it bursts. If a mortar is cracked, or the bottom blown open, all shells fired from that particular mortar will be low breaks. This happens only when shells are repeatedly fired from an aluminum or heavy gage PVC plastic mortar with a wood bottom plug. It has never happened with a steel (welded bottom) mortar, except when shells detonate within. If a steel pipe blows its bottom, it suddenly won't be there anymore with only a crater left behind. Aluminum or plastic mortars must never be used as battery mortars, (those reloaded during a hand fired display;). Steel mortars have been know to develop cracks only if they overheat while taking a constant pressure pounding from repeated firings. This is why two 3" and two 4" steel battery mortars should be issued on every hand fired display. By firing alternately between the two mortars of each size, overheating is avoided. The larger 5" and 6" mortars can absorb and dissipate much more heat due to their shear mass and surface area. Also there are fewer 5" and 6" shells in any display compared to the quantity of 3 and 4" shells, which comprise the bulk quantity of display shells.Lower than normal altitude breaks can occur if a shell is not seated in the bottom of the mortar when fired. Gas pressure and driving energy is expended in the void beneath the shell with reduced force to send the shell to its normal altitude. This problem has been observed when a tight-fitting shell is lowered into a mortar and then becomes stuck half way to the bottom. It would be insane to try to push the shell down with a hand or even a tool. If the shell is then fired to clear the mortar, the result will be a low star burst.In the next issue, the "flower pot" shell, along with more display safety tips, will be discussed. - WO **CAUSES OF DISPLAY DEFECTSPART II**Fireworks defects occurring during a display are defined here as anything that causes a deviation from a normal intended function. Malfunctions that have been experienced on occasion are often the fault of an operator, such as a loading and firing mistake, equipment set-up error, or sloppy set-piece or finale assembly work. The aim of this continuing series of articles is to discuss the common malfunctions, causes, prevention or action to take in their event. The intention of these articles is not to get into an in-depth study of assembly or functional detail but to isolate common errors and causes of display problems. In the last issue, low breaking shells were discussed. We now continue with:**The Flower Pot Shell**A flower pot effect is caused by a shell bursting in the mortar at the same instant the lift charge has fired. The reason may be due to a damaged or defective shell that has "weak wall" construction or toomuch lift powder. Sometimes a shell will burst as it is leaving the mortar or just a few feet above the mortar. In any event, the shell is in vertical motion at a high velocity from the lift charge, which will cause the bursting stars and/or effects to blossom out in a vertical direction much like a mine shot or flower bouquet. Multiple break shells, color and report shells, or multiple report (effects) shells, will usually have their effects go while ascending vertically. For this reason, flower pot display shells, if they occur, are not "usually" hazardous. There are two cases where a definite hazard exists: (1) If a salute is fired from a steel mortar and it should flower pot (steel shrapnel) and (2) if a hard breaking ball shell should burst just after it leaves the mortar pipe.In the first example, this is the reason salutes must never be fired from steel mortar pipes, only cardboard! If this rule is observed, the danger is minimized.In the second example, the hard breaking ball shells burst with equal force in a spherical direction. If a ball shell flower pots while in the mortar, it will create a large mine shot in a vertical direction. If the shell bursts within a few feet of leaving the mortar, it will drive high velocity flaming stars (bullets) in all directions radiating from the center of the burst. This is one important reason (of several) the "ready box" or shell container must be covered or have its lid shut tight as the shells are launched. In the event a large caliber oriental ball shell bursts within a few feet of the mortar muzzle, a real danger exist for the operators. Safe distance with remote electrical firing or the erection of a body-protecting barricade to crouch behind (such as the Japanese are commonly known to use) are the only real protection that can be established.The instance of flower pot shells are rare when good quality shells are fired. However, they do sometimes happen, even with the best shells. Regardless of the statistics, you never really know what the next shell is going to do. Therefore, the thoughtful, professional operator will take the necessary precautions, as if the next shell fired will be a flowerpot of the worst kind. And then if it should happen, the consequences may only be disappointment that the shell didn't make it into the sky.The next article in this series will discuss "dud" shells. - WO **CAUSES OF DISPLAY DEFECTSPART III**Fireworks defects occurring during a display are defined here as anything that causes a deviation from a normal intended function. Malfunctions that have been experienced on occasion are often the fault of an operator, such as a loading and firing mistake, equipment set-up error or sloppy set-piece or finale assembly work. The aim of this continuing series of articles is to discuss the common malfunctions, causes, prevention or action to take in their event. The intention of these articles is not to get into an in-depth study of assembly or functional detail but to isolate common errors and causes of display problems. In the last issue, flower pot shells were discussed. We now continue with:**The Dud Shell**There are two basic types of dud shells. The first type is when a shell fires and the burning time delay fuse goes out while the shell is ascending. The shell does not burst in the sky but instead falls cold to the ground. A slight 5 degree tilt of the battery mortars away from spectators on a windless night will assure that a dud, should one occur, will drop down range a ways, instead of on top of the operators or spectators. If there is any wind or breeze, you must take it into account before set-up. Wind direction and the location of spectators are very important factors in determining the exact placement of mortars. Should a dud fall to the ground, it MUST be found after the display at all costs! If it falls to the ground near spectators, it must be found and guarded immediately, with the spectators moved a safe distance away until it can be disposed. Also keep in mind you cannot be sure there were no duds in the grand finale. It's impossible to track every shell in a finale. Therefore, a good search of the display site is mandatory after the display. If possible, return at first daylight to closely inspect the display site and fallout zone. If you cannot return at first daylight, at least have it in your contract that your customer must do the inspection before allowing any children into the area. If you KNOW you have a dud and have not found it on the display night, you MUST make every effort to locate it at first daylight. Failure to do so may result in more legal grief than you can imagine with your negligence in the center of the plaintiff's claim.When a cold dud is found, the proper way to dispose of the shell is to dig a hole in a remote place and bury it, out of the way of prying eyes of children. Some experts claim you should soak the shell in a bucket of water first. However, if the shell is a plastic one, it should be soaked outdoors in a bucket of solvent (such as Xylene) until the shell casing is mostly dissolved. The remaining contents (sludge) should then be buried.The second type of dud shell is a shell that stays in the mortar after the quickmatch long-fuse leader has been fired. This type of dud has also been called a "hang fire". The proper way to handle this problem is to flood the mortar with water, then dump the soaked shell out of the mortar. However, this is not always practical during a display and should you decide not to, LEAVE IT ALONE! Never, repeat NEVER, under any circumstances whatsoever, attempt to fish a dud shell out of a mortar. NOT with a stick, NOT with ANYTHING! Just leave it alone. It is not uncommon to see the shell fire by itself several minutes later. During hand fired displays, NEVER load another shell on top of the dud to try to clear the mortar. This may cause both shells to detonate resulting in the mortar bursting. Just leave the dud and its mortar alone until after the display when you can properly flood it with water. Go to other mortars to finish the display. This is a good reason to have at least two mortars of each size. Remember, after flooding the mortar and retrieving the wet shell, dig a hole and bury it in a remote location.The next article will deal with flight (or salvo;) problems.- W.O. **CAUSES OF DISPLAY DEFECTSPART IV**Fireworks defects occurring during a display are defined here as anything that causes a deviation from a normal intended function. Malfunctions that have been experienced on occasion are often the fault of an operator, such as a loading and firing mistake, equipment set-up error, or sloppy set-piece or finale assembly work. The aim of this continuing series of articles is to discuss the common malfunctions, causes, prevention or action to take in their event. The intention of these articles is not to get into an in-depth study of assembly or functional detail, but to isolate common errors and causes of display problems. In the last article on this subject, dud shells were discussed. We now continue with:**Flight Problems**Flights of shells are salvos or multiple shells fired in a group, to highlight the display like a miniature finale, or to display a sequence of effects. Flights may contain as little as three shells and as many as twelve shells. Five shells seem to be common. They may all be the same size or they may be a mixture of sizes. Some are fired rapidly and some have pyro-fuse delays assembled into the quickmatch between shells. Sometimes flights of the same size are hand fired out of one or two flight racks, reloading after each launch by a flight crew. The most common (and safer) method is to provide a rack of mortars for each flight and preload each flight into its own mortar rack before the display.Hand firing flights is difficult and risky and should be avoided if at all possible. When done, the rack(s) must be cleaned after firing and before reloading to prevent harbored sparks from igniting the next flight as it is loaded. Two flight racks are always better than one. Alternate cleaning and loading allows time for one rack to cool as another is in use. Flight firing with this method is spaced throughout a hand fired display thereby allowing time between the flights for cleaning, cooling and reloading. Extreme caution must be exercised in the event of a hang-fire type dud that stays in one of the mortars. If you have only one flight rack on that display, flight firing is then over until after the display, when the mortar can be flooded with water, and the shell disposal accomplished. It is difficult to tell if a dud shell was left behind after a flight is fired with this method. It is not recommended that tape (for detecting misfired mortars;) be placed over the muzzle of the mortars after reloading because of the risk in placing hands over the mortars. It is therefore strongly suggested that one rack of mortars be provided for preloading each flight before the display.With multiple flight racks, all the flights may be preloaded before the display, with misfire detection (masking tape) placed across the mouth of each mortar. The individual shell leaders should be held down against the outside of the mortar with string, rubber bands, or tape with a slight loop allowed where the quickmatch enters the mouth of the mortar. This helps prevent misfires caused by one shell firing and yanking on the quickmatch connection to the next shell. When using a rack of mortars for each flight, the flights may be hand fired or electrically fired. If hand fired, only one crew member is needed to light each flight in turn.When single flight racks for reloading are used, the mortars must be made of aluminum or steel. When one rack for preloading each flight is provided, the mortars may also be of cardboard. Reloading cardboard mortars is hazardous because the walls tend to harbor sparks and glow or burn. Spiral cardboard mortars tend to peel after firing causing a blockage to reloading the next shell. When this happens, the temptation to jam the shell down with the hands or a tool is far too great, giving credibility once again to Murphy's Law.Single flight racks must be trenched in and barricaded on both sides with a berm of dirt, sand or sand bags. If the ground is too hard to dig, there is a risk the rack may jump or bounce as the shells are fired. When this happens, one or more shells may fire at a dangerously steep angle. If a single rack is used, the support brackets or legs must be anchored to the ground with sand bags or stakes driven into the ground and nailed to the rack. If multiple racks are used, the legs or brackets may be joined and nailed together for added support to minimize bounce. One method is to align the racks such as the rungs in a ladder and join them by nailing 2 X 4 lumber along the sides. Nails smaller than 10 d should not be used.As with any aerial shell firing, observe the wind direction before the display and allow a slight angle tilt on the mortars during set-up to prevent duds or fall out from dropping on the display operators or spectators. Be conscious of the end of the rack that will be ignited and what mortar will fire first. Align the racks so the quickmatch fuse joining shells, burns in a direction away from the crowd. In this way, should a shell blow in the mortar and knock over any live mortars, they will point in a direction away from the spectators.The next article in this continuing series will deal with ground set-piece problems. - WO **CAUSES OF DISPLAY DEFECTSPART V**Fireworks defects occurring during a display are defined here as anything that causes a deviation from a normal intended function. Malfunctions that have been experienced on occasion, are often the fault of an operator, such as a loading and firing mistake, equipment set-up error or sloppy set-piece or finale assembly work. The aim of this continuing series of articles is to discuss the common malfunctions, causes, preventions or action to take in their event. The intention of these articles is not to get into an in-depth study of assembly or functional detail but to isolate common errors and causes of display problems. In the last article on this subject, flight problems were discussed. We now continue with:**Ground Display Set Piece Problems**Experienced problems with set pieces have included the following: (1) Signs hung up-side-down (2) set pieces that have fallen due to wind or vibration (3) wheels that come off the hub spindle when a locking pin, nail, or cotter pin was missing (4) pieces that have cross fired out of timing sequence (5) devices or sections of a piece that have failed to fire.Once a set piece is ignited, there is nothing that can be done to correct any errors. If there are errors, you can only stand there in embarrassment to watch the set piece fizzle, fail, fall, or if the wheel drops off its spindle and roll towards the spectators, watch it part the crowd like Moses and the Red Sea. During set-up is the time to think and inspect for possible problems. Trace the matching to follow the sequence it will create. On signs and image lance pieces, look for incomplete connections in the fuse, loose connections at the lance heads, and any broken lances. Be sure the sign or image is right-side-up and the starting lead fuse is connected before raising. Also be sure that multiple frames of a phrase or scene are fuse;-interconnected so all parts of the piece fire. Inspect wheels for the locking pin on the hub spindle. Unlike lance pieces, wheels must have all match piping in perfect condition, i.e. no holes or tears, or the piece may cross fire out of sequence. If you find any holes, repair with masking tape. Be sure all time delay fuses are secured with string so they won't jump fire during the initial violent ignition of the piece. Delay fuses are usually secured with string on the back side of the wood frames. Inspect all revolving or fountain pieces for loose gerbs or drivers. Secure devices to frames with string and tape.Be sure to brace all set pieces so they won't fall due to wind or vibration. All support masts and braces should be 2" X 4" framing lumber. Vertical up-rights should be 12' to 16' and angled braces should be at least 8' and attached to the mast at approximately 5' above the ground. Two angled braces should be placed 90 degrees apart. Two by four pointed stakes are driven in the ground at the ends of the angled braces, with the braces then nailed to them.When set-pieces are a part of a display, operators should plan to arrive at the display site early to allow ample time for proper assembly, inspection and/or repairs. - WO **A MATTER OF ATTITUDE**I am the first to admit (to myself for sure) I could have a fireworks accident. I run that risk every day and am consciously concerned. Yet because of that daily consciousness, the probability of an accident is considerably reduced. My concern causes me to take steps and make decisions with regard to safety first. It has become a matter of habit and a matter of attitude.At the beginning of each production day, I review the operations with my partner and co-workers. We look at set-up, equipment, routines, tools, sequential procedures, etc. Our minds are actively scrutinizing: are we safe? Did we overlook anything? We often check each other to assure ourselves we are each properly concerned for each other's welfare. When one of us forgets, the other is quick to remind. For this reason we usually work in pairs and rarely alone. We know it's the small details that count. From shell assembly to cleaning tools, every detail has a reason. And that ounce of extra effort to carry out the detail is indeed cheap insurance.Proper human attitude is perhaps the single most important factor in accident prevention. Accepting personal humility or the act of being humble in the absence of knowledge is most important to intellectual growth. (The more I learn, the more I realize how much I don't know). There is nothing wrong with one admitting he doesn't know, especially when he has reasonable doubt on a particular subject. This often commands instant respect from others. It's dangerous to state conjecture or opinions as fact. In the essence of a professional atmosphere, opinions are meaningless unless you are an established authority on the subject. Even when generating professional reports, opinions (if necessary) are reserved for the conclusion of the report and must be stated as the author's opinion. Saying, "I don't know," goes beyond honesty. It opens the door to knowledge, personal intellectual growth, and maturity.On the other hand, arrogance breeds contempt and creates an atmosphere conductive to accidents. To argue blindly with reality, out of stubborn pride, can lead to disaster. Some people are overly sensitive and react to reasonable safety suggestions by easily becoming offended and defensive. Safety discussions should be encouraged and rewarded with compliments. The topic should be "neutral territory," free of prideful defensiveness, especially if we are stopped by a co-worker while in the forgetful act of violating a rule. Don't get mad if this happens to you, say thanks instead. After all, the person reminding you is looking out for your life as well as his.Safety is a matter of attitude and I often wonder: how many fireworks accidents to date could have been prevented by a simple, open minded, change of attitude. - WO **PRO FAX**Most of you are probably wondering, "PRO FAX? What happened to SAFETY FAX?" The truth is I wanted to expand the available subjects to write about, including of course, safety. I spoke to AFN's editor, Jack Drewes, and we decided it would be a good idea to write about subjects that have a professional slant. Since I am a co-owner of a display fireworks manufacturing firm (Ed. Note: now retired) and have been accused (more than once) of being highly opinionated (aren't we all?), I am hoping PRO FAX will be much more than mundane. Jack and I decided that this timely feature should appeal to the many professional operator subscribers of AFN as well as the amateur interest in professional current events.PRO FAX will feature safety articles as in the past but will now also include expanded coverage of business events with the emphasis on professionalism. I am especially looking forward to writing about subjects such as professional display operator career development, how-to articles, the financial analysis of a display, inside tips of how to maximize profits, and how to reduce liability risks. I hope to stimulate controversy in some areas and maybe report some of the reader reactions to hot topics! I would also like to impress readers with the incredible "would you believe...." type features and I invite readers to write to me with details of incredible experiences involving fireworks, either pro or amateur. You can write to me at:B & C Associates66 Holt RoadHyde Park, NY 12538I promise all correspondence will be kept confidential to protect the guilty as well as innocent! Also, if you would like to have me research and write about any particular subject, I will be honored to read your request.Next month, PRO FAX will feature a discussion of interest to all fireworks display shooters.- WO **WHAT ABOUT FLASH?**Of all the thousands of variations available in the elements of fireworks, flash powder is perhaps the most spell-binding fascination to capture the attention of most pyros. Perhaps this is due to the high energy, awesome nature of its effects. The blinding white flash, sometimes followed by a cluster of titanium sparks, then followed by a gut tickling sound pressure wave, is somewhat exciting to say the least. The remarkable aspect is that flash powder is relatively inexpensive and simple to manufacture when compared to stars, for example. Fireworks makers (in the U.S.) use more flash and report components in aerial shells than any other single device or color.When accidents involving flash powder occur, the high energy, violent performance of flash results in serious and catastrophic damage. In recent times, the legal as well as illegal fireworks trade has experienced the (high incidence) tragic loss of human life with almost all involving devastating flash powder explosions. The problems that lead to "accidental" disaster are all too common: complacency, carelessness, forgetfulness, apathy, contempt, and blind trust ("it won't happen to me, never has, therefore never will"). Those who fit this last category, the never-never people, cop a narrow minded attitude of "don't confuse me with facts, my mind is made up!" Notice that all these categories are products of the human mind: attitude and awareness. Can it then be questioned: are the "accidents" occurring from these problems really accidents? I think not. Irresponsible attitudes where safety is compromised can only be truthfully stated as negligence. When a bolt of lightning strikes the powder shed, - that's an accident;!Lets examine some facts about flash and some safety tips on handling. A good quality flash has a critical mass of about 50 grams (less than 2 ounces). This means it will detonate with concussion in open air (no container), when ignited. Less than 50 grams will burn violently but without report. Compare this with black powder which has a critical mass of about 500 pounds!A three inch aerial salute (2-1/2" X 2-1/2") containing about 4 ounces of flash, when ignited and if held in the hand, will dismember the human torso, not just a hand. Large salutes are very lethal;! The thought is rather horrifying, yet we must be realistic to understand the nature of the beast. Be thinking about this and the safety rules before you blend your next 10 pound (160 ounce) batch!In a recent demonstration of the power of flash, a 1 pound bag was detonated electrically inside a wood structured shed. The blast and fireball was awesome! The shed was demolished with chunks scattered around where it once stood. Imagine 100 pounds of flash in an accident;! Instantly lethal in a 25 foot open air radius, and lethal up to several hundred feet if hit by missiles propelled from the blast. Windows will break for a 1/4 mile radius, and buildings will sustain structural damage to window and door frames up to 600 feet away. Buildings within 200 feet will sustain structural damage to framing timbers. Think about this: as the size (density) of the flash charge doubles, the force (or energy;) of the blast increases 8 times!Here are some do's and don'ts on handling flash;:1. Do mix outdoors only in humid weather .i.;(above 50% relative humidity;) to reduce the hazards of static electricity sparks.2. Do wear only cotton clothing when mixing flash.3. Do remove all jewelry and all metal including belt buckles.4. Do spray yourself down and all tools, tables, etc. with Anti- Static Spray (aerosol cans). This material is amazingly effective in eliminating the chances of static electricity from ever occurring. I have personally tested this material while observing the results on a sophisticated electrostatic field strength meter. Anti-Static Spray is available in cases of 12 cans from Chiswick Trading, Inc. 31 Union Ave., Sudbury, MA 01776-0907. Similar material can also be purchased in super-markets and is known as Static-Guard laundry treatment spray.5. Do screen all chemicals separately to remove lumps. Never screen flash powder after chemicals have been blended! The risks of friction ignition should always be avoided. A second and very real reason for avoiding screening any mixtures containing large quantities of conductive aluminum powder, is that the resulting aluminum dust cloud can and does generate static charges. Although humid conditions reduce the risk here, a life is not worth the risk.6. Do mix flash on a large sheet of paper, rolling the pile of pre-screened chemicals as diagonal corners of the paper are lifted and pulled towards the center. (This is also known as the diaper method of mixing;). This method is common throughout the explosives industry (not just fireworks) and is practiced with making many types of sensitive explosives)7. Do add the titanium last after most of the mixing of each batch is complete.8. Do mix outdoors, isolated, away from people and buildings.9. Do limit batch sizes to no more than 10 pounds (it's now an ATF regulation) or to the smallest batch needed to satisfy your requirements if less than 10 lbs.10. Do limit to one batch and one worker in the work room when charging salute casings.11. Do remove all charged casings from the work room to a magazine before introducing a new batch of flash to the same work room.12. Do wear a dust respirator when mixing flash or charging it into salute casings.13. Do clean up any chemical or flash powder spills immediately, especially if titanium is present.14. Don't store bulk quantities of multiple batches in the same container, i.e. drums, etc. The larger the container, the heavier and harder to handle, which can result in catastrophic consequences if dropped.15. Don't mix in plastic bags. (static)16. Don't store in plastic containers!17. Don't use plastic scoops or utensils - use only wood or aluminum.18. Don't screen flash after blending chemicals. Never screen any formula with titanium present.19. Don't mix, handle or use flash formulae containing potassium chlorate, especially if sulfur, antimony sulfide or titanium are included.20. Don't mix indoors where aluminum dust suspended in the air can be ignited by the electric spark of appliances or light switches. The resulting blast has been known to level buildings such as in a gas explosion.21. Don't smoke, even in a safe area, if your clothes are contaminated with flash powder.22. Don't expose too many workers to flash operations. Limit the number of workers to only those necessary to complete the assigned task (usually 1 or 2). Keep all operations in separate sheds or limit one work room to one operation at a time. -W.O. **THE STATIC SEASON IS UPON US!**With the approach of winter comes cold dry air out of the Arctic. The dryness in the air is an essential cause of the increased occurence of static electricity build-up on people and objects. When the air is humid, the water vapor in the atmosphere helps to keep the static charge voltage low by "bleeding" off any "excess" electrical charge above a certain threshold established by the level of relative humidity and the laws of nature. As the humidity drops, the build-up of static electrical charge (and its electrostatic field voltage;) increase. When the charged object or person comes near or in contact with another person or object of opposite polarity charge or ground potential, a discharge of the electricity will occur. This is when we see a small blue spark, feel a slightly uncomfortable tingle and perhaps hear a faint snapping sound.Static electricity discharge is, without a doubt, the most hazardous phenomenon in the fireworks and explosives industry. We can control the use of non-sparking tools and keep cigarette smoking, open lights and sources of flame out of the work place, thereby maintaining our sense of control. However, static electricity is somewhat difficult to see coming (without sophisticated instrumentation to warn of a build-up) and in most workshop environments it is impossible to predict. We can, however, take some rather simple steps to minimize or prevent the occurrence of static problems.Anyone who mixes fireworks chemicals that contain conductive charcoal, aluminum or other such chemicals should take precautions to guard against static electricity hazards. The use of humidifiers in the workshop (at least 2 in a 20' X 20' room) greatly reduces the risk. A good relative humidity gage is helpful, and if you use one, make it a rule to not work, especially with powders, if the relative humidity falls below 40%.It is also a good idea to wear only 100% cotton clothing such as denim and to watch out for visitors who may be wearing sweaters, nylon articles or other static producing synthetic materials. Keep a few spray cans of anti-static laundry treatment spray on hand and use it liberally.Avoid carpets on the workshop floor. Install a conductive anti-static floor if you can afford one. Insist that workers purchase and wear conductive shoes. Install a conductive wall plate (connected to a good earth ground source) near the entrance door and insist everyone touch it as they enter or after they remove static generating overcoats. A thin chain curtain hanging in the doorway (also attached to earth ground) can accomplish the same.Avoid the use of plastic materials and containers that can generate static charges. Use instead, paper or cardboard containers.Install aluminum or copper cladding on the work bench and electrically ground through a 100 K ohm resistor (to prevent an arcing static discharge).All of these are good working solutions to avoiding the hazards of static electricity and should be practiced for assuring a safer work environment. - WO **CHLORATES AND THE SUN**We have often heard the warnings, KEEP CHLORATES AWAY FROM THE SULFUR COMPOUNDS!!! It's been said so often that a "ban potassium chlorate paranoia" has crept into the minds of many a pyro. I personally believe that potassium and barium chlorate do indeed have a place in making fireworks as long as mother nature's chemical rules are strictly followed. As Dr. Takeo Shimizu states so well in his book, Fireworks - The Art, Science and Technique, 1981, p. 90, "It would be ideal to reject this material (potassium chlorate;) from fireworks, but it is quite difficult even at present, because no other oxidizer can surpass potassium chlorate in burning speed, in ease of ignition or in noise making, using the smallest amount of composition." Potassium chlorate is also an ideal oxidizer for colored stars because it produces a high temperature flame, rich in chlorine atoms, which intensify colors. This allows commercial fireworks manufacturers certain economics as well. One thing is for sure, chlorates are here to stay. Fortunately, advances in the learning and sharing of knowledge within this industry over the past 30 years, have lead to a decline in the number of accidents involving the chlorates. There probably aren't any professionals worth their salt today that are not aware of the ingredients that sensitize barium and potassium chlorate. Even so, there are those that go so far as to promote the use of a few percentages of barium carbonate as an acid neutralizer (buffer) in meal powder, and then dust their chlorate stars with this primer.Accidents attributed to the use of the chlorates should not be blamed on the chlorates but to the carelessness of the user. Perhaps the user was ignorant of the "potential" dangers or if he knew, he forgot, or was apathetic. In which case his future in this life and industry is limited. We've seen a lot written on the dangers of chlorate mixtures with sulfur, sulfates, sulfides, ammonium compounds, etc. But I haven't seen too much written about the dangers of ultraviolet light, - the sun!From time to time, we see articles written, or hear someone talk about the (unconditional) merits of drying fireworks in the sun. Certain conditions do exist where the sun can be a direct cause of a pyro disaster. Sulfur reacts with water to create a weak form of sulfuric acid (H2SO3). Potassium or barium chlorate reacts with sulfuric acid to form chlorine dioxide (ClO2) which is decomposed explosively by sunlight into chlorine and oxygen. If there are any fuels present, spontaneous combustion is a definite certainty! Think about this the next time you are considering sun-drying chlorate stars dusted with meal or pulverone, barium carbonate or not!Chlorates demand to be understood. Beginners to the art should definitely avoid fooling around with the chlorates until they understand the nature of the beast. There are many other warnings and cautions regarding chlorates and their incompatibility with other substances besides those mentioned here, which make them potentially dangerous. (See also "On Chemical Sensitivity", page 5). However, in the hands of trained professionals, chlorates have for many years produced some of the most beautiful effects offered in the fireworks art.- WO **IS STAPLING QUICKMATCH HAZARDOUS?**The practice of stapling quickmatch with a staple gun has gained popularity over the last decade. The introduction of the Hansen Tacker staple gun to the display fireworks trade rapidly grew in popularity among operators as a fast and easy way to secure quickmatch to lance work set pieces. It appears the vast majority of operators have never experienced any accidental ignition of quickmatch using this method and it therefore follows reason that many would find other uses of the staple gun to expedite work. One such use has been to fasten quickmatch finale chain to the wooden frame of a finale mortar rack. Common sense would dictate the user to be aware that staples are made of steel and to avoid shooting staples near nails, other staples or hard knots in the wood. Any ferrous metal striking a hard surface can produce sparks, which increases the risk of quickmatch ignition. Of course, this line of thinking presumes the black powder within quickmatch is, in itself, impervious to ignition from the impact of a staple. Recent events indicate the contrary.Everyone has heard of "Murphy's Law;" which states: "If something can go wrong it eventually will." The consequences of Murphy's Law in the fireworks industry can be extreme. If something bad can happen, it often is too late when we find out i.e. too late for the victim of the bad event. However, the rest of us MUST learn from the example if we are to prevent an identical recurrence of Murphy's Law.Perhaps many of you have learned of the tragic death of a fellow display operator in Las Vegas last December (1984). After a lengthy and thorough investigation, the cause of the accident was determined as the impact of a chiseling staple against the black powder composition of quickmatch. The operator had been loading the finale and was leaning over a mortar when the match took fire from a staple shot from a staple gun. Samples of the match were tested for the presence of potassium chlorate and potassium perchlorate by an investigator, with none found. Samples of the match were also tested for impact ignition. After many unsuccessful trials, ignition was eventually achieved. It is theorized that the spring loaded impact of a staple gun can concentrate an enormous amount of impact energy into the tiny surface area at the points of a staple hence creating the conditions for impact ignition of standard black powder within quickmatch. (Ed. Note: see following article "New Facts On Staples", which zeros in on the most probable cause of this tragic accident;).Contrary to popular belief, standard commercial black powder can indeed be set-off by severe impact. It is true that in normal and even rough handling, the occurrence is extremely rare. However, it has been proven black powder can be initiated from the impact of a bullet in ballistic tests. For this reason, it makes sense the concentrated impact energy at the points of a staple could do the same. About six years ago (1979), I had a conversation with an operator who told me he had set off an entire finale (on a display in Connecticut) during the afternoon of the display date. He said it happened when he shot a staple into quickmatch to secure it to the wooden finale rack. No one was hurt in that incident and I have not heard of a similar accident until the recent tragedy in Las Vegas. What has astounded me is the similarity of claims from the investigations of both of these incidents. The operator of the Connecticut display swore to me that his staple that caused ignition did not hit any other metal, and he had cleaned the rack of old staples before set-up. In the Las Vegas investigation, a lone staple was found protruding from the finale rack in front of the mortar that discharged to cause the fatality. No other metal was found in the vicinity of that staple. I for one, am now convinced an inherent hazard does exist in this practice. Since this controversial topic has surfaced, I have heard from several sources, stories of a similar nature involving lance ignition on set pieces during assembly with a tacker staple gun.The source of ignition with lances can be: upon impact of the staple with the quickmatch;; impact against the lance head or upon piercing the lance head and penetration of the column of powder within the lance. Those with experience stapling quickmatch to domestically produced lances will attest to the hard, solid nature of the black powder primer-plug at the head of the lance. The hardness of the prime, which extends approximately 1/4" deep into the lance tube, appears to vary from lance to lance. I have seen the primer plug on some lances shatter from the brittleness upon impact of a tacker staple. On other lances within the same set-piece, the staple will penetrate without so much as cracking the primer plug at the lance head. The color formula of the powder, under the lance head primer, may involve oxidizers notorious for impact ignition such as barium chlorate, potassium chlorate, or potassium perchlorate. I was recently asked, "Does a tacker staple have enough impact energy to ignite the color composition inside a lance after penetrating the quickmatch and primer plug?" Perhaps, and especially if a particular lance has a shallow or soft primer plug. We must also consider the staple is rapidly decelerating from the moment it leaves the gun and penetrates the quickmatch. In any event, the impact compression and crushing of oxidizer crystals will, under certain conditions, cause ignition. The hard primer plug on some lances offers the greatest resistance to the impact of a staple. For this reason, I believe it is the most likely place ignition will occur if it does occur.Common sense dictates exposure must be limited if lance work is to involve the use of a tacker staple gun. Work outdoors at a safe distance and down wind from all other sources of explosives. Do not clutter your work area to impede your escape in the event of accidental ignition. Move finished pieces a safe distance away from the work zone (up wind;). Wear cotton or nonflammable and non-meltable clothing. Keep a bucket or two of water nearby.A trite cliche states: "History is doomed to repeat itself." This thought manifests itself in Murphy's Law. No doubt there are staple shooting display operators who will not see this article, or who will refuse to heed the warnings that an inherent hazard exists when stapling match to racks or lances. They may be blinded by self-serving motives to save an extra few ounces of work effort. After shooting tens of thousands of staples without incident, they may be thinking ignition can't happen. Perhaps the shooter in Las Vegas thought the same, or perhaps it was the first time he shot a staple into match. I suspect the "old timers" to this trade have experienced these same concerns when they lectured their apprentices on the proper use of twine. I have seen some of them shake their head and scowl at "new" ideas or methods. Perhaps in their wisdom from many years of experience, they recognize the importance of harmony with nature;'s fireworks rules. - WO **NEW FACTS ON STAPLERS**The Hansen Tacker staple gun has seen a resurgence of use in the fireworks display industry this season. A supplier to the professional fireworks industry reports the 1988 fireworks season has been the busiest ever seen for the Hansen Tacker . Orders were backlogged for 6 to 8 weeks last Spring. This stapler is popular for lance work quickmatch assembly, and if used, should be restricted to only that use. Also, it should be used only outdoors with plenty of room to escape, should there be a rare accidental ignition of the set piece while using the tacker. (Ed. Note: See previous essay).Many of you readers will recall a few years ago the tragic death of a fellow display shooter in Nevada. He was assembling the grand finale of a fireworks display, using a Hansen Tacker staple gun, when a 3" shell suddenly discharged striking him in the forehead.There was much talk and writing at the time about the source cause of ignition with much speculation on many theories. The quickmatch shell leader had apparently ignited as the display operator was firing a tacker staple into the quickmatch, attempting to secure it to the mortar rack's wooden frame. Most everyone agrees that black powder is nearly impossible to ignite with impact or friction and the rare circumstances that it can happen are severe (i.e. high-speed bullet impact;). Examination of the rack at the time revealed there were no other staples, nails, or even knots in the wood to provide a hard surface to cause the staple to spark. Black powder (especially dusty black powder on quickmatch;) ignites easily from a spark or incandescent energy source.During a recent conversation with the general manager of a staple manufacturing business in New Jersey, a more probable theory has come to light. When told the story of what happened in Navada, this gentleman said, "Oh hell, that's easy to understand! The Hansen Tacker is constructed in the same manner as most staple guns. A spring loaded anvil is released from a cam to strike the staple forcing it out the guides into the work piece. If you were to fire a staple gun in the dark, you would see the sparks that sometimes follow the staple. The sparks are created by steel against steel, the anvil against the staple or the friction of the staples riding in the guides before it leaves the gun. For some industries, this is one of the reasons we copper clad some of our staple products." (This particular manufacturer does not make staples for the Hansen Tacker;). This idea now raises suspicion that a spark was generated in the tacker and it followed the staple into the quickmatch.Display operators who use staple guns of any sort, beware!-WO **GIVING AWAY THE STORE**The serious amateur one day decides the back yard lab, and back yard displays, are not fulfilling his "calling" to the art. Like many before him, he may seek shooting experience with a professional company or he may go directly into the jobbing business. "Jobbing" is a word that describes a display contractor who is not primarily a manufacturer. (He may add to his displays some or, at times, many of his special back-yard-lab shells for fun or imagined advantage. A jobber sells and shoots public fireworks displays. He is a contractor, but does not have a plant or factory, and may not even have a storage magazine. He probably stores his shooting equipment and mortars in his back yard, and can handle one, maybe two displays (with hired help) on the same day. He is most likely to be a part-time pyro, who does not depend on fireworks for his sole source of income.This "imagined" advantage is usually born out of a lack of confidence and experience with designing and shooting displays. The new jobber believes he must load up the show with an excessive shell count, and perhaps excessive shell sizes, for the allowed display budget. He thinks this will launch him into pyro stardom, and beget a host of new customers on this new reputation, born out of "giving away the store". Nothing can be farther from reality.First of all, it must be understood that no business ever succeeded by giving away its goods and services. The practice of overloading a display with shells, can only serve to outrage those who depend on fireworks for a living. It should be understood that competition is stiff and pricing of product is depressed in this industry. In other words, there is not a hell of a lot of money in this business to begin with. Those who make money do so after working their buns off on a continuous basis.When displays are overloaded with shell count, the customer expects this on every display of the same price in the future. If the jobber cuts the shell count in the future (presumably to then make money) his reputation will suffer, and he may not recover to remain in business. If the jobber continues to overload future shows and, in effect, works for nothing but the fun and pride, he will either burn out, or burn his bridges. His source of commercial shells will get wise to his raping the market, and suddenly he can't find a supply of shells to do his displays. Remember, it has taken years for the industry to condition customers to price / display size ratio.If the jobber keeps on overloading his displays, he will definitely acquire more displays requiring him to spend more money for equipment and probably hire shooters. Because he has been overloading displays, his profits are very low or non-existent. Therefore he will be overwhelmed by the expenses and forced to turn down the business. Those who go blindly ahead, borrowing money to make ends meet, are eventually forced to fold. There are many stories floating around about jobbers who don't pay their bills to the shell manufacturers and trade suppliers. Perhaps their fate was the same described above. Those jobbers who have gone this route, leave the market in a mess to be cleaned up by those successful professionals, who depend on fireworks for a living. It's not easy to pick-up the pieces and reconstruct a customer's trust, while trying to convince him he should accept a legitimate proposal for a display that has 40% less shells than last year.So what's fair? The fireworks business is no different from any business. Mark-up and profits are always seen as percentages by banks, accountants, business course professors and successful businessmen. The percentages are close to the same for all successful businesses, whether fireworks or something else. Basically we are talking about two price structures. The wholesale and the retail. Wholesale is the price the middleman pays the manufacturer. Retail is the price the final customer pays the middleman. Jobbers are middlemen. When manufacturers fire displays, they are also "acting" as the middleman. Wholesale prices are doubled (marked up 100%) to establish retail price. Another way to look at this is wholesale prices are 50% of retail prices. Both are mathematically equal statements. This is true for just about all merchandising businesses. The middleman takes his expenses out of the 100% mark-up, and what is left are his profits. When the manufacturer acts as his own middleman when selling displays that he will also fire, he has the advantage of making mark-up on his products to get to the wholesale price, and then mark-up again to the retail price. He can be more flexible with bidding or negotiating situations, but remember, he generally has a great deal more overhead than the jobber. The advantages are only apparent and temporary. Neither the manufacturer nor the jobber has any competitive edge over the other. If everyone who is involved with selling fireworks displays, both manufacturers and jobbers, would adhere to the golden rule of selling at retail, there would be less cut-throat and more profits for everyone. The design of the display, including insurance cost, should add up at retail price to the customer's contract price. - WO **ON THE SUBJECT OF ACCIDENTS**What is an accident;? An undesired event that results in physical harm to a person or damage to property. An accident is, by dictionary definition, "A happening that is not expected, foreseen, or intended. An unfortunate occurrence or mishap." Accidents are certainly unfortunate when they occur but are they really unexpected or unforeseen?A research firm in Hartford Connecticut recently reviewed more than 11,000 industrial accidents and found several reasons for predicting accidents in almost all the cases reviewed. What they found was: improper maintenance, lack of any maintenance program, no written procedures for operating equipment, no procedure for periodic testing of controls, little or no concern for operator training, absence of any education or training program, improper installations, improper applications, no maintenance records, no use of log books, and little or no common sense.ALL accidents are caused (natural catastrophes excluded); they don't "just happen" as many people think. It can be said that accidents are the result of two immediate concerns: (1) the existence of substandard practices and conditions and (2) ERRORS! Whenever substandard acts or conditions are allowed to exist, the door is open to an incident in which the result is left largely to chance. The result can be minor, serious, major or catastrophic loss.The basic causes of accidents fall under two categories:1. Personal FactorsA. Lack of knowledge or skillB. Improper motivationC. Physical or emotional problems2. Job FactorsA. Inadequate job standards or trainingB. Inadequate design or maintenanceC. Poor working conditionsD. Equipment or tool deterioration due to aging and normal wearE. Abusive or abnormal use of equipment and toolsAccident prevention is everyone's responsibility. Every human being has a primary responsibility to use his only tool of survival: his mind. We have volition to choose to think or to default into laziness and not think. When we choose to think, we are then capable of identifying reality and exercising control over our environment and actions. Accident prevention requires control over the causes of accidents. We must set standards (or adopt those already existing), identify problem areas, train and educate fellow workers, set standards and emphasize awareness as well as conformity to those standards. There is no trying. There is only doing or not doing when it comes to accident prevention.1988 can be accident free for the fireworks trade if we all take the necessary steps to do what is necessary for accident prevention. WO **"UNAVOIDABLE" ACCIDENTS**Here's a story for you that reads like a novel. It's the story of an event that really occurred in a large industrial plant.A man removed a guard from a machine to do some oiling. The oil can he was using had a long spout for getting into the more remote parts of the machine. While he was oiling the machine, the guard he had removed fell over, struck the oil can and catapulted the spout so that it cut an ugly gash across the man's right eyebrow, just missing the eye itself. A little later this man was in the emergency ward receiving attention for the cut. He spoke about the accident to the nurse who was attending him. "You know", he said, "that was an unavoidable accident;! You can talk safety as much as you please, but there are always unavoidable accidents and this was one of them."Then the nurse asked, "Do you mean that you are going to let that same thing happen to you again?""No," answered the man, "it will never happen to me again.""But how will you avoid it?" continued the nurse."By laying the guard in another position," answered the man.So this man, who began by proclaiming this to be an unavoidable accident, concluded by explaining just how it might be avoided. And he, by the way, was considered a very intelligent man by his fellow workers.There are two things we can say on this subject of "unavoidable" accidents: (1) Accidents for which we are to blame, we tend to blame on others or proclaim them as "unavoidable", and (2) scientific studies reveal that 90% of the so called unavoidable accidents are really preventable. Accidents don't "just happen." Good housekeeping, careful habits, proper design and adequate safety training will decrease the number of so-called "unavoidable" accidents, especially in the fireworks trade where the consequences are so severe. There is a statement which I wish we might all keep in mind: "Accidents are someone's fault don't let one be yours!" If we all motivate ourselves to learn and practice safety if we avoid being lazy and take that extra step to do what's right to assure safety, it should save us and our loved ones much suffering.When we work with fireworks, we must constantly be on guard against complacency. Because we work with certain chemicals and do certain operations all the time without incident, does not assure us an accident can't or won't happen. All it takes is a source of energy, a minute spark to create a disaster given the right conditions. And those conditions are the ones we must avoid as well as the source of energy;! Remember, that extra effort to promote safety or prevent accidents is cheap insurance indeed. - WO **FACTORY SAFETY: OSHA & THE COURTS**No malicious intent is needed to constitute a "willful" violation of OSHA standards, according to a ruling of the Fifth Circuit Court of Appeals. The court further declared: "Intentional disregard of or plain indifference to the OSHA rules makes it a willful violation. A common sense safety policy that leaves judgment up to the workers is insufficient." The case involved a company that warned a crew to avoid overhead power lines, but did not tell workers exactly how far they must stay away from the lines under OSHA standards. A worker was electrocuted when a steel pole he was maneuvering touched a power line. The company was fined $7,150.In another case, the claim that an employee exhibited "idiosyncratic behavior" was ruled no defense against an OSHA citation. This case involved a steel plate in a shipyard that fell onto and killed a worker as it was being welded. Necessary supports were removed. The company said it was employee error that caused the accident, but the Occupational Safety and Health Review Commission found that a better worker training program would have prevented the "idiosyncratic behavior." An appeals court upheld the commission.So how does this affect the fireworks industry? It is true that better than 60% of the fireworks businesses employ 10 or less people. This means that OSHA will not target those businesses for periodic inspections. However, they are mandated to inspect whenever they receive a complaint on that business, or if there is ever an accident involving serious injury or a fatality.When serious injuries and fatalities occur, one of the first questions that OSHA officials will ask is, "Was the employee trained?" and, "What records do you have of the training;?" The philosophy involved in the OSHA law says in effect, "If a worker is exposed to a hazard, he must be trained so that he is aware of what the hazard is and how to avoid it." Employers must be aware of the hazards inherent to the nature of the work and must make sure everyone understands what those hazards are. He must know and train his people in the correct procedure, rules and regulations to follow, in order to avoid an accident. Further, workers must know what to do if a dangerous situation suddenly arises and be familiar with emergency procedures to follow in order to avoid injury to themselves and others. Where potentially dangerous work is involved, some companies write "shop order procedures" (SOP) which is a training document detailing the routine for each job. The SOP lists conditions, equipment to be worn or used, hazards to avoid and details tasks step by step. Upon training, the employee is given a copy of the SOP and signs a document attesting he was given and has read the SOP. The courts hold, it is the burden of the employer to provide and maintain safety for the employees.This thinking is basic to the law. It covers all recognized hazards. There must be training, and hand in hand with training must be proof: procedures, training records, records of instruction or documented evidence of some sort that says the worker was told and shown how to do the job right. The philosophy of training in the OSHA law doesn't stop there. They go further and say that it is the employer's responsibility to see to it that the employee follows instructions and protects himself from hazards. If the employee is not properly supervised and the worker is injured because he didn't wear safety protective equipment, for example, the law places the blame on the employer, not the employee.The argument that a man was told about the hazard and was told to wear his safety equipment, but failed to follow instructions, doesn't hold water. The attitude of the OSHA Administration (supported by the courts) is that, "Management must Manage." It is then management's responsibility to take the steps necessary to assure that the man follows procedures and uses the protection provided for him in the work place. One more thing to think about. When OSHA charges and the courts find that an employer was willfully negligent by not managing, training or removing known hazards ( for example, more than 10 lbs. of flash;) from the work shop an employer becomes wide open for civil lawsuits regardless of the workers compensation rules. The worker's compensation law is designed to protect employers from employee law suits in the event of employee injury provided the injury was not willful. - WO **MORE ON ELECTRIC SQUIBS**It was previously mentioned (Aug '84 AFN, Safety Fax) the primer spot on electric squibs are friction sensitive and should be regarded with care and caution handling. Although the primer spot is somewhat desensitized by a nitrocellulose lacquer coating, it can still be set off by rough handling such as yanking from a quickmatch shell leader. It should also seem reasonably logical to avoid setting heavy boxes down on top of squibs that may be laying on a table top or to avoid stepping on squibs that may have dropped to the shop floor. The squib itself is relatively harmless, but should be respected as a serious source of ignition to other nearby material.Electric squibs are in essence electric match heads. They are similar or identical in construction to components of electric blasting caps and have identical electrical characteristics. Squibs should, therefore, be regarded with the same respect as electric blasting caps. They should be kept shunted at all times (bare ends of lead wires twisted together). The shunt is an important safety precaution. It prevents stray electrical current, either by induction or by conduction, from setting off the squib. The shunt must not be removed until field wiring interconnection. At that time, it is a good practice to have the cabling shunted at the control firing box end, while connections are made at the mortars and until just before the display begins. A specially wired shunting connector could easily accomplish this, with the operator transferring the cable connector to the firing panel output connector of the box a few minutes prior to starting the display. (This presumes, of course, circuit debugging was accomplished earlier in the day). Control panel designers should give this safety feature serious consideration.Electric squibs should never be stored in a magazine with other stocks of fireworks or explosives. They should be kept separate and stored in a portable steel box type magazine. It is possible for a nearby lightning strike to set-off squibs via electromagnetic interference (EMI) and it has been known to happen on rare occasions even with a good shunt in place. EMI is also a hazard in the field and another good reason for shunting cables at the control box during set-up and while waiting before the start of a display. Long lead wires and cables act as antennae for absorbing EMI and radio frequency energy. Multi-conductor cables used in field wiring should be the twisted pair type with full shielding.When hooking up squib wires, it is important to keep bare wire connections from touching the ground, especially if the ground is damp. Tape over connections or support them so no electrical contact is made with earth ground. The reason is stray electrical currents flow within the earth's ground. Sources of stray current can be utility pole transformer grounds (ground loop currents between poles) or the ground plane of a nearby radio broadcasting station transmitting antenna. Nearby high tension towers humming at 500,000 volts can induce stray current into the ground or your antenna-like field cables. A thunderstorm several miles away can cause stray ground current surges in your area as lightning strikes the ground and finds paths through underground mineral deposits, the water table or underground stream or aquifers. As little as 150 milliamps (.150 amps or 150/1000 amps passing through the resistive bridge wire (heating element) of the squib can set it off. A standard 1-1/2 volt D cell flashlight battery can deliver 4,000 milliamps or 4 full amps and an alkaline D cell can deliver twice as much again. It has been recorded that lightning bolts can deliver 100,000 full amps at a million volts in a single bolt! Given the right conditions, a distant thunder storm that you may not even see or hear can deliver stray ground current to your bare squib connections touching the ground. The likelihood of the squib being in the path of a stray current is extremely remote. However, these are the conditions that are reported to have caused disasters with similar electric blasting caps over many years of experience by blasting engineers.It should be understood that voltage is the electrical "pressure" that causes electrical current or amps to flow in a circuit. Current flowing through a resistance creates heat which dissipates energy. The more current flowing , the more heat energy and the quicker it is generated. The most common way to increase current flow where resistance is fixed, (squib bridge wire plus length of circuit wire) is to raise the voltage at the electrical power source. This is the basic principle of the squibs ignition element current flowing through a resistive wire finer than a human hair to create heat and ignite a primer spot which produces a flame.With more and more electrical firing of display fireworks taking place each year, the operators must recognize and practice a new set of safety guidelines. Without forming new electrical safety habit awareness or by taking squib safety for granted, accidents will occur given the right conditions. Many will agree, including myself, that electrical display firing is far less hazardous than hand firing. Yet we must be aware of and respect the subtle dangers lurking in the shadows of ignorance and avoid complacency in order to seek out and enjoy safety perfection. - WO **UPDATE ON ELECTRIC SQUIBS**Extensive studies on electrical bridge wires for explosives initiation have been undertaken for may years at the Franklin Institute and at companies such as Atlas Explosives, Dupont and Ireco, Inc. where this writer is employed as a staff Electrical Engineer. Resistive bridge wires of varying length, diameter, alloy and hence resistive and thermal value are used in virtually thousands of devices of differing design. Devices such as: squibs (a catch-all broad and vague term in the industry), igniters, explosive bolts, detonators of many different sizes and shapes, safe & arm military devices and blasting caps are to name but a few. Electric igniters (or squibs as we fireworks people call them) are electrically very similar to the electric circuit in blasting caps. In fact, the ICI squib so commonly used by professional display operators, is the exact same igniter manufactured and used in Atlas blasting caps. (Atlas is a division of Gulf Explosives, Inc.). The electrical studies made on bridge wire initiated devices involve, for example, environmental studies of performance under extreme conditions. These tests include, but are not limited to, freezing, baking, pressurized submergence in salt water, mechanical shock and vibration to many g's, static electricity discharges, and RF energy excitation of finished devices. Parameter measurements include studies for changes in: bridge wire resistance, elapsed time from electrical initiation to detonation, fusion time (initiation to bridge wire melt-down time), initiation energy requirements (all-fire and no-fire current limits), explosive power output of the device, and high voltage static electricity sensitivity.The all-fire and no-fire current limits, RF energy excitation effects and static electricity effects on fireworks squibs at ambient environmental conditions is easily recognized as a safety concern. The all-fire current is defined as the level of applied current at which 100% ignition is guaranteed by the manufacturer. Generally, this figure is 1.0 amps flowing through the bridge wire after allowing for wire line losses. The no-fire current limit is somewhat more complicated and vague as environmental conditions have a great effect on the value. Conditions such as temperature, ground leakage current , RF energy excitation, the presence of static charges, etc. adversely affect the value of this limit. However, no-fire current limit is generally defined as the minimum applied current at which a squib is guaranteed to not fire under lab conditions. This value is generally given at 0.1 amps (100 milliamps). For field circuit testing, the Institute of Makers of Explosives (IME) recommends the test current for measuring the resistance of field wiring by the user be limited to under 0.01 amps (10 milliamps).Beware of the output test current of your ohm meter. Some meters, such as the Simpson Model 260 Volt-Ohmmeter (VOM) can output as high as 200 milliamps of test current on the ohms X1 scale (range). To test the output of your meter, set the meter up to read ohms and measure the current with a second meter set-up to read current. Read the test leads of the first meter directly with the test leads of the second meter. Check each of the ohms multiplier scales by switching the range selector switch on the first meter.For more detailed information on the application of firing display fireworks with electrical squibs, I recommend readers absorb the past and on-going fine articles written by Sam Bases for AFN. (Incidentally, I have examined Sam's panels up close and they are truly a work of art!) - WO **THE RESPONSIBILITY OF CHOICE**We have all heard or read about safety abuse issues having their root cause in such things as: risk management, or risk analysis, or poor attitudes, or statistical observations of so many near misses equal an incident, and so many near incidents equal an accident. All of these observations are interesting to think about and yet are open ended without integration into the reality of human behavior. They don't really explain WHY accidents happen and continue to happen despite all we learn or know! A search for the root reason brings us to an understanding of the nature of choice.Choice and the responsibility that comes with making choices allows us to act for our survival or for our destruction. Plants and the lower conscious animals can act only for their survival. Their behavior in the quest for nutrition and other survival needs is automatic. They cannot form concepts or think in concepts and therefore are not aware of their own self concept. They have no ego. Man has no automatic survival behavior. He does have a concept forming conscious mind with an ego. He must use his mind to act for his survival by identifying what is good for him or what is bad for him. He has choices and can also choose to act for his own destruction. To be successful at surviving, he must exercise thinking effort to raise his consciousness and predict the outcome of his choices. He is free to make any choice but he is not free to escape the consequences of the wrong choice. Their are several ways he can fail.If he chooses to suspend his conscious thinking before he acts, he will make mistakes. If he acts on his emotions or feelings instead of his conscious thinking, he will make mistakes. If he chooses to be lazy and not do his "homework", i.e. read instructions, read labels, review safety rules, etc., he will make mistakes. If he chooses to evade reality to satisfy a whim or want, he will make mistakes. If he represses his mind to suspend his thoughts because those thoughts may invoke fear, he will make mistakes. Notice how in all these observations, a choice was involved. The choice to think or not think.I have often wondered why the vast majority of humans spend their entire lives evading the responsibility that comes with choice. A fundamental conflict within each of us seems to be involved. Our self concept demands that we be productive to be happy. We enjoy our achievements and knowledge at living competently. Pride in our achievements is a virtue. However, we sometimes do take chances when we suspend our conscious thinking efforts before we act. If we make a serious mistake, we evade the responsibility and often fail to learn. We are afraid of rejection, ridicule, emotional pain or punishment. Much of this fear is a product of our childhood where we learned to evade truth for fear of pain and punishment. The reality we experienced was a successful avoidance of pain when we deceived the authority figures and the perceived threat. We learned to avoid truth and equated it with surviving successfully. We were often punished for telling the truth, which was always stated with innocence, then fear. All of us have experienced this to one degree or another. We should have been patiently taught to think, which is the root of responsibility. Instead, we were taught rule following obedience, which is the root of a habit-forming suspending of one's consciousness and looking to outside authorities to do our thinking for us. The reality of this is no matter how many rules we memorize, we will not be able to memorize a rule to solve every problem life presents us with, nor remember it in the immediacy of an action demanding situation. At best in this circumstance, we could only act on a feeling and most often it results in a mistake.There is no substitute for conscious thinking effort, and no one can do our thinking for us. It is our nature that we have choices and can act for our survival or destruction. Our only tool of survival is our mind. We have choices, and must exercise thinking effort to be able to make the correct choices for successful survival, and to live competently. Accidents involving human effort and actions are the result of one's failure to think consciously and predict the outcome of his actions. To be safe means to be conscious with focused awareness.- WO **THE BEAUTIFUL 4" SPIDER WEB SHELL**One of the most spectacular, yet simple to make fireworks bombshell, is the Spider Web. It is also one of the most inexpensive shells. Some companies call this shell an Octopus, but the effect is the same. This shell packs a dramatic punch when it bursts. Exploding with a bang, it instantly fills the sky with golden tentacles spreading radially in straight lines and in all directions from the center. The gold stripes are formed from the burning powdered charcoal trail left behind as the stars are hurled at high speed. The pattern just hangs in the sky for many seconds before fading. A four inch canister Spider Web shell, when made properly, looks like a six inch chrysanthemum. Fire 5 of these in a salvo or flight and an awesome checkerboard spider web fills the sky! Here's how I have refined the Spider Web to perform better than any others I have ever seen:Stars are cut 5/8" or 3/4" (large) square. The formulae:FORMULA 1 FORMULA 2Commercial Meal D 10.0 Lbs.Potassium Nitrate 7.5 15.0 Lbs.Air Float Charcoal 7.5 9.0Sulfur 1.0 2.0Dextrin 2.0 2.0While the formulae are given in Lbs., smaller batches can be made by substituting grams, ounces, etc. for the Lbs. or by multiplying or dividing all the quantities by the same number, keeping ratio relationships the same. For example, Formula 1 can be weighed out in ounces with each quantity multiplied by two to make enough stars for 3 or 4 shells. Formula 1 is a very fast burning star because it is 50% commercial Meal D black powder. It will ignite 100% from the strongest flash bag. The stronger, the better! Formula 2 needs to be ball milled for at least ten hours to be almost as fast, yet just as ignitable as formula 1. Because it burns slightly slower than formula 1 (after ball milling;), these stars achieve a larger spread in the sky. Ball milling also serves another purpose. It reduces the amount of ash and shortens the charcoal glow time. Without ball milling, some of the sparks may glow all the way to the ground. With ball milling, the golden stripes are more uniform and more beautiful, fading in unison. Formula 1 (less the Meal D;) can also be ball milled to achieve uniformity and less ash. Add the Meal D after ball milling the rest of the chemicals. Very slight dampening with a volume mix of 80% water with 20% denatured alcohol is helpful during ball milling. By slight I mean just enough to settle the dust but the mass still feels dry and flows freely as a powder.Commercial quantities can be ball milled in an electric cement mixer that has been modified. I did this by removing the blades and reinstalling the bolts to prevent leakage of powder out of the bolt holes. I also removed the motor and replaced it with a totally enclosed (sealed) motor, and thoroughly electrically grounded the machine. Ball milling of a mixer charge of 28 Lbs. of Spider Web mix, was done with a set of inexpensive Bocce Balls! The mouth of the mixer was sealed with a sheet of heavy plastic cut in a circle larger than the opening of the mixer vessel. The plastic cover was held in place with bungee cords. After 10 hours, the powder was absolutely beautiful and performed exquisitely after the stars were made.If one tries to burn the star composition after mixing and ball milling, one will be disappointed. It appears to be smoldering and slow as if something were done wrong. This is normal. After the stars are made by thoroughly dampening with water, forming loafs in a frame, slicing, dicing, dusting and drying the stars perform quite differently! Burn time for a 3/4" star is less than 1 second. The star is very sensitive to low temperature incandescent heat ignition, yet is very stable and insensitive to friction or impact. This makes the star ideal for hard breaking flash bag bursts!Once the stars are made, I use the following materials to assemble a 4" Spider Web Shell;:\*Paper Can with end caps 3-1/2" dia. X 4" long\*3 Chipboard discs, 1/8" thick X 3-1/2" dia.\*Jap 1/4" Time Fuse, 3 seconds between cross match\*Dime size Coin Wrapper for making Flash Bag\*Wooden Dowel, 5/8" X 4" for making Flash Bag\*Masking Tape\*Spool of 12 ply Cotton Twine or equal shell twine\*Enough good Flash Powder to fill a dime wrapper\*Igniter Cord for cross matching time fuse\*Elmer's White Glue and/or Hot Melt Glue & gun\*Pulverone or home made granulated black powder\*Wallpaper wheat paste\*Kraft Paper, 70 Lb. and 20 or 30 Lb grades\*Quickmatch fuse\*FFA Black Powder for Lift Charge, 2 Oz.The shells can be made the traditional way of rolling a paper casing but my way (with paper cans;) is easier to assemble and performs equally as well. Two of the chipboard end discs should have center holes to receive the 1/4" Jap time delay fuse. With Elmer's white glue, I fasten a disc inside the loose end cap of the paper can (the can bottom end cap should already be glued in place). A weight is then placed on this disc and set aside to dry. Next, I slide the dowel inside the dime size coin wrapper almost the full length of the wrapper. I then crimp the end of the wrapper over the end of the dowel to close off the dime wrapper forming a bottom. A short piece of masking tape is then placed over this crimped end to seal the bottom of this soon to be flash bag. Using a hot salute flash powder, I fill the flash bag 3/4 full. Next, the time delay fuse, cut to the correct length and cross matched with igniter cord, is inserted (with cross match) into the flash bag. The bag is gathered around the time fuse and tied with twine just above the cross match.Being sure to center the flash bag among the stars, I next load the stars and flash bag into the paper can. The spaces between the stars can be filled in with pulverone or granulated homemade black powder. The pulverone filler is necessary with hand rolled casings but optional if using a paper can. This type of shell functions equally well without pulverone. The top edge of the flash bag where it is gathered around the time fuse must be kept even with the top edge of the paper can. Next, I smear a generous portion of Elmer's white glue around the inside circumference of the paper can end cap that was previously set aside. Holding the time fuse centered, I lower the paper can end cap with chipboard disc (glued inside cap) onto the fuse and paper can. Once the end cap is seated onto the paper can and while applying hand pressure to keep the cap from springing back up, I apply masking tape around the circumference of the cap where it meets the can wall. The bottom end cap of the paper can is also taped and sealed.I next gently pull up on the time delay fuse to assure the top of the flash bag is against the inside disc. A generous portion of Elmer's glue is smeared on the outside of the top end cap and around the time fuse to seal against lift flame entry. I then assemble another chipboard disc with center hole over the fuse and down against the paper can end cap. This disc is taped down in four locations 90 degrees apart to hold it in place while the glue dries. The third solid chipboard disc is glued to the bottom of the shell in an identical manner. Next, I glue a generous fillet of Elmer's around the time delay fuse to complete the double seal against lift flame. The shell is now set aside for the glue to dry overnight.The next step is spiking the shell with twine. Two parallel lines of twine are applied simultaneously to give a strong hard break and symmetrical star pattern.I start by looping the free end of the twine around the time fuse, holding the end down, as twine is fed out and laid down against the shell wall, crossing over the top of the free end. The spiking pattern follows the sketch in Fig.2, and is tied off with a clove hitch knot around the entire circumference of the shell, after spiraling up the side. Running cotton twine through a wheat paste slurry and wiping off the excess as it is applied to the shell, will greatly enhance the strength of the spiking.After spiking, the shell is ready for pasting. Kraft paper (70 Lb. rating) is cut so the paper grain will lie parallel to the shell length. The width of the paper is cut so that it will cover the full length of the shell, and fold over to cover 2/3 the diameter of the shell at each end. The length of the paper should be 48 inches. Each shell gets pasted with a sheet this size. A slurry of wheat paste is prepared and generously brushed on both sides of the paper. The paper must be thoroughly soaked. The paper is folded like a bellows and squeezed with the hands to make the paste penetrate the fibers of the paper and to soften the paper. I then smooth out the paper on a formica table top and roll the shell tightly, centering the shell in the paper while working out any air bubbles. The paper that extends over the ends of the shell is torn in strips about an inch wide. The tear is made from the end of the paper to the end of the shell. These strips are laid down over the end of the shell and smoothed tight against the spiking, working out air bubbles. On the fuse end, I keep all the strips on the same side of the fuse as I rotate the shell laying down each strip. I make sure there is a good tight seal around the time delay fuse. When finished, the shell is set aside to dry in the air stream of a fan or out in the sun.The shell can be finished as any shell. The final cross match hole is punched in the fuse and a piece of igniter cord is inserted. I have also split and primed the time fuse with nitrocellulose lacquer and black powder when out of igniter cord (igniter cord can be purchased from Coonie's Explosives, Hobbs, NM). Some shell makers finish the shell with the time fuse up and a pass fire quickmatch connecting the top of the shell with the lift powder at the bottom. The quickmatch long fuse is introduced to the top of the shell where the time fuse and pass fire are connected. I prefer to invert the shell putting the time delay fuse directly into the lift powder. However, I wouldn't do this if I were using a spoolette time fuse. Spoolette fused shells have to be fired fuse end up or the spoolette core will blow through on lift.For final assembly, I roll the shell with a quickmatch long fuse, in 3 turns of 20 or 30 Lb. dry kraft paper. The long fuse lays parallel to the shell. The paper should be wide enough to cover the length of the shell plus cover the full diameter of each end of the shell. The end of the quickmatch has the paper trimmed back 3/4" exposing the black match. This end is bent over the end of the shell where the lift charge will be introduced. Two ounces of FFA commercial black powder is poured into this end of the shell covering the bare end of the quickmatch and surrounding the time delay fuse. The paper, starting with the inside rolled layer, is laid down over the black powder. The final turn of paper is gathered and tied off. I then trim off any excess paper beyond the clove hitch knot. The final touch is to install a mopoline or safety cover on the end of the long fuse to be ignited. The long fuse is then folded and secured with a rubber band and labels placed on the shell. - WO **REDUCING THE CHANCES OF ACCIDENTS**No where is the potential for accident more real than in the operations of making fireworks. I have heard comments ranging from, "it just happens," to "all accidents are preventable." I'm not a fatalist and do not subscribe to the idea that, "accidents just happen." The fact is that accidents are preventable. This fact gives us the incentive to avoid the known hazards. It also gives us the incentive to identify the unknown hazards during experimental research and to investigate the probable cause hazard after an accident. If you believe "accidents just happen," then you have a limited future in fireworks.The hazards of fireworks can be placed in four categories:1. Accidental ignition due to spontaneous combustion.2. Accidental ignition due to static electricity.3. Accidental ignition due to human carelessness.4. Poisoning due to mishandling of toxic chemicalsIn the first category, ignition due to spontaneous combustion, the accident usually occurs from mixing chemicals that are incompatible, especially in a wet state such as in making stars. Sometimes the reaction can be subtle (without ignition;) and go unnoticed until the stars have dried. Then the mixture may be unstable and extremely sensitive to friction or be so hygroscopic that it becomes wet again on a future humid day. Combining ammonium perchlorate and potassium nitrate yields this reaction. Stars that are hygroscopic can also become wet again inside a shell that has recently been pasted. A wet star containing sulfur could spell out spontaneous disaster when assembled with a potassium or barium chlorate star. Leaving wet star composition laying around (in bulk), especially if they contain any metal powders, is an invitation to spontaneous combustion. Acids or alkalinity can form to attack and corrode the metal powder creating heat. The increased temperature aids the reaction by stimulating more electron activity to form stronger acids or alkalinity, which further increase the heat. The water begins to vaporize and the heat continues to build until there is not enough water to prevent combustion. Toxic gases can be released during the heat;-up stage making the air dangerous to breathe. Some reactions are slow taking days, weeks or months and no combustion occurs due to the low level of heat generation. Yet the products of reaction can be hazardous or render the intended mix useless as a fireworks item.In the second category, accidental ignition due to static electricity, we can also include electric sparks from other sources such as light switches, motors, etc. If fireworks powders are to be mixed indoors, a tremendous amount of electrical engineering and special fixtures are necessary for assurance against ignition of airborne dust due to electrical spark. Explosion proof conduit, lighting and outlet fixtures, and junction boxes are also very costly. The easiest way to avoid that cost is to simply mix powders outdoors. A pole barn or gazebo structure overcomes the problem of rain, and the electrical hazards to air born dust are isolated.Static electricity is a problem all of its own, and controlling it is more difficult simply because we never know when it is going to occur. We can, however, take steps to reduce its hazard.Workers should wear only cotton clothing and this includes socks and undergarments. The work room floor and tables should be conductive and earth grounded through a 100 thousand ohm resistor. The resistor allows the static charges to "bleed off" and prevents a sparking arc. The resistor should be in series with the ground source. Workers should also wear special conductive shoes which, if worn daily, should be discarded for a new pair at least once a year. Conductive shoes can be obtained through most popular shoe stores, or orthopedic specialty shoe stores. Chemical mixing, especially with metal powders, should be done on days when the relative humidity is 65% or better and during the warmer seasons. When the air is warm, it holds much more water for a given percentage of relative humidity than for the same percentage when cold. Humid air reduces the chance of an arcing static spark because the charges bleed off at lower voltage levels than necessary for an arc to occur. If mixing is done indoors, the work room should be climate controlled for 65% relative humidity at 70 degrees F, +/- 10%. Avoid using plastic containers for mixing, measuring, or storing. Solidly ground all electrical equipment and machinery.In the third category, human carelessness is where most fireworks accidents can be attributed. "The responsible person knew better, but took a chance anyway," or "he just didn't know any better." The number one rule everyone making fireworks should adopt is: "If you don't know, you don't do!" At least until you know all the facts about what it is you intend to do. I firmly believe one of the biggest contributing factors for this industry's poor safety record (in the U. S. A.) is the prevalent attitude of prideful secrecy among professionals, and the ignorant curiosity of man. Don't do unless you know. For example: you have just mixed a 5 ounce batch of a new formula using chemicals you know nothing about. The formula works. Should you go ahead with making a 20 pound batch? Have you done friction sensitivity tests? Impact tests? Chemical compatibility research? Toxicity research? Or have you only decided a 5 ounce sample worked good when ignited? A lot of unknown hazards could exist that are difficult or impossible to control or need special handling consideration in larger batches, especially when wet mixing for stars.Familiarity breeds contempt. The fire worker should remind himself of this daily. We are all prone to fall into the trap. When a particular operation has been accident, or incident free for many years, it doesn't mean an accident can't ever happen. If we let our guard down, or take short cuts and chances, an accident will happen.Mother nature (physics and chemistry) has set the rules that we must identify and abide by if we are to play with her toys. In fireworks, you can't fool nature and get away with it. It makes no difference who you are, how much money you have, or how much knowledge you possess no man is forgiven for breaking the rules. It takes self discipline to be careful, and being careful is cheap insurance. One who scoffs at safety rules is truly a fool.Poisoning due to mishandling chemicals seems to be the least concern of most pyros, as so little has been written on the subject. Fires and explosions make spectacular news reports, and the thought of being involved is certainly terrifying. Yet death by poisoning is the same as death by fire, and can be equally agonizing for the victims and their families.Have you ever mixed a batch of black powder, then blew your nose to find the tissue paper full of black? What about the black that didn't come out? You can be sure that some of it made it to your lungs. Finely powdered chemicals become air born during mixing, and almost all fireworks chemicals are toxic to one degree or another. They can enter your blood stream through your lungs, eyes, ears, mouth, throat, stomach, under fingernails or in some cases are absorbed through the skin. Symptoms of poisoning include any one of the following: fatigue, headache, nausea, vomiting, dizziness, cramps, double vision, diarrhea, nose bleeds, burning blood shot eyes, or skin rashes. Poisoning can be mild (unnoticed) to severe (resulting in death). But I ask, what are the long term effects to exposure? Know your chemicals! Most public libraries have chemical dictionaries which spell out the toxic hazards. Ask suppliers for material safety data sheets. Obtain and use quality safety equipment such as: dust respirator, face shield or safety goggles, apron, and rubber gloves. Shower after handling or mixing chemicals. Clean your fingernails which can trap nasty little doses that will inevitably end up in your mouth, eyes, nose or other personal body parts of yourself or other intimate loved one. Wash your clothes twice and separate from the laundry of others. Again, this is cheap insurance.I believe most, if not all people, love the spectacular beauty of fireworks. Yet these same people are the first to ask: "You make fireworks? Isn't it very dangerous? Are you nuts!??" It is we, all of us who make fireworks, who have given this industry a black eye. Isn't it time to turn it around?Safety is a constant and on-going state of consciousness. It doesn't exist unless we make it exist, daily. All the aspects of safety and accident prevention can not be stated in such a brief essay on the subject. If I have made you think, than some good has been achieved. Always think safety first! - WO**ABOUT THE AUTHOR**Bill Ofca began his technical education in the United States Air Force, from 1966 to 1970, where he completed fifteen different technical courses in electronics. He graduated the USAF 3380th Technical School with honors. Bill was stationed from 1967 to 1970, with the 76th Aerospace Rescue and Recovery Squadron in the Pacific, in direct support of splash down recovery for the Apollo space missions to the moon.From 1967 to 1970, Bill attended night classes at the University of Hawaii. From 1970 to 1973, he attended classes at the State University of New York and the University of Connecticut.Bill was employed by the Alpha Laval Co. for ten years in progressive positions including: Factory Service Engineer, Assistant Manager of Quality Control, Electrical Control Design Engineer, Field Engineering Supervisor of Fuel Treatment Systems Group, Process Control Engineer, and Chemical Process Engineer of Mineral Oils Division. During this time, Bill gained valuable experience designing explosion proof systems and controls. Extensive international travel for field commissioning of systems was a major part of Bill's experience.For the past eleven years, Bill has been employed by IRECO, Inc., one of the largest explosives and detonator manufacturers in the world, and the largest in the United States. His position at IRECO is Electrical Engineer, and Supervisor of the Electronics Lab.From 1980 to 1990, Bill was co-owner and chief executive officer of the Legion Fireworks Co., Inc. of Wappingers Falls, New York. He has extensive knowledge and experience in the design, manufacture, and display of exhibition fireworks. His credits are many and include designing and operating very large, electrically fired, FM radio music simulcast displays. He has lectured at business seminars, and trained many professional display operators to shoot displays.For the past nine years, Bill has been writing "Safety Fax" and "Pro Fax" feature articles for American Fireworks News, and has occasionally written articles for Fireworks Business News.In 1988, Pyrotechnicians International, Inc., a large mid-western organization of fireworks businesses, recognized Bill's contribution to fireworks safety by awarding him the PI Safety Award for that year.Bill is married, with two grown boys, and lives in Hyde Park, New York. |

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