THE BEST OF AFN IV

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Edited by Jack & Dorothy Drewes

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PREFACE TO THE 4TH VOLUME

It's hard to believe that five years have passed since we introduced *The Best of AFN III.* It seems like such a brief period, yet the fireworks experimenters and writers who bless American Fireworks News with their articles each month have managed to give us enough work to make this the biggest of the three *Bests.* And we have enough great articles left over to get started on *Best V.* Indeed, we do owe it all to those fine people who want to share their fireworks information with the world.

Eighty-three (83) pyro writers are represented in these pages. What a cross-section of incredible fireworks knowledge is found in that group! None of this would be possible without their courage in discovering this fireworks information and then deciding to pass it along to other fireworks enthusiasts.

The fireworks scene has changed a great deal since our first tentative steps with the skinny *Best of AFN* (later absorbed into *Best II).* That was a little over ten years ago but developments have been so fast that it could have been one hundred. We've seen effects such as glitter and strobe emerge from the obscure or secretive to main line effects that everyone can achieve. We've seen rapid development in enthusiasts becoming hobbyists and then becoming professionals. We've seen technological developments such as displays that used to be fired with guys running around in the dark with red fusees to wireless shooting systems and computer-operated displays.

The *Best* series is keeping pace with those developments. *Best IV* contains some truly advanced pyrotechnic information, such as mortar separations, and fusing problems, and other display situations. But we managed to keep some basic material available too, and a whole bunch of how-to articles. We are very pleased with some of these how-to articles, because they show how easily obtained Consumer Fireworks items can be used to make display-quality devices. And new developments like StickyMatch® just make it so much easier!

It's time to get started with your new book. If you are rather new to all this, I urge you to begin with the very first two articles, STARTING OUT and ORDERING. They were written by the fellow who wrote *Introductory Practical Pyrotechnics,* a book that we highly recommend for anyone who wants to do hobby fireworks in a systematic and, well, practical manner. These two articles are a fitting beginning of *The Best of AFN IV.*

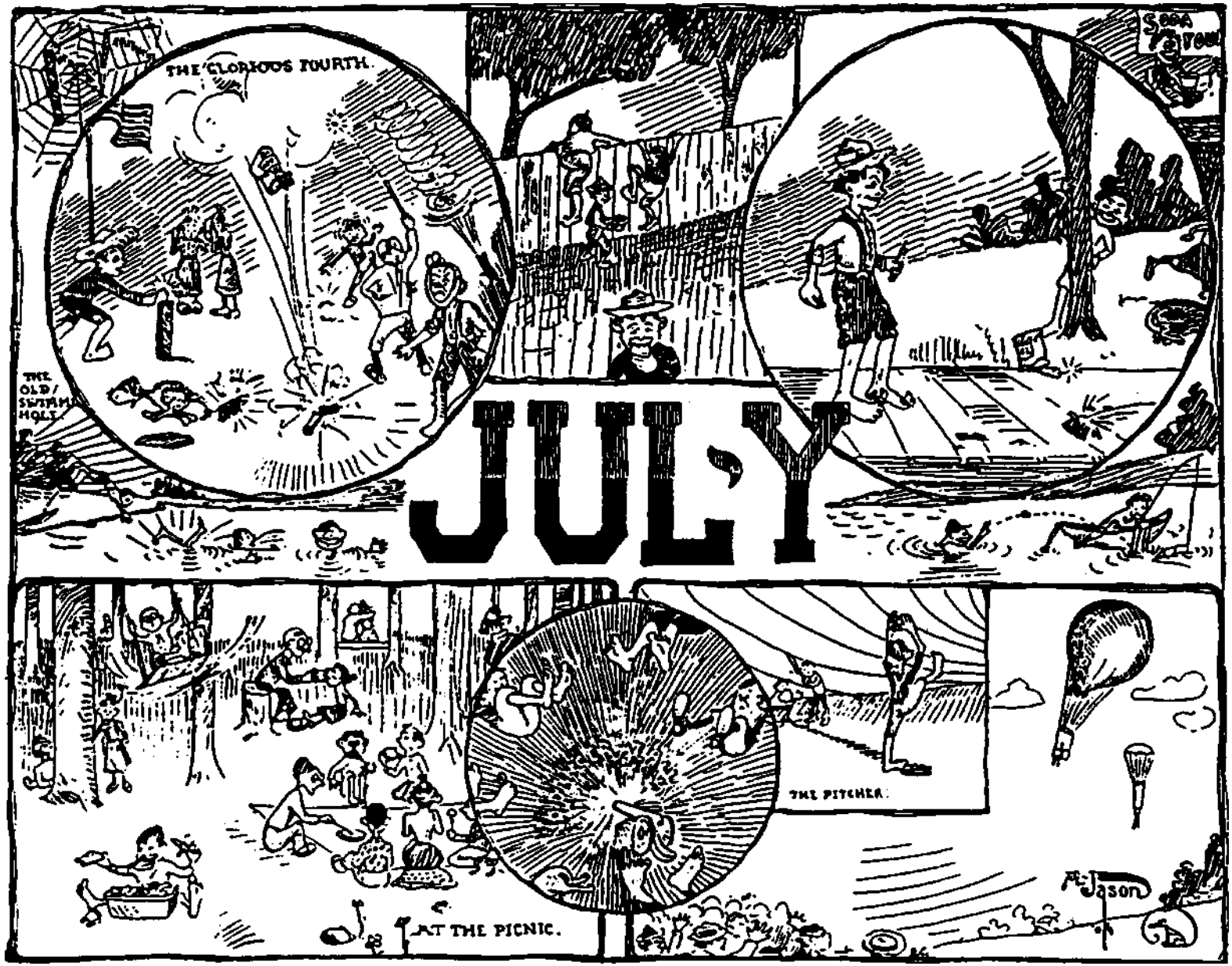
As you work your way through the book, please keep in mind that an accident usually leads to very dire consequences, both physical and legal. It is healthy to keep reminding yourself that things happen fast in high energy reactions, so careful workmanship and good housekeeping are essential.

Fireworks clubs offer great opportunities for every fireworks enthusiast, regardless of his experience. We asked Ken Barton, President of the Texas club to tell us about such clubs:

REASONS FOR JOINING A FIREWORKS CLUB

Pyrotechnic Artists of Texas has been in existence only since 1997 but has already created subtle changes in Texas fireworks, and more dramatic changes in the lives of its members. Many PAT members have learned much about pyrotechnic safety and at least five, possibly ten PAT members have gone on to get their Texas Pyrotechnic Operator's License as FireAnts.

We in PAT have become more exposed to the fireworks industry and its products, and our children have also experienced more thrills with fireworks at our events. (The smiles attest to the happiness.) We have also learned more about Texas and federal fireworks laws, and that knowledge keeps us out of difficulties we'd rather not experience the hard way.


JULY
THE GLORIOUS FOURTH.
THE OLD SWIMMIN HOLE
THE PITCHER.
AT THE PICNIC.
Jason

STARTING OUT

One of the hard things in any endeavor is getting started. There you are at home - you know you want to get involved in amateur pyrotechnics, you may have just recently discovered that you are not alone and that there are thousands of amateur fireworkers all over the world, but you are still at a loss about how to start. It seems so daunting - there is so much to learn, you have to gather together materials, and you want to do it safely. Where to begin?

In my opinion, acquiring knowledge is the first and most important step. Knowledge is the key to success and survival. Let's face it - fireworks are dangerous, and the only way to reduce that danger is through good working habits and knowledge. If you are going to use flash bags to break your shells, then it is important that you know how to mix and handle flash powder. If you want to begin modifying existing formulations then it is important that you know that a mixture of a chlorate, a nitrate and finely divided aluminum is known as a "Death Mix". Why? Because some books have formulations that contain such a mixture, or you may someday be tempted to use chlorate if you happen to run out of perchlorate. In any case, this chlorate/nitrate/ aluminum mixture can occasionally suddenly heat up and catch fire or explode, and the inexperienced worker should avoid such mixtures. Where do you find this knowledge? Well, there is very good news - there are numerous sources of that information now available, due to the efforts of groups like the Pyrotechnics Guild International, authors like Dr. Shimizu, and journals such as AFN. In my opinion, you cannot buy too many books, tapes, and magazines. However, buying them all is expensive, and so you might want to prioritize your purchasing order. I would suggest the following order:

First, I would suggest that you buy my book at around $40 (shameless plug!). I'm not just saying this because I wrote the thing, but because I wrote it to fill a gap in the existing literature. It was designed to be a lab manual for the absolute beginner. *[Introductory Practical Pyrotechnics,* available from Skylighter.]

Which book to buy next depends a little on your goals and inclinations. I personally enjoy reading and rereading Dr. T. Shimizu's book "Fireworks: The Art, Science and Technique". It is primarily written with an eye towards aerial shells, and it is written by a scientist and discusses some of that aspect, as well as focusing on the techniques. It's a bit pricey at around $70, but I have read my copy ragged. I don't think anyone will go wrong buying it. Alternatively, one could spend about the same money to buy the Best of AFN numbers II and III (Where is Best of AFN I ? Best of AFN II ate it). These are collections of best how-to articles of AFN, and include technical, craft, scientific and humorous articles. The articles were mostly written by amateurs for amateurs, and deal with their trials, tribulations, successes and learning-experiences. Overall these collections form a mine of information.

There are other books available, including the Rev. Lancaster's book ("Fireworks, Principles & Practice", which is an excellent technical book on many aspects of fireworks), and the affordable but somewhat out-of-date books by Davis and Weingart. These latter books are very interesting sources of constructional details, but many of the formulas are considered outdated and too dangerous for modern use.

Once one progresses past the stage of rank beginner you will want to consider books such as Bill Ofca's *Technique in Fire* series, and the various educational books by B. and K. Kosanke, Bleser, Oglesby, etc.

Another excellent source of information is magazines, newsletters and journals. Apparently you already know about AFN. Another good source is club newsletters. You will probably want to join the PGII, and they send out a bulletin that contains a lot of information about PGII events and technical articles about the construction of fireworks. The advertisements are also an excellent place to search for suppliers. Recently I have been very impressed with the newsletter put out by the Florida Pyrotechnic Arts Guild.

Of course, you will want to search out and join your local pyrotechnic club (if you are lucky enough to live in an area that has one). The advantages are numerous - most importantly,

they can give you hands on mentoring. Many clubs will often host informal classes, and they can help you gain experience to get your shooter's certification, and they will know the local laws and regulations.

However, not everyone is lucky enough to live in the area of a pyrotechnics club. There are many parts of the country without. In some cases you might be able to find a local mentor. You can try to find one by advertising in AFN, the PGII Bulletin, or on the Internet (below). You can also get the next best thing through videos. There are numerous videos available through AFN and through private individuals. Advertisements for these videos can be found in the back of AFN, the PGI Bulletin, etc. There are both "convention videos" and "topic videos". The former cover talks and classes given at various conventions, and may have from five to ten different short classes or topics. The latter are "purpose made", and cover topics such as making cut stars, making single and multi-break shells, shooters safety, etc.

Of course, one of the best learning experiences (short of working with an experienced fireworker) is to attend a convention, such as the annual PGI convention, Western Winter Blast, or some of the more local conventions such as Fall Florida Fireworks Festival, the Summer Fireworks Festival, etc. The larger conventions not only have lots of shooting every evening, but they have full schedules of classes and seminars. In fact, they often have to schedule two or three talks/classes at the same time, and the problem lies in selecting from this cornucopia of possibilities. In addition, the contacts you make can lead to many learning opportunities throughout the entire year - for example, during my first convention I met people who freely said "call me if you have questions".

Then there is the Internet. Beginners should approach the Internet with caution, both pyrotechnically and socially. ANYONE can publish anything on the Internet - there is no censorship for content or quality. There have been many cases where malevolent or ignorant people have published dangerous information — "recipes" which have such high risk factors that I shudder to think about them. On the other hand there is a lot of very good information out there - award winning fireworkers and professionals also publish on the Internet. One good place to start is to browse the world wide web starting at my web page: www.pyrosafety.com People have told me that it's a good page, and it has a good list of pointers to good information.

Another Internet resource is the Usenet newsgroup rec.pyrotechnics. Unfortunately, about two-thirds of the postings on rec.pyro are ... how do I say this... "ca ca". Few are of any value. How can you tell them apart? Well, first of all you should "lurk" (just read without writing a lot of stuff). After a few weeks I think it becomes obvious who are the serious fireworkers... They cite examples, they quote sources such as Shimizu, they explain the experimental basis for their conclusions, and they generally discuss issues in a calm and mature fashion (even the most knowledgeable occasionally get angry when faced with a particularly dense and dangerous individual). Rec.pyro also abounds with "flamers", people who are rude, and who enjoy ad-hominem as an art form... don't let them discourage you.

There are also a few semi-hidden mailing lists. Somebody will invite you to join one or more of these when you start to get noticed as being a serious poster on rec.pyro. Yes, I know this is a little elitist, but the people who manage these mailing lists have established this policy to try to keep the signal/noise ratio high. In fact, these mailing lists were pretty much formed as a refuge from the garbage on rec.pyro

Finally, I would like to give you some anti recommendations - books or pamphlets that are SO bad they deserve special mention. High on this list are The Anarchists Cookbook, Ragnars Guide to the Recreational Use of Explosives, The Big Book of Mischief, The Terrorists Handbook, and Phone Phreaking and Kewl Bombz. In fact, anything with typography of the sort "kewl bOmz" is automatically suspect. There are a lot of kids who delight in copying and re-editing the same garbage, and passing it around. For some reason they have developed the use of alpha-numeric substitution for phonetic spelling, along with random capitalization (They s33m to thlNK it is k3wl!). Also, many of the books from the militia movements are of exceedingly low quality.

Start getting books, and start READING. TIP

ORDERING

Some of the questions I often get over the Internet is "What should I buy?", "How much should I buy?" and "Where do I buy it?". These are all excellent questions. Beginners don't want to buy useless chemicals, paper or plastic products, or buy far too much or far too little of something. They also don't want to pay too much, or receive bad material, or have somebody take their money and not deliver the promised goods. The good news is that it is possible to determine what one needs by oneself. The bad news - nobody has a "kit" that one can buy, and so everyone has to figure it out for themselves.

The key to the first step is planning and visualization. And the first step of planning is to set goals. One can hardly plan on how to get "somewhere" if one doesn't have a "somewhere" as a goal. Oh, I suppose a person could just randomly do things until they discover that they have completed a project, but that's inefficient (and generally very dangerous in pyro!). So, a beginner would be well advised to set one or more goals. There is something to be said for starting with simple projects, and working up to more complex goals. This helps give the person practice in handling fireworks, and helps build confidence as each small project succeeds.

Thus, let us say a person's prime goal was to make a 3" round shell with color changing stars. This is where the beginner must either rely on local tutoring, or where reading, knowledge and visualization are critical. The person must read up on the topic until he can visualize each step. The books I mentioned in a previous article are a good place to start. This reading will help determine what materials and tools are needed. For example, the building of a 3" round shell has several subgoals built into it - the shell consists of hemis, and requires a quickmatch leader which contains black match, lift powder, time fuse, cross match, burst, and stars (how about the gun to fire it?). This is where flowcharts come in handy. One can use these to help plan out projects and to help determine proper sequencing. For example, since home-made meal is used in making coated rice hulls, black match, cross match, and priming stars, this material should be made early so that it is available for every one of these processes.

Once the flow chart is made, there will be entries such as "make meal coated rice hulls" and "make stars". Each of those entries will have sub entries, such as "weigh out chemicals", "screen them", etc. (Of course, these entries can be dropped when one becomes more experienced and is sure that the equipment is on hand). At this point the types and amounts of various pieces of equipment and chemicals start to become more obvious. It can be seen that a balance is needed, as well as cups or dishes to hold the chemicals while weighing, screens, bowls, etc. Once those have been identified, it is generally the case that the expensive specialty items come in singles (balances, ball mills, etc.), while the multiple items are cheap and relatively commonly available (cups, spoons, mixing bowls, etc.). It is a good idea to order the specialty items early, since the project will be delayed until they arrive. The cheap stuff from the supermarket can be obtained at almost any time. That leaves the chemicals. One of the most common questions that I get in e-mail is "What chemicals should I buy, how much of each, and from whom?".

The flow chart and the goals can help determine this. Let us take as an example a person who wants to make round shells. They can use a spread-sheet program to help determine what they will need. First, they need to select a limited number of types of stars and compositions. There will be Black Powder for various purposes, as well as some color stars. The beginner should choose relatively simple stars, avoiding magnesium metal and chlorates. The beginner should also choose a limited number of stars, such as red, white, blue, green, yellow, charcoal tail, blond streamer and perhaps one or two more.

The left most column (called column A) will be a listing of the names of each type of

chemical, starting in about row 5 (rows 1 through 4 will be used to label the columns and other things). Then, the percentages for the first composition chosen can be entered into column B. Thus, for Shimizu's Blue #2, the numbers would be 67 for potassium perchlorate, 10 for red gum, 13 for black copper oxide, etc... Next, column C can be used to calculate how much of each chemical will actually be needed. To calculate how much of each chemical will be needed, one has to estimate the total amount that will be made before the next order. This is entered into cell C2 (column C, row 2). This weight can be given in pounds, since the chemicals are generally ordered in pounds. Then the amount needed for each chemical is calculated using a formula (all formulas are given in Excel, but other systems are similar). For each cell, the formula is =(C2*B<row number>/100). Thus, if the potassium perchlorate is in row 5, then this formula would read =(C2*B5/100). In this case, if the user wanted to be able to eventually make 5 pounds of Shimizu Blue #2, then this would calculate that the user needed 3.35 pounds of potassium perchlorate just for these stars. This process is repeated for each of the other compositions - for example, the red stars can be put in columns D and E, and the green stars put in columns F and G, etc. Always keep the percentages for potassium perchlorate in the same row (for example, row 5). Add new rows as needed for new chemicals. In this example, a new row would be needed for strontium nitrate for the red stars, and another one would be needed for barium salts for the green stars. However, do not make new rows for old chemicals. In each case the first of the two columns will contain the percentages, and the second column will contain the amount needed calculated by a formula similar to the one given above.

When all of these numbers have been entered, then the total amount for each chemical can be calculated in the next empty column by summing up the individual needs for each star type. Thus, if one was only making blue, red and green (as above) then the formula for the total amount of potassium perchlorate (remember that it is in row 5) would be placed in cell H5, and would be =C5+E5+G5. Of course, if columns H and I were used for yellow stars, then the total would be in J5, and so forth. This will give the minimum necessary amount for each chemical. Don't forget to round up when ordering. Also note that most distributors give price breaks at 5 pounds and 10 pounds, so it might be cheaper to order one 10 pound package rather than a 5 pound and three 1 pound packages.

If a person is especially ambitious they can then utilize the spreadsheet to determine who would give the lowest price on the entire order. This entails entering the prices from each distributor's catalog, and using some simple functions to figure out whose price is less. However, there may be a reason to split the order - for example, one dealer may be more expensive on some items, and less expensive on others. An alternative is to use this to try to dicker - sometimes the dealers might discount one or two items by a small amount just to get all of your business and to make you into a loyal and exclusive customer. Other times, they may just tell you to go get stuffed. I think it depends on a lot of factors, including their current bank balance, phase of the moon, and mood of the spouse. The distributors can be found in the classified ads in AFN.

One final hint - don't overlook the benefits that can arise from ordering in really large bulk. First of all, it can be the case that a 50 pound drum or bag of some chemical might only cost about twice as much as a 10 pound package. That is because the suppliers don't have to pay somebody to repackage it, and labor costs aren't cheap. In addition, some companies charge a lot of shipping fees, such as UPS, Hazmat, etc. However, when the order gets big enough it may suddenly become cost effective to ship by surface common carrier. While that may cost over a hundred dollars, this can be offset because there are no special box or hazmat fees to consider. And that shipping cost is for hundreds of pounds, not tens of pounds. I have seen two or three people pool their resources and buy a quarter ton of chemicals, and the overall shipping costs were far below the normal costs. TIP

CUT STARS

My procedure for making 3/8" cut stars follows: (All measurements are by weight.)

After star comp is mixed, I put one cup of the mixture in a plastic bowl and wet down using a spray bottle of water. I don't wet it too much - a half dozen sprays are all that is needed. I then mix by hand until a doughy ball is made. I know I have used the right amount of water when the small amounts of comp that are stuck to the sides of the bowl stick in a doughy ball when pressed.

I built a star press frame by taking a 8x8x1" square piece of wood and then built a frame around it using 1 x 1/2" strips of wood. I lay the frame down and put a piece of plastic saran wrap over it, then put my wet ball of comp in the middle of the frame on top of the plastic wrap. I then spread out the comp with my fingers as evenly as possible, then put another piece of plastic wrap on top of the comp. I take my 8x8x1" piece of wood and put it on top of the comp in the frame and press down hard, then remove the block of wood and the frame; what I'm left with is a solid slab of comp.

I remove the comp-slab from the plastic wrap and dust the comp with meal powder on both sides. I let it sit for 10 minutes, then cut it into cubes using a thin, but solid piece of plastic. Then I separate the cubes, mist them with water and roll them around in more meal powder. I let them dry for 7 to 10 days.

USING THE STARS IN SMALL SHELLS

My shells are 2-inch plastic canisters using a homemade visco time fuse. With black match being difficult to obtain, I just pour my lift charge down the mortar and install the shell so the reinforced fuse touches the lift charge. A hole was drilled in the side of the mortar near the bottom to accept the igniting fuse. I christened the skies this year on the 4th of July. My breaks were fair, but my colors were great! Upon inspection of what was left of the shells, I found that just the tops were blowing off. My bursting charge was a mixture of meal powder and 4F. Back to the drawing board.

All joking aside, I have found this undertaking to be one of the most infectious, stimulating and fascinating adventures I have ever been on. I feel I have learned a lot, but at the same time I know I have just scratched the surface. You will be hearing from me again. If the pyro is ever needed, just look up to the skies, that's where I will be. GD

	RED	GREEN	BLUE	YELLOW	WHITE	GOLD STREAMER
Potassium perchlorate	6	6	12	8		
Potassium nitrate					28	8
Barium nitrate		6		3		
Strontium nitrate	6					
Shellac	1	1		2		
Dextrin	1/2	1/2	1	1	1	1/2
Dechlorane		3	5			
Black copper oxide			3			
Charcoal - air float	2	2	2	2		1/2
Sodium oxalate				1		4
Antimony sulfide					5	
Sulfur, flour					8	2

METHOD OF PRODUCTION OF MICRO STARS

Micro stars are used in such items as gerbs, comets with crackling stars, and small bombettes. For a long time I have been searching for an appropriate production method for amateurs, without success.

I started my first attempt by drilling 3mm holes in Teflon plastic sheets of 3mm thickness. Then I placed the drilled sheets on a plain, smooth surface and started to paste a slightly wetted star composition into the holes, using a plastic spatula. I left it to dry for a few days. I thought that when the star composition had dried the cylindrical micro stars would be easy to remove. It did not work at all. Nearly all the micro stars were damaged when I pushed them out.

Another method I tried was to form a 3 mm layer of wetted star composition and to cut it into 3mm cubes, like cut stars. In general, it is difficult to get uniform cubes and, in most cases, they stick together, especially if you use nitrocellulose lacquer. Not a method to be recommended.

For my next attempt I searched for a plastic matrix, like a grid. Again I pasted my damped star composition into the matrix, thinking that after drying it would be easy to remove my cubes by bending the plastic, but that was just wishful thinking.

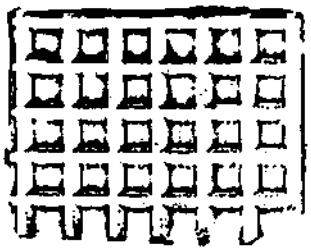
After some time, having already buried my idea of easy-to-make micro stars, I saw a plastic cutlery box in our kitchen. It was the shape of the grid-like spaces of the box that caught my eye. They had the form of little quadratic, truncated pyramids with a 4.5mm edge length and 2.5mm height.

Again, using a plastic spatula, I pasted my damped star composition into the matrix, which was then placed on a smooth plastic surface. After having left it to dry for a several days, I bent the plastic matrix a little bit and - what a surprise - the little truncated pyramids, my micro stars, jumped out. Enthusiastic about my success, I tried an NC lacquer bound ("wetted") star composition.

Even this star composition showed no tendency to remain in the matrix after drying, and after a short drying time I got my pyramid micro stars.

I hope I am not wrong if I say that the plastic is polyethylene.

This method is not suitable for large scale production, but works very well for amateur micro star production.



The photocopy above may give you an idea of my cutlery box matrix.

If you do take your wife's cutlery box, please remember to buy her a new one! HWW

BARGAINS IN ODD PLACES

Let me encourage every pyro to watch their local newspapers for school district surplus equipment auctions. This is because old lab equipment seldom attracts a lot of interested bidders. This weekend I went to such an auction and got some real goodies for cheap! I paid $15 each for 5 lab benches, each 6' long with a thick chemical-resistant top. Each bench has 16 drawers for each individual student and a central cabinet for joint equipment. I paid $20 for a 6' by 3' rolling chemical demonstration table with a small hand-pump sink and plastic waste receptacle. I also got a box full of ring stands, tripods, clamps, and assorted lab hardware for $2. The kitchenware sections provided some real opportunities as well - stainless steel counters with sinks, Hobart mixers, etc. In the past I have purchased a fume hood for $25(!) and various old balances at bargain-basement prices. TIP

AN INTERESTING CUT STAR METHOD

I'm not very good at getting all my cut stars the same size. I don't know -- maybe these old eyes just can't see a straight line, anymore. But I found a way to make nicely uniform stars without any skill.

I roll out my cake between gauge strips, like usual. Then, instead of a "long knife", I use a multi-wheel vegetable cutters to make the lines. These cutters are like a pizza cutter, but with four or five wheels, instead of just one.

They make perfectly spaced cuts in the dough. I overlap the next cut by putting the first wheel in the last groove which automatically controls the width. Even if the stars aren't actually cut, it's an easy way to mark out the cuts for evenly spaced lines.

The only things I don't like about my present cutters are:

1)The method only works with a pretty dry dough. Otherwise, since I'm not pulling each row away from the mass as it's cut, the dough tends to 'heal'. Dusting the cake lightly with meal powder helps prevent the stars from sticking back together.

2)I could find cutters only in two spacings (for two different star sizes). I'd like more control over the size.

Actually, with two sizes of cutter, I can make three sizes of star: 1) wide-by-wide; 2) wide-by-narrow; 3) narrow-by-narrow. With various thicknesses of gauge strips, I could increase that even more. My narrow cutter has five wheels on 3/8" spacing, and the wide one has four at 1/2" spacing. Local kitchen accessory stores carry them.

Maybe I'll make a custom cutter with adjustable wheel spacing. LES

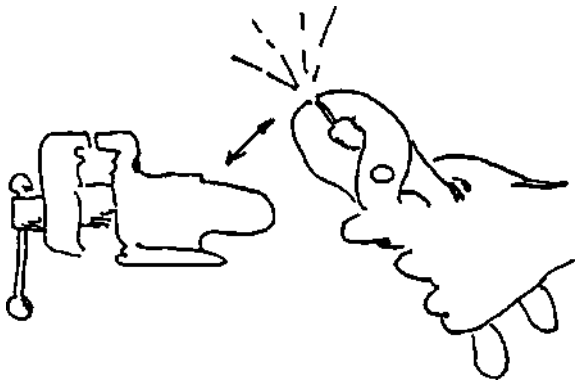
CAP CRAP

I've been a pyrotechnics hobbyist since the early age of around eleven years. My friends had fireworks and I didn't, which were hard to come by and expensive. I was determined to make by own. It helped that my father was a chemistry teacher and that we lived in a rather isolated rural area.

With my father's help I learned a lot, and maybe he did too, as we learned first hand the properties of pyrotechnic chemistry. No pyrotechnic literature seemed available even to a chemist! We didn't know where to look, but we found that most publishers find that type of literature censurable.

My earliest "invention" was affectionately called "cap crap". It was a mixture of 4 grams of potassium chlorate and 1 gram of sulfur. I would grind each of these chemicals very finely in a freshly cleaned mortar and pestle. I would make only very small quantities of this mixture at a time.

Previous to this "invention" a suitable report resulted from taking a roll of caps and striking in on a hard surface with a hammer. Cap crap behaves similarly. When a small quantity was squeezed between the jaws of a pliers and struck against a hard surface it produced a satisfying report.



Years later, another use for cap crap surfaced. I used a loose packet of about 12 grains and attached it to silhouette style steel rifle and pistol targets. A "bulls eye" hit produced a satisfying report and smoke cloud. Even the energy from a .22 caliber long rifle reliably triggered the cap crap. CD

PILL BOX STARS

Making pill-box stars is really not that hard. Here is a simple way:

Rolling tubes: I use a 3/4" steel rod to roll on. Any type of material could be used, as long as the rod is smooth. I feel that the weight of the steel rod makes it easier to roll the tubes.

Paper: 65 or 70 lb. virgin Kraft, three turns. For a 3/4" rod, about 7 1/2" of paper will be needed for three turns.

Manipulation: The paper is cut 20" wide and 7 1/2" long, with the grain running the 7 1/2" direction. Paste is applied to two-thirds of the paper, which is then rolled around the rod, continuing into the pasted area. When completely rolled, the tube is slipped off the rod. Some people paste the entire paper, including the area that touches the rod. That's acceptable, but the rod can get tacky and would need to be cleaned.

Drying tubes: The tubes should be allowed to dry slowly, not in the sun or oven as that could cause them to wrinkle or curve. When dry they may be cut to the desired length.

Composition: There are specific compositions for pill-box stars. Many formulas will burn too long in the tubes.

Pink & Silver Pill-Box Star	
Potassium perchlorate	68%
Strontium carbonate	14
Strontium nitrate	2
Red gum	6
Aluminum bright	4
Aluminum flake, small	3
Aluminum flake, med/lg	3
Dextrin	+2

The composition is moistened with not more than 8-9% 35/65 alcohol/water.

Match: A piece of flat blackmatch is cut to protrude 1/2" from each side of the tube.

Assembly: The piece of blackmatch is placed inside the tube, protruding equally from both ends. The tube is then picked up and scooped into the moistened composition, which is then pressed with the finger and thumb on each end of the tube. This is continued until the tube is pressed full of composition. The star loading may be finished by placing the tube on a ramming tool and tapping lightly. Too much compression will cause the star to burn too long. LP

RED ILLUMINATING STAR

	1	2
Strontium nitrate	55	4
American Dark aluminum #809	-	1
German Pyro aluminum	15	-
Sulfur	15	1
PVC	10	1/2
Red gum or shellac	5	1/3

Notes:
1) Dampen with alcohol. May be cut or pumped not much larger than 1/2" or pillbox.
2) Prime with hot prime like meal/silicon

JB

MAKING COMETS

My first tests were hand-mixed, hand-pressed, and way-too-wet comps. I was mixing the willow and other black powder types until they stuck together like tar. Even with hand-pressing the comps into shape, they were spewing water everywhere. It's a wonder any of them lit.

I bought a rubber rock tumbler and have been milling the black powder comps for 20-24 hours with some 50 cal. lead balls. It has made a difference in burn quality compared to the hand-mixed. I'm also using an arbor press to compact the comets now. It really makes a hard comet. With two wraps of paper on the sides and a thin piece of cardboard on top, these things really throw off some fire dust. It's amazing to me how a 7/8"xl-l/8" comet can spread a 10" diameter lightning strike of fire 150' long.

I've also been working on color comps. I've got a red and a blue that work really well. Firing a color comet with some willow mix on top makes an interesting effect. The color burns going up and at the peak the fire dust kicks in. Once it noses over, it looks like a meteor burning up in the atmosphere.

I've seen the "snowfall" formulation in a couple of books, but haven't tried it yet. It will be on my list of things to do since I've heard it's really impressive when done right! I'm also going to add more color comps. to that list. I'm a little leery of comps with metal additions and don't want to push too fast until I understand more of the basics.

I sure wish somebody would come out with a book or video about comet-making. My guess is there's just not enough interest to do such a thing. Maybe I will in a couple of years. I hope I know enough about it by then that I could. JRT

FURTHER TO MY QUEST FOR GOOD COMETS

I finally got my comets to work! I started using charcoal briquettes for the fuel!

I bust them up and put them in a blender, then screen out the unburned wood and rocks, then ball mill 8 oz. at a time. For some strange reason this stuff helps my comets to stay together.

The fire dust and length of tail look the same as when I was using pyro grade charcoal. It's messy stuff to work with but the results make the effort worthwhile: I'm amazed at how much fire these 3/4" comets produce. I'm in awe at the sight of each and every one.

I haven't had a failed comet since I switched to charcoal briquettes. JRT

CUSHIONING COMETS

I cushion my comets from the shock of the lift charge with thick corrugated cardboard discs. These are cut from dishwasher boxes and the like. The "shock absorbers" keep the comets from breaking up on the way out of the mortar.

GC

LATEX GLOVES REDUCE STATIC HAZARD

In the mixing and use of various pyrotechnic formulas, static electricity is always a hazard to the fireworks maker. Wearing latex surgical gloves greatly reduces this hazard, and may help prevent an accident while mixing or working with various pyrotechnic formulas. The gloves are available through any medical supply house, or ask your local pharmacist to order them for you. The average cost is about $15 per 100 pair. JMcN

BLUE & ORANGE GO GETTERS WITHOUT MAGNESIUM

It all started several years ago when I watched a video of a PGI convention. I observed this new-to-me effect which looked like the stars were "swimming". After cleaning my glasses and viewing it again, sure enough, self-propelled stars. I already had Troy Fish's article entitled "Green and Other Colored Flame Metal Fuel Compositions Using Parlon" published in *Pyrotechnica VII* but had not made the connection. It all became crystal clear after obtaining a copy of Dave Johnson's book "Go Getters". Well, for one reason or another, the idea somehow got shuffled to the dark reaches of my mind. Although it did resurface from time to time, the final catalyst didn't come until the 1994 convention in Pennsylvania. I witnessed some Go Getter shells in the opening display by the CPA and particularly liked the blue ones. Next came the Go Getter seminar by Dave Johnson and Mark Raitzer, which explained how to make the little critters. Unfortunately, the seminar only presented the same three colors that had been listed in Johnson's book, namely red, green and yellow. All utilized magnesium as the metal fuel. Since I really like the color blue, the hunt was on. Inquiries of several fellow pyros resulted in no answer for blue Go Getters. The puzzle finally started to fall into place following a perusal of Joel Baechle's "Pyrocolor Harmony". Right there on page 34 was an ammonium perchlorate formula for violet with an interesting footnote stating "The violet with 10% aluminum and no hexamine is an excellent 'Go Getter' composition".

ORIGINAL VIOLET FORMULA	
Ammonium perchlorate	50%
Cupric oxychloride	15
Aluminum, fine atomized	7
Hexamine	3
Rosin or Vinsol	5
Parlon	20

Having neither rosin nor Vinsol, I substituted saran resin (I figured a little more chlorine donor couldn't hurt). Also, for the atomized aluminum, I used 325 mesh, 30 micron, spherical (KSI, now Skylighter #007) aluminum. While this revised formula worked nicely in initial tests, I soon started observing bubbling and foaming in the tubes about one hour after they had been poured. In most of the tubes the fuses disappeared completely, as they sank out of sight to the bottom of the tubes due to the agitation provided by the bubbling. The foaming was probably caused by the formation of acetone acids which reacted with the aluminum. In any case, the Go Getters were useless since most of the fuses had disappeared and I didn't like the looks of them anyway.

In desperation, I tried something that shouldn't have worked quite as well colorwise as the oxychloride. By substituting copper carbonate for the copper oxychloride, the foaming stopped and, judging by the comments I received at the PGI convention, the effect was quite well received. The final formula is presented below, along with a formula for orange Go Getters. If you want to shift the color more into the "pumpkin" range, eliminate the cryolite and increase the calcium carbonate to 15%.

	Blue	**Orange**
Ammonium perchlorate	50%	50%
Copper carbonate	15	-
Calcium carbonate	-	14
Aluminum, 325m, 30u	10	10
Saran Resin	5	5
Cryolite	-	1
Parlon	20	20

All chemicals are run through a mixing screen a few times and, with the aid of a funnel, are poured into an acetone-proof plastic (I used an empty mustard squeeze-type bottle made of LDPE (low density polyethylene)). Without access to LDPE containers, one must experiment to find a flexible plastic material that is not affected by acetone. I find that, except for occasionally plugging up, the squeeze-type container works very well and gives more control over the flow of material.

As a side note, these aluminum Go Getters do not explode or burn all the way to the ground like the ones made with magnesium.

Dave Johnson's book covers the construction of Go Getters in great detail so I will cover only the highlights and differences.

THE TUBE

I use a standard 9/16" i.d. x l 1/2" long spiral-wound, machine-made tube with a 1/16" wall thickness, and standard 9/16" plugs. The end plugs do not need to be glued in as the parlon, once it sets up, is quite hard and will not blow the plug until the Go Getter is almost done burning, if at all. The tubes are then bundled into a convenient size package (I use bundles of nineteen) with rubber bands and set on plastic film (Saran Wrap), ready for filling. While Go Getters made with these tubes go quite nicely, the tubes are still relatively heavy. One variation would be to try hand-rolling some tubes from Kraft paper with a thinner wall, to see if they fly better. Go Getters are end burners, so we should not have to worry about blowing out the tube.

THE SOLVENT

A 90:10 mixture of dry acetone:xylene is used as the solvent. Acetone is hygroscopic so it is important to use dry material. Fresh acetone is best, but material of doubtful quality may be dried in the following manner. A small quantity (an ounce or so) of drying agent (calcium chloride or "Damp Rid" in Florida) is placed in an acetone-proof plastic container, the acetone is added, the container is capped and shaken to allow the drying agent to absorb the water. Care must be taken to release the pressure in the container by loosening the cap/lid from time to time. Only a brief time is needed to absorb the water and then the acetone is allowed to settle for a few minutes. Lastly, the acetone is filtered to remove any solids by pouring it through a double layer of coffee filters; then it is stored in an air/moisture proof plastic container and the drying agent is discarded (it's cheap). It is a good idea to dry only as much acetone as is needed for the batch of Go Getters being made. Caution is needed to remember that acetone evaporates very quickly, the vapors are heavier than air and extremely flammable. Good ventilation and no sparks are a *must.*

The acetone/xylene solvent mix is added to the composition in the squeeze bottle at the rate of 33-38% by weight. Some experimentation may be necessary to get the proper viscosity of the mix. The correct consistency is somewhere around a slightly thickened pancake batter (depends on your recipe). After placing the top on the squeeze bottle, about 25% of the air is squeezed out to allow for expansion of the acetone vapor. Then a gloved finger is held over the spout and the bottle is shaken vigorously for two to three minutes or until everything is thoroughly blended. Depending on the size of the batch, the operator may give the bottle a good shaking every once in a while just to keep everything in suspension, and the air must be squeezed out first. Then the tubes are filled to the brim, ready for insertion of the fuse. It is a good idea to keep a toothpick handy to unplug the nozzle, and some paper towels to wipe the nozzle and the operator's hands.

THE FUSE (THE SECRET)

Black match or any other potassium nitrate-containing fuse cannot be used with aluminum Go Getters like it can with the magnesium varieties. This is because of the ammonium perchlorate and potassium nitrate reacting to form the very hygroscopic aluminum nitrate, which will quickly result in a wet interface between the fuse and the composition (believe me, I tried). The trick is to use Thermolite. The Thermolite will not react with the composition, and it provides a nice hot flame to ignite the Go Getters. The Thermolite is cut in pieces about an inch long, then as much of the fabric-wound outer layer is removed as possible. Then it is bent into a narrow U shape and inserted into the Go Getters, U end first, about half way, then laid over against the side of the tube. Once the slurry is poured, the Go Getters set up quickly, so the operator must prepare enough fuses to complete the job. After the fuse is in

serted, the tubes are set aside to dry on a piece of plastic wrap until no acetone odor is detected, which should be 3 - 4 days. As the Go Getters dry, they will shrink back into the tube a little because one third of the slurry, by weight, evaporates.

By having two ends of the fuse exposed to the expanding flame front with the shell, ignition of the Go Getters is improved and more initial thrust is generated due to the two points of ignition.

CONSTRUCTION OF A SIX-INCH ROUND GO GETTER SHELL

A round Go Getter shell is constructed much like any other ball shell of comparable size, with a few minor differences. The time fuse is cut to allow a delay of about 4% seconds between cross matching. A fuse extender made from three turns of 30 lb. Kraft is rolled on a suitable former and pasted only on the last 1/4-inch or so of the trailing edge - just enough to keep the tube from unrolling. The tube is then slipped over the cross-matched end of the time fuse and securely taped in place (remember that at this time only the end of the fuse that goes inside the shell is cross-matched). The fuse is glued into the hemisphere and the fuse extender is cut off so that it just reaches the center of the shell. The extender tube is filled with 4f and sealed against leakage with either a small piece of masking tape or pasted paper.

THE BURST

There are two theories behind the burst charge for Go Getters shells. The first is to use a relatively hard burst to scatter the stars and let them swim back toward each other. Since the stars are placed randomly in the shell, and they are not smart enough to know which way to go, the result is a big boom and Go Getters scattered all over the sky, with the distinct possibility that some of them will be driven toward the ground hard enough that they will not burn out before impacting the earth. My preference is to use a soft break, only strong enough to open the shell and light all the stars. Meal powder on rice hulls works well for this purpose. I use a 5:1 ratio of meal to hulls, up to 6-inches, and 4:1 for larger shells. Remember, they are <u>self-propelled</u> stars and don't need to be blown all over the place.

PUTTING IT ALL TOGETHER

Two pieces of tissue paper are cut to a size sufficient to line the hemispheres with enough left over to fold across the top of each shell half to hold the contents in the halves while assembling the shell. A hole is pierced in one piece of tissue and the tissue is inserted over the time fuse and smoothed out against the inner wall of the hemisphere. The second piece of tissue is placed in the other half in a similar manner except for the hole for the time fuse. The Go Getters are then placed against the inner wall of the shell about half way up the wall. Care must be exercised not to obscure any of the fuses.

Now burst is poured in to fill all of the crevices between the Go Getters. At this point, just enough burst is used to fill the crevices and leave a thin layer over the already placed stars. Stars and burst are added in alternating layers until the hemisphere is full. Burst must be forced into the crevices between the Go Getters as this is the only way to ensure shell integrity. The extra tissue that has been hanging over the edge of the shell and getting in the way is now folded toward the center of the shell, secured with a couple of pieces of masking tape. The other shell half is finished in the same manner and the two halves are joined using typical shell glue.

As was discussed earlier, Go Getter shells do not need a hard break. Consequently they do not need to be endlessly pasted with tape or paper strips. My preference is to use two layers of filament (strapping) tape on the 6-inch plastic shells. Paper hemispheres probably need three to five layers of pasted paper. After taping or pasting, the shell is finished in the normal manner with the final cross match, lift and leader. JWD