WPA

Western Pyrotechnic Association

Newsletter

Volume 11– Number 1 – August 1999

The Western Pyrotechnic Association, Inc.

8673 56th Street
Riverside, CA 92509
Web site: http://wpa.pyrotechnics.org

Officers for 1999

President
Tom Grace
Phone: (909) 591-8319
E-mail: tom@pyro.org

Vice President
Greg Boyd
Phone: (760) 326-3131
E-mail: greg@pyro.org

Secretary
Keath Nupuf
Phone: (818) 993-6173
E-mail: keath@pyro.org

Treasurer
Glenn Vodhanel
Phone: (714) 990-6441
E-mail: glenn@pyro.org

Communications VP
Mike Workman
Phone: (408) 741-8501
E-mail: mike@pyro.org

Area Vice Presidents

Northern California
Mark Devon
Phone: (408) 725-0943
E-mail:

Northwest
John Childs
Phone: (253) 531-1658
E-mail:

San Juaquin
David Bogren
Phone: (209) 529-1485
E-mail:

Los Angeles
Paul Salverson
Phone:
E-mail: psalverson@mvfnc.com

San Diego
Rudy Schaffner
Phone: (760) 356-5426
E-mail:

Arizona/Nevada
Mike Carter
Phone: (602) 788-8259
E-mail: redgum@pyroblaster.com

Eastern and Foreign
Bruce Blom
Phone: (740) 332-3202
E-mail: opag@bright.net

Rocky Mountains
Charley Wilson
Phone:
E-mail: cwilson@celinr.storlek.com

Featured in this issue...

Instructions for Authors and Advertisers

The WPA Newsletter is published quarterly (2/1, 5/1, 8/1 and 11/1) by the Western Pyrotechnic Association, Inc. Articles submitted to the Newsletter may be on any topic of potential interest to WPA members. The Newsletter Staff will do their best to publish any reasonable manuscript submitted by WPA members. Electronic submission of manuscripts is strongly preferred. Guidelines for preparing manscripts appear in the first issue each year. If you have an article, advertisement, or other information you wish to submit to the Newsletter, please send the material to:

Mike Workman
14918 Three Oaks Court
Saratoga, CA 95070
E-Mail: mike@pyro.org

Guidelines for Preparing Manuscripts (1999)

by The Newsletter Staff

General Policy:

The WPA Newsletter is a vehicle for disseminating information about all areas of interest to WPA members. It is a voice for all WPA members, and all points of view are welcome. Every latitude in the form and style of articles is permitted, and no rigid pattern for either is prescribed, provided that authors remain within the bounds of generally accepted practices for responsible journalism. The editing style of the Newsletter Staff is friendly, and authors will make the final decisions about what changes, if any, are made to their manuscripts. The receipt of all articles will be acknowledged by the Communications VP, who will also provide a target date for publication. To the maximum extent possible, manuscripts will be published in the order received and with a minimum amount of editorial changes. Authors will receive final page proofs for approval and will make the final decision regarding what editing suggestions are accepted.

General Writing Style:

The Newsletter Staff is committed to publishing all manuscripts submitted by WPA members, but adherence to the policies outlined below is recommended.

- Avoid the use of slang and jargon. The Newsletter is a great way for members new and old to broaden their knowledge. Clear writing – free of slang and jargon – is the most effective way to make any point.
- Make an effort to define abbreviations or chemical formulae that might be foreign to follow WPA members. Many "common" abbreviations used by scientists and pyrotechnicians are not that common to members with less experience.
- Use the "active voice" whenever possible.
- The use of "third person" is strongly encouraged, except in cases where "first person" increases clarity.

Format:

The Newsletter Staff is committed to handling any manuscript submitted by a WPA member. Nevertheless, it greatly prefers to receive electronically submitted manuscripts prepared using standard desktop publishing software. Most manuscripts submitted electronically can be processed using software available to the Newsletter Staff. At the moment, this software includes:

Pagemaker 6 for creating the newsletter
Office 97/98 for word processing, spreadsheets and graphing
ChemDraw 4.5 for chemical equations
Photoshop 3.0.5 and Canvas 6 for photos and graphics
Adobe Illustrator 6.0 for graphics
Endnote 3.0 for references

The Newsletter Staff has access to a wide variety of other desktop publishing programs and hardware. Authors with questions or concerns about the preparation and/or submission of manuscripts are encouraged to contact the Communications VP.

Submission:

All manuscripts should be submitted to the Communications Vice President. Contact information is provided at the bottom of pages 2 and 3.

From Your Leaders

Dear Fellow WPA members:

The 1999 Winterblast - our tenth Winterblast - is now behind us. Like all Winterblasts before it, this year's event had it high points and its low points. On the positive side, Bill Page put on a terrific public display, and the product displayed by members during open shooting was some of the best stuff we have seen in recent years. Overall attendance and activity in the Class C tent were also at an all time high. The WPA has quickly become the 2nd largest pyro organization in the US, and our combined talent is downright impressive.

For those of you who were unable to attend the business meeting at the WWB, it is our pleasure to inform you that the WPA has several new officers: Greg Boyd has taken over as Vice-President, Keath Nupuf is now our Secretary, Glenn Vodhanel is our new Treasurer, and Mike Workman has taken the helm as Vice President for Communications. These guys are energetic, talented and committed to the club. We are all fortunate to have them on board, and the future of the WPA is very bright if we can continue to attract officers of this caliber. On the down the side, the club must still address many of it growing pains. We are no longer the small, informal gathering of pyro enthusiasts we used to be, and we must make appropriate changes to deal with the simple fact that our membership is above 500 and still growing.

As your club's leaders we are committed to moving the club forward in ways that effectively manage the needs of our ever expanding organization while preserving the character of the club as we know it. We have a great club, and we look forward to serving as your leaders as the club enters its second decade.

From the Vice President

by Greg Boyd

Members of the WPA:

Let me first thank all of you for electing me to the office of V.P. I will do my best to make the club everything that you would like it to be.

We on the B.O.D. would like to hear from all of you. Where would you like to see the club headed? Right now we are looking into holding two "Pow Wow events", if we can generate enough interest from the membership. These events will be held at the Avi Hotel and Casino in Laughlin, Nevada. As you may have heard, the Avi is located on the Fort Mohave Indian Reservation. The Indians are fireworks friendly and welcome us holding events there. In fact, the Indians have expressed interest in hosting the Winter Blast at the Avi. There are many potential benefits to holding club events at the Avi. We are looking at this situation closely, and we will be reporting back to you as soon as we have more information.

We are also working hard to organize many area meetings. Try to make it to one, if you can. It's a great place to get together to swap lies. The Southern California areas will soon be holding several meetings and building HDPE guns and racks for use at the Winter Blast and Pow Wows. We will inform you well in advance when these meetings will occur so that we can attract as many volunteers as possible. If you are willing to build mortars and racks on your own at just the cost of the supplies, please let us know so that we can order extra supplies. It's a great way to help the club while building yourself a set of HDPE guns.

Mike Workman has taken over as Communications VP. Let him know what you think of his first newsletter. Mike has created a regular section in the newsletter called "Workman's

(continued on page 6)

(Continued from page 5)

Comp Corner". In this section he will introduce formulae that we have tried and found to be worth reporting to club members. If you would like for us to evaluate one of your formulae, please contact Mike.

The newsletter is put together with articles about you and for you. It cannot happen without your input. Please submit articles to Mike. Your articles do not have to be fancy. ANYTHING that you find interesting is interesting to us.

The WPA Board of Directors looks forward to moving the club in directions that you, the club members, want to go. Please let us know what you want. We can all be reached by phone, letter or E-mail.

Greg Boyd, your new Vice President

From the Vice President for Communications

by Mike Workman

Dear Members,

This is our first Newsletter since the transition to a new set of officers for our WPA. I would like to thank all of you who contributed with articles, and with advertisements for making what I believe is an interesting and fun newsletter. Going forward, we will need to keep the flow of material at a high rate so that we can publish our newsletter more often.

For all of you camera bugs out there, please send me your pictures of the events you attend, or the events you instigate (legal of course). The officers are planning some fun get-togethers along with the leadership of some of our more active members like Kief Adler (pyro-stud). These should provide lots of good material we can have fun with. For Workman's Comp Corner, I would appreciate your inventions, or leads onto good formulae that you are willing to share with the membership. In this printing, we have contributions from some of the great folks of today's pyro community: Bill Bahr, Steve Majdali, Charley Wilson, and Guy Lichtenwalter. To all of you, thanks so much for your time, effort, and sharing of expertise. You make this hobby and profession a lot of fun for us all.

I personally consider it an honor to work with all of you. The folks at Iowa Pyro, Skylighter, and Firefox have kindly advertised in this newsletter, so consider stocking up from them at Fargo if you can. Your patronage comes back as support for your WPA (and our fun!).

Thanks for voting me into office at the business meeting in Lake Havasu at WWB #10. It was my first Blast and it certainly isn't my last if I have anything to say about it. Please send all the ideas and articles you can, and we'll put out the next newsletter much sooner.

Warm Regards,

Mike

VP Communications

From the Secretary

by Keath Nupuf

So... you would like to keep in touch with all of your WPA pyro friends during your off time. There is a great place to do this: the WPA internet e-mail list server. You can view the posts in two ways, "List Format" or "Digest Format". With list format, you will see every message posted to the group as it is posted to the group. With digest format, you get a single e-mail message at 5:30 pm PST containing all posts for that day. If you have an e-mail account and would like to take part in this great year-round club activity, send one of the following e-mail messages to: **list-admin@pyro.org**

To receive messages in list format, the message should be:

subscribe wpa-list you@domain.com

To receive messages in digest format, the message should be:

subscribe wpa-digest you@domain.com

(In both cases, you should replace "you@domain.com" with your email address.)

I will look forward to interacting with all of you in cyberspace.

Keath Nupuf
Secretary

From the Treasurer

by Glenn Vodhanel

1998 WPA Finances

Since my election in February, there has been quite a bit to do:

- Locating and obtaining the WPA financial records
- Entry of payment and deposit information starting from 1/98-present.
- Communication with our bank, Home Savings, to obtain missing bank statements and other detail.
- Sending letters to those whose checks were returned with insufficient funds.
- Reconciliation of bank statements
- Issuance of a formal request to the IRS to change our fiscal year to end March 31st rather than December 31st as previously adopted by the membership at our February 98-membership meeting.
- Review of all accounting transactions.
- Preparation of preliminary financial statements for review by our CPA
- Communication with our CPA to prepare our 1998 Federal Tax filing.
- Follow up with State of California and completion of our California non-profit filing.
- Receipt of returns from our CPA and review of returns for filing.

As of 12/31/98, we have $9,810 in association funds. With the above 1998 statement completed, these items remain:

- Prepare financial statements for our short accounting year of 1/1/99 to 3/31/99
- Provide board with a list of "members" who have yet to make good on NSF checks for suspension.
- Submit California non-profit application.
- File California tax returns
- Ensure association finances can easily pass audit muster.
- Arrange audit services for the period from 4/1/1999 to 3/31/2000.

(continued on page 9)

Below is the Western Pyrotechnic Association, Inc. financial statement for the year ending 12/31/98.

Income	
Interest Income	$195.52
Membership Dues & Assessments	$27,940.00
Special Events & Activities	$34,694.70
Total Income	**$62,830.22**
Convention Expense	
Advertising/Promotion	$3,030.92
Badge Holders	$2,025.62
Display	$10,150.17
Insurance-Display Liability	$3,797.50
Medical/Safety	$232.64
Miscellaneous	$1,750.00
Registration Supplies	$656.83
Communications	$987.50
Site Transportation	$100.00
Seminars	$2,582.35
Site Preparation	$3,291.77
Support Services	$3,753.08
Vendor Infrastructure	$1,409.90
Vendor Tents, Tables, Chairs, Etc	$3,454.71
Vendor Transportation	$1,700.00
Security	$1,925.00
Volunteer Incentives	$117.05
Room Comps	$1,114.91
Shirts, Mugs, Pins	$532.00
Total Convention	$42,611.95
General Operations Expense	
Advertising/Promotion	$823.00
Bank Service Charges	$94.63
Internet	$462.31
Telephone	$617.76
Legal Settlement	$10,000.00
Miscellaneous	$749.97
Office Supplies	$315.43
Corporation Filing Fee	$70.00
Taxes - Other	$125.00
Total General Operations	$13,258.10
Officer Stipends	$1,785.00
Printing and Postage	$5,775.03
Total Expense	**$63,430.08**
Net Loss	**$(599.86)**

(Continued from page 7)

The financial statement on page 8 reflects the categorizations based upon the records we received. I expect to present audit recommendations to the board for their approval to ensure that appropriate detail is obtained and retained.

Yes! There has been a lot of catch up to do! However, I am finally starting to see light from the end of the fusee. Ensuring the future of our association as well as other pyrotechnic associations is very important to me. It is a pleasure to be of service and I look forward to seeing you all soon.

Making Black Powder

by Charley Wilson

from the winner of the pyrogolf contest at WWB 10

CHARCOAL

The secret to fast black powder (BP) is the charcoal. The secret to the best charcoal for fast BP depends on three factors:

(1) the starting materials for pyrolysis
(2) temperature and duration of pyrolysis
(3) exclusion of oxygen

Even if you have a supply of excellent starting materials for pyrolysis, you can ruin it by not being careful with the temperature and duration of pyrolysis. Unfortunately, the literature about charcoal making in AFN and other pyrotechnic sources is all garbage. The AFN booklet "making charcoal by the retort method" is bad information. Commercial air float charcoal makes very slow BP.

So what is the big deal? Graphite. Graphite does not 'burn'. In fact, graphite is used as rocket nozzle material for high power rocketry. If you cook charcoal in an inert atmosphere for long enough and hot enough, it turns into graphite. In fact, the point at which reactive charcoal becomes unreactive is much closer to the incomplete pyrolysis of the material than most people think. Another aspect of the pyrolysis is to avoid oxygen. The retort must not allow fresh air. Air increases the ash percentage by burning part of the charcoal completely. I have tested charcoal from sticks that were obviously not completely carbonized, and from deep black crumbly sticks. The former is much faster than the latter. An interesting propellent that demonstrates this to an extreme was the 'cocoa powder' which was used around the time of the Spanish American war. The charcoal in this material is lightly charred straw. (See: Tenney L. Davis, *The Chemistry of Powder and Explosives*, for more details.)

An interesting but problematic phenomenon which occurs during pyrolysis (if you are not careful) is a thermal runaway. An exotherm can occur if the temperature is too hot and too much material is present. The best procedure that I have yet seen is a retort which is cooked in an electric kiln at exactly 540 °F (282 °C). Those of us who lack such esoteric equipment are left to try more artistic methods. One of these is the method that Guy Lichtenwalter uses: steel drums and paint cans.

My own method was devised to avoid the thermal runaway, and allows a regulation of the temperature to some extent. The retort can is a steel pet food can with the lid reinserted. Tabs are cut in the side of the can, which are then folded down over the lid. The sticks of wood are cut 1/2 inch shorter than the length of the can. The can should be packed tightly with sticks. The heat source, to get things going, can be a wood stove or an outdoor charcoal barbecue. Place the retort can in a circle of coals. Eventually, the destructive distillation will begin, and outgassing of the various products will ignite around the base of

(continued on page 10)

(Continued from page 9)

the can. This will be enough heat to complete the pyrolysis within about 30 minutes. When the flames stop, you are done. Don't leave the can in the heat. To improve economy, several of these cheap recycled retorts can be operated simultaneously.

Several people have me asked about the starting materials for making charcoal. A few East coast pyrotechnists swear that "maple" makes the best charcoal, and that is what GOEX uses. However, the literature *clearly* indicates that White Willow, European Alder and Alder Buckthorn were used in the heyday of black powder. Note that Elephant brand black powder is made from charcoal of the Umbauba tree from the fringes of the Amazon jungle in Brazil. Napoleon conquered Europe with Alder based BP.

Research indicates that many good BP charcoals may not have been available in the last century. Two that I have found are Narrow Leaf Cottonwood and Ailanthus. Red Alder, from the Northwestern U.S., also makes a very fast powder. Keep in mind that *none* of the species used and documented by the European powder makers (as above) are native to the U.S. The fastest powders tested in pyrogolf have been Black Willow (TD, GL and JF) Alder Buckthorn (JF) and Narrow Leaf Cottonwood (CW). The conclusion is inescapable: *all other things being equal, the largest difference between any two black powders is the charcoal used.*

PROCESSING

Now that you have completed the most important step – making high quality charcoal – you may go on to create high quality BP from your charcoal. The first thing you will need is a ball mill. A ball mill is a piece of equipment that every serious pyrotechnist should own. Lloyd Sponenburgh has published a monograph (*Ball Mill Theory and Practice*) that contains plans for construction of a mill. However, the Lortone and Thumler's rock tumblers work just fine, and both have the added advantage of using a hard rubber jar instead of Lloyd's PVC jars. For milling media, lead rifle balls can be used, but ceramic media obtained from Coors Porcelain also works well. Fisher Scientific sells a mill media called "Burundum" (FSC1237, cat no. 08-412-15B) which is very hard. (Also see: http://www.usstoneware.thomasregister.com/olc/usstoneware/stone6.htm)

Going by Lloyd's advice, the mill is filled almost half full with media. Then dry powder to be ground should be added to the point where media is barely visible when everything is settled in. The first order of business is to ball mill the charcoal down to air-float size. You may need to mash the sticks up beforehand to get it into the mill. Filling the mill completely to the top with charcoal sticks will result in a powder that takes less than 1/3 of the volume of the mill after 12 hours of milling. After 12 hours, the media are separated from the charcoal powder with a 12 mesh basket sieve. Before proceeding to the next step, take the time to wash and examine the media. This extra step ensures that the proportions of ingredients are correct. If you find pieces of dark brown partly carbonized wood in the sieve, these should be discarded.

The next step is to mill the sulfur and charcoal powder together. There are many varieties of sulfur that will work just fine, but for safety try to use those which are not acidic. "Flowers of Sulfur" or "Roll" Sulfur, which are often very acidic, can be used to make lift powder, but this powder should not be used for priming stars (especially chlorate-containing stars). For every three parts of charcoal, you need two parts of sulfur. For instance, if you created 240 gm of charcoal powder, then you need to mill that quantity with 160 gm of sulfur to give 400 gm of the charcoal/sulfur mix. The mix is milled for another 12 hours.

Finally, the charcoal/sulfur mix is milled with dry potassium nitrate powder, outdoors away from habitation. A 12 pound Lortone barrel will accommodate 450 gm of nitrate plus 150 gm of charcoal/sulfur mix to give 600 gm of mill powder. In any case, use 3 parts of nitrate for every 1 part of sulfur/charcoal mix. Again, the media should be cleaned and dried

(continued on page 11)

(Continued from page 10)

before this step. 12 hours is plenty of time for this run. The result of this step will hopefully be a precursor of black powder with the famous 75/15/10 (15/3/2) Waltham Abbey proportions of potassium nitrate, charcoal and sulfur.

One safety precaution that should always be followed is to clean the outside of the mill. At least one reported mill explosion was actually due to a leakage of powder, which ignited outside the mill jar and ignited the contents like a firecracker fuse.

PRESSING AND GRAINING

Perhaps the most misunderstood aspect of powder manufacture is the need for pressing. The reason that black powder manufacturers press their powder at very high pressures before corning is to create hard and durable grains of powder. This does *not* increase the speed of the powder. In fact, powder which is faster than GOEX can be made by simply dampening the mill dust with water, pushing it through a sieve, and then allowing it to dry. When dry, powder made in this fashion should be sieved for size just like any grained powder. It can be used as the "rough powder" called for in many projects. One sure sign of overcooked charcoal and/or high ash content is that powder made as just described literally falls apart.

Mill powder can also be coated onto rice hulls for filling shells. When coated 4:1 or 5:1 on rice hulls, the fastest powders can be used without any "augmentation" as burst in cylinder shells ≥4 inches and round shells ≥5 inches. A practical lift powder can also be made simply by dampening the powder with alcohol/water mix, and pressing pellets with an ordinary comet pump with hand pressure, then allowing the "comets" to dry for about a week. This powder will be the most efficient use of the powder for lift - and it is durable enough for this purpose - but it will not work as a roman candle propellent or rifle powder because the grains will not stand up to ramming.

The process of "corning" the powder – that is, breaking up the large pellets with a hammer – may be the most dangerous aspect of powder making. One technique for doing this is to make bags of heavy 4 mil or 6 mil polyethylene sheet. The large pellets are then placed in the bag and smashed with a 2-pound dead blow hammer. The contents of the bag are then passed through a 5 mesh sieve; that which remains is reintroduced to the bag and then corned again. Polyethylene may not be the safest material to use due to static. Cardboard has been suggested instead, and it is known that leather bags were used in the old days. The bag technique keeps powder dust under control to some degree. Whatever method is used, it is a good idea is to only corn small amounts (one or two pellets) at a time and to keep the sieved and corned powder in a covered container in a separate location.

The following powder grain sizes are the most convenient to make, since they are exclusive of each other:

Size	Mesh Size (passed/retained)	Typical Usage
1FA	–3 / +5	Lift for LARGE shells
2FA	–5 / +12	Lift for most shells (≥5" ball and ≥4" cyl)
4FA	–12 / +20	Lift for all small shells
	–20 / +36	Burst for small shells or glitter
	–36 / +100	Glitter
meal	–100	Re-wet and re-grain,or use where meal powder is called for

(continued on page 14)

(Continued from page 11)

FINAL OBSERVATIONS

The so-called CIA method or precipitation method has many adherents, mostly it seems from the inexperienced. Note, however, that no "CIA method" powder has ever won or come close to winning the pyrogolf event. The biggest drawback of the technique are losses and imprecision of the mix, not to mention the expense and mess. The method may have a safety advantage. However, if you live in an apartment or in a highly populated area, working with *any* pyrotechnic composition, much less black powder, is a bad idea.

The type of charcoal used is the largest single variable in the speed of the powder. The type of ball mill and milling technique is a distant second, and finally, pressing the powder to a high density decreases its speed.

Pyrogolf at the '99 WWB

by Guy Lichtenwalter

We teed-off at 3 PM Friday afternoon, in the oval at Sara Park. Due to the wind, the mortar was slightly angled into the wind. After a couple of test shots, it was agreed that two-gram loads would be used because it allowed the ball to land close to the mortar (which made it easier to time the flight). In previous pyrogolf events, 2.5 and 3.0 gram loads were used, but the conditions at Sara park were not suitable for these higher loads.

There were many more entrants than expected, which meant that the actual shooting didn't start until about 4 PM. Out of boredom, many spectators walked away while samples were screened and weighed. Due to the large number of BP samples, some people did not get all of their samples tested. A special thanks needs to be extended to David Martin and Charley Wilson for their efforts in screening and weighing the many BP samples. Also, thanks to everybody else who participated in this event.

A BP sample was poured onto stacked 10 and 12 mesh screens. Powder that passed through 10 mesh but which caught on 12 mesh screen was poured into a small plastic bag and labeled. This year, another data point was collected: the "relative density" of each powder sample. This was not the density of large, pressed pellets, but rather the apparent density of a sample of screened grains, which was determined by filling a 10 cc container with 10/12 mesh BP grains and weighing. The relative density is less than the density of pressed pellets because of the air between the grains, but it allows the density of one sample to be compared to another. After the density measurement, 2-gram samples of each BP were weighed into two plastic cups. A few BP samples received only one shot, but most had two shots.

As the shooting began, a plastic cup was selected at random and dumped into the top of the mortar. The fuse was lit and everybody with a stopwatch waited to hit the start button. The inside of the mortar was brushed between each shot and the fuse hole was occasionally cleaned. We were lucky that most of the balls landed within ~50 ft of the mortar. An assortment of used golf balls were weighed and found to vary by as much as 0.2 grams. Several weighing 45.5 ± 0.1 grams were selected, but only two balls were used for the competition. Both weighed 45.5 grams; one was lost during the event.

The mortar was made from a piece of seamed, automotive exhaust pipe. The ID of the tube was ~1.80 inches. An aluminum plug was made for the closed-end of the pipe. The part of the plug inserted into the pipe was cut with a 45 degree angle to resemble a funnel. In the center of this funnel shape, there was a cylindrical cavity about 0.72 in diameter and about 0.90 in deep. At the bottom of this cavity, a fuse hole was drilled. Powder poured into the top of the mortar therefore funneled into the cylindrical powder cavity. The golfball sat in the funnel-shape of the plug. The distance from the top of the golfball to the top of the mortar was 9.9 in. Data from this pyrogolf event are collected in Table 1 on page 15.

(continued on page 16)

Table 1. Data from Pyrogolf at the '99 WWB.

Entry	Raw Test Data (line 1 is shot 1; line 2 is shot 2)	Avg time (sec)	Grain density (gm/cc)
DM-1	4.29, 4.30, 4.18, 4.48, 4.17 5.47, 5.50, 5.47, 5.42, 5.34, 5.55	4.92	0.76
DM-2	3.01, 3.16, 3.03, 3.11, 3.18 4.00, 4.09, 4.01, 4.00, 4.05, 4.24	3.62	0.79
VFW-1	5.50, 5.34, 5.70, 5.20, 5.24 6.43, 6.29, 6.15, 6.24, 6.16, 6.18	5.86	0.87
VFW-2	7.02, 7.03, 7.70, 6.90, 7.17	7.16	0.88
VFW-3	5.50, 5.50, 5.50, 5.60, 5.39, 5.14 7.49, 7.51, 7.53, 7.58, 7.50, 7.72, 7.53, 7.52, 7.28	6.68	0.89
VFW-4	2.38, 2.33, 2.23, 1.99, 2.29 4.90, 4.84, 4.81, 4.74, 4.79, 5.03	3.66	0.87
CW-1	lost ball 9.96, 9.90, 9.96, 9.96, 9.75	9.90	0.61
CW-2	7.13, 7.15, 7.17, 7.17, 7.10 9.59, 9.59, 9.62, 9.72, 9.70	8.39	0.78
SH-2	4.14, 4.13, 3.85, 3.96, 3.93 6.90, 7.11, 7.18, 7.20, 7.04	5.54	0.70
SH-5	4.00, 3.13, 3.36, 3.23 3.90, 3.80, 3.66, 3.50, 3.89, 3.95	3.64	0.80
MC-1	6.59, 6.81, 6.25, 6.52, 6.60 6.55, 6.65, 6.37, 6.85	6.57	0.80
MC-2	7.71, 7.75, 7.80, 7.81, 7.76 8.15, 8.21, 7.98, 8.13	7.92	0.87
RH-1	3.33, 3.66, 3.29, 3.42, 3.04 4.51, 4.80, 4.70, 4.83, 4.78	4.04	0.65
RH-2	5.30, 5.40, 5.14, 5.23, 5.10, 5.22	6.08	0.62

Author comments about the data

1. It is interesting to note that the second shots for some powders recorded significantly higher numbers than the first shots. I was puzzled by this result and initially thought that it might be due to a slight rise in temperature of the mortar after the first shot. However, the mortar did not feel warm. After returning home, I took the mortar apart and found that the powder cavity had decreased in diameter due to the excessive residue left by lower-quality powders. In future pyrogolf events, it is might be worthwhile using a special cavity-cleaner between shots.
2. No Goex BP was tested, but all of the powders were as good, or better, than the one commercial powder that was tested (Elephant Brand). The one powder that I thought was the most interesting, belonged to MC. The performance of this powder indicates that "days" of ballmilling are not required for good quality BP.
3. There is no apparent correlation between the density of a powder and its speed.
4. Due to miscommunication, one shot for WFV-3 was really the second shot for WFV-2.

(Continued from page 14)

The following information was supplied by each participant about their BP:

DM-1 Lab grade KNO_3 was used, along with sulfur flour. White Alder charcoal, made in a retort, was used for this BP. The charcoal and sulfur were ballmilled for about 1 hour. The CIA precipitation method was used for this BP. After drying, the BP was ball-milled for 12 hours and then pressed into pellets. The density of this BP was 0.76 g/cc.

DM-2 Champion brand fertilizer KNO_3 and sulfur flour were used. Ailanthus tree charcoal was made in a retort and was milled with the sulfur for about 1 hour. The CIA precipitation method was also used for this sample, with the entire mixture being milled for 10 hours. The milled BP was then pressed at 2 tons for 30 minutes. After drying, the pellets were broken and screened to size. The density is this powder was 0.79 g/cc.

WFV-1 K-power fertilizer KNO_3 was used along with agriculture-grade sulfur. The charcoal was made from grapevine in a retort. All materials were ballmilled for 3 hours, then moistened and pressed into 3" diameter cakes. The cake density was 1.7 g/cc. (It's not known if this density is for the dry or wet cake.) The density was 0.8 g/cc.

WFV-2 The same KNO_3 and sulfur were used as for WFV-1. Charcoal was made from Fremont Cottonwood in a retort. The manufacturing process was also the same as WFV-1. The density was 0.88 g/cc.

WFV-3 The same materials and process as with WFV-1, except that the charcoal was made from weeping willow, in a small retort. The density was 0.89 g/cc.

WFV-4 The same materials and process as WFV-1, except California willow charcoal was used. The density was 0.87 g/cc.

CW-1 Service Chemical KNO_3 was used along with "Hi Yield" brand soil sulfur. This sulfur is stated to be 90% pure, but it appears to be much better than that. Handmade charcoal was used. For this sample, wood was obtained from Narrow Leaf Cottonwood trees which are native to the western United States. The initial interest in using this tree was sparked by the strong physical and biological similarity between this tree and both Black and White Willow, long regarded as the best source of charcoal for fast black powder. The wood was made into short sticks with the bark removed, and cooked into charcoal in a very small retort in a wood stove. The retort was made from a discarded large Alpo brand dog food can, approx 3" in diameter and 5" high. Tabs were cut in the wall at the open end of the can. The sticks of wood were cut 1/2" shorter than the height of the can. The sticks were packed tightly into the retort can, and the lid was dropped into the open end. The tabs were then folded down over the lid to hold it in position. The retort was placed into a stove with the vented end pointing down. Each batch was cooked for approximately 30 minutes, which is ususually long enough for the outgassing and flames to die down. The charcoal was first ball milled by itself in a 12 pound Lortone rock tumbler filled nearly half full with ceramic milling media obtained from Coors Porcelain Co. The charcoal was then milled with the sulfur in the 3:2 ratio by weight. Both runs were allowed to go

(continued on page 17)

(Continued from page 16)

for 12 hours. Finally, 150 gm of charcoal/sulfur mix were combined with 450 gm of potassium nitrate and milled for 24 hours. This is much more milling time than is truly necessary, and it makes little difference to the powder strength. To obtain a higher density and higher burn rate, the powder was dampened until it reached the clumping state (in a stainless steel bowl) and then pumped with firm hand pressure in an ordinary 1 inch star pump. The damp composition compresses by more than 25%. The powder "pucks" were allowed to dry for one week before they were corned and grained to pass 5 mesh. The density was 0.61 g/cc.

CW-2 The same KNO_3 and sulfur as with CW-1. The charcoal for this sample was made from Carolina Buckthorn, which is a native American species of Buckthorn. It is very similar in charcteristics to the Alder Buckthorn "Dogwood" used by the British to make Black Powder. Processing was identical to that used for CW-1. The mill powder was prepared as described above for CW-1. This powder was dampened slightly and then pressed in a 2.5 inch aluminum die using a 6 ton hydraulic press. The powder pucks were allowed to dry for more than one week. Pucks were corned by smashing with a two pound dead blow hammer between sheets of heavy polyethylene. The powder was sieved to –5 mesh and +12 mesh for this test. Grains were very hard and durable. The density was 0.78 g/cc.

SH-2 K-Nit fertilizer KNO_3 was used along with CSC dusting sulfur. The charcoal was made from hemp hurds. SH claims he did not smoke the leaves to obtain the hurds. The 75:15:10 ratio was used. The materials were milled together for 12 hours and then pressed (2 tons) into pellets, which were broken with a dead-blow hammer. The density was 0.70 g/cc.

SH-5 The same chemicals and process used with SH-2 were used for this BP, except that Aspen charcoal was used. (It is assumed that this is retort – made charcoal.) The density was 0.80 g/cc.

SH-1, SH-3, SH-4 and SH-6 were not tested.

MC-1 Pyro-grade KNO_3 and a pyro-grade sulfur were used. The charcoal was made in a retort from Sandbar Willow. The charcoal and sulfur were ball-milled together for 12 hours. Then, 25% of the KNO_3 was added and milled for another 12 hours. The remaining KNO_3 was then added and ball-milled for 15 minutes. The powder was then pressed in a 1" comet pump with a 2-ton arbor press. The interesting aspect of this powder is that the period of "high-risk" is reduced to 15 minutes, as compared to several hours. The density was 0.80 g/cc.

MC-2 Everything from MC-1 was also used for this BP, except that the charcoal was made from Red Pine (Loblolly). The density was 0.87 g/cc.

RH-1 K-Power fertilizer KNO_3 and farm sulfur (98%) were used. The charcoal was made from White Willow in a retort by RH. Materials were milled as 2 parts and then the precipitation method was used. The BP was then granulated. RH didn't indicate any pressing, but I think the powder was pressed because its density was 0.62 g/cc.

(continued on page 18)

(Continued from page 17)

RH-2 The same chemicals and process used for RH-1 were used for this BP, except that Driftwood of unknown origin was turned into charcoal in a retort. The density was 0.62 g/cc.

StHi-1 K-Power flowable KNO_3 was used along with Skylighter sulfur. Perley Willow charcoal was used. The materials were milled for 3 hours. This powder had a density of 0.89 g/cc.

MB-1 All chemicals were obtained from Skylighter. The CIA precipitation method was used. A 2 kg batch of powder was made and precipitated with 600-700 mL of –10 °F denatured alcohol. The BP was then granulated, dried and ball-milled for 72 hours. This milled powder was moistened with water/alcohol and granulated through a window screen and dried. This material was smaller than 12 mesh.

MB-2 This powder used the same materials as MB-1. A 1 kg batch was made by the precipitation method using 400 mL of denatured alcohol at 0 °F. After drying, the BP was milled for 48 hours and then processed through a screen as with MB-1. No density numbers are available.

Elephant Brand Cannon grade BP from a 1 pound can. No density numbers available.

A Round Star Planning Guide

by F. J. Feuerwerker

The production of round stars with good size uniformity is critical for the construction of spherical shells with multiple-effect stars. The techniques for making round stars are well described in the popular pyro literature,[1] but one important aspect of the process is rarely addressed: how does one determine the number of cores to use and the amount of dry composition required to make a finite number of stars of the proper diameter? This is a serious issue if the quantity of chemicals on hand is limited or if magazine space for components is limited.

When it comes to making relatively small quantities of round stars, a little planning can avoid many potential problems. As outlined below, it is relatively easy to estimate both the number cores needed and the amount of composition that must be prepared ahead of time. These estimates will be relatively crude, but they are especially helpful when it comes to producing a limited number of round stars for a small number of shells.

Estimating the number of cores required

Ideally, one core is required for each round star to be produced. Estimating the number of cores is therefore equivalent to estimating the number of stars. For a single layer of stars aligned along the inner surface of a spherical shell, the number of stars required is given by equation 1, where d is the diameter of the star and D is the inner diameter of the shell case.[1,2]

$$N = 3.63\,(D/d)\,[(D/d) - 2] \qquad \text{(Equation 1)}$$

For "Poka" shells, where stars are usually dumped into one hemisphere of a ball casing and "Italian-style" shells, where stars are loaded into a hollow cylindrical shape.

(continued on page 19)

(Continued from page 18)

similar relationships between N, d and the shell dimensions can be derived. Assuming that the stars settle into a "closest-packed" arrangement, the number of stars required to fill a ball-shell casing is given by equations 2a and 2b; the number of stars required to fill a cylindrical shell is given by equation 3.

$$N = 0.74 \cdot (D^3 - B^3)/d^3 \qquad \text{(Equation 2a)}$$

where D is the inner diameter of the ball shell casing, B is the diameter of a spherical burst core (or inner pistil) and d is the star diameter

$$N = 0.74 \cdot [D^3 - (6F/\pi)]/d^3 \qquad \text{(Equation 2b)}$$

where D is the inner diameter of the ball shell casing, F is the total volume occupied by a flash bag and d is the star diameter

$$N = 1.11 \cdot L \cdot [(D^2 - C^2)/d^3] \qquad \text{(Equation 3)}$$

where D and L are the inner diameter and length of the shell casing, C is the diameter of the burst core, and d is the star diameter

Equations 2 and 3 will generously over-estimate the number of stars required because a closest-packing arrangement is almost never achieved during shell construction. Keep this in mind when you are tempted to make additional stars to avoid running out.

Estimating the amount of composition required

If you know the number of stars required, the initial diameter of your cores, the final diameter of your stars and the specific gravity of your composition in the finished star, it is relatively easy to estimate the amount of dry composition required. Table 1 lists the amount of dry composition that must be prepared in order to enlarge 100 stars, assuming that the specific gravity of the composition in the finished star is 1.00 gm/cc. For example, the last column in the first row of data indicates that 2896 gm of composition are required to produce 100 stars with a diameter of 1.50 inches if the initial diameter is zero. If the initial diameter is 0.75 inches, "only" 2534 gm of composition are required (assuming that the specific gravity of the composition in the finished star is 1.00 gm/cc).

Most star compositions have a specific gravity greater than 1.0 gm/cc. If you do not know the specific gravity of your composition, it is normally possible to estimate it by finding a similar composition in Shimizu's book.[3] Somewhat surprisingly, the specific gravity of many popular compositions are not provided by Shimizu. In particular, there are no data for charcoal spider or glitter compositions. Using the procedure outlined below, the author has determined the specific gravity of Chrysanthemum #6 (1.33 gm/cc) and Winokur's #39 glitter (1.49 gm/cc). These values are good places to start for estimating the specific gravity of other charcoal and glitter formulae.

To determine the amount of dry composition to prepare, simply multiply the appropriate number from Table 1 (pg 20) by the specific gravity of your composition and the number of stars required divided by 100. For example, if your colored cores have an initial diameter of 3/16" and you wish to prepare 900 stars with a final diameter of 5/8" by coating with #39 Glitter, the amount of composition required is: 204 x 1.49 x (900/100) = 2736 gm.

It is worth noting that the amount of composition required to enlarge a core increases very rapidly as the final diameter increases. This has many practical implications, including

(continued on page 21)

Table 1. Mass of composition (in grams) required to enlarge 100 round stars.
(The specific gravity of the composition in its final form is assumed to be 1.00 gm/cc.)

INITIAL DIAMETER (inches) \ FINAL DIAMETER (inches)	0	1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1.00	1.125	1.25	1.375	1.50
0	0	0.2	0.7	1.6	3.2	5.6	9	13	20	45	72	107	153	209	279	362	460	575	707	858	1222	1676	2231	2896
1/16		0	0.5	1.5	3.1	5.4	8.8	13	20	45	72	107	153	209	279	362	460	575	707	858	1221	1676	2230	2896
3/32			0	1	2.8	4.9	8.3	13	25	45	71	107	152	209	278	361	460	574	706	857	1221	1675	2230	2895
1/8				0	1.6	4	7.3	12	25	44	70	106	151	208	277	360	459	573	705	856	1220	1674	2229	2894
5/32					0	2.4	5.7	10	23	42	69	104	149	206	276	359	457	572	704	855	1218	1673	2227	2893
3/16						0	3.3	7.8	21	40	66	102	147	204	273	356	455	569	701	852	1216	1670	2225	2890
7/32							0	4.4	17	36	63	98	144	200	270	353	451	566	698	849	1213	1667	2222	2887
1/4								0	13	32	58	94	139	196	265	349	447	561	694	845	1208	1662	2217	2882
5/16									0	19	46	81	127	183	253	336	434	549	681	832	1195	1650	2204	2870
3/8										0	27	62	107	164	234	317	415	530	662	813	1178	1631	2185	2851
7/16											0	35	81	138	207	290	388	503	635	786	1150	1604	2159	2824
1/2												0	45	102	172	255	353	468	600	751	1114	1569	2123	2789
9/16													0	57	126	209	308	422	554	705	1069	1523	2078	2743
5/8														0	69	153	251	365	496	649	1012	1466	2021	2686
11/16															0	83	181	296	425	579	943	1397	1952	2617
3/4																0	96	213	345	496	860	1314	1869	2534
13/16																	0	115	247	396	761	1215	1770	2436
7/8																		0	132	283	647	1101	1656	2321
15/16																			0	151	515	969	1524	2189
1.00																				0	364	818	1373	2038
1.125																					0	454	1009	1674
1.25																						0	565	1220
1.375																							0	685
1.5																								0

(Continued from page 19)

the fact that the final diameter of a large star is about the same for compositions with specific gravities differing by as much as 20%. Table 1 on page 20 lists exact numerical solutions; for most purposes, the level of precision implied by the number of significant figures is unnecessary.

Helpful hints and other information

1. Cut or pumped stars work well as cores for small batches of round stars. For most purposes you can assume that the dimensions of these cores are equivalent to the diameter of a sphere. Nevertheless, it is easy to determine the diameter of a sphere with the same volume as your cut or pumped stars. Purists who want to use this diameter with Table 1 should use the following conversion factors, which assume that cut stars are cubes and pumped stars are cylinders with equal diameter and length)

   Cube to Sphere conversion: sphere diameter = cube edge length x 1.24
   Cylinder to Sphere conversion: sphere diameter = cylinder length x 1.14

2. It is relatively easy to determine the specific gravity of your favorite star composition:

   (a) Prepare a batch of stars using the lightest, smallest cores available.

   (b) Place as many stars as possible into a small "graduated cylinder" (a 50 cc graduated cylinder with 1 cc markings works especially well).

   (c) Add clean, fine sand to the cylinder. Tap it to be sure that there are no air pockets. Make sure that the stars are completely covered with sand, then note the total volume (in cc) occupied by the stars and sand; this is Vtot.

   (d) Empty the contents of the graduated cylinder into a clean bowl. Pour the sand back into the cylinder and note the volume occupied by the sand; this is Vsand. The volume occupied by the stars, Vstars, is (Vtot – Vsand). Weigh the stars (in grams); this is Mstars.

   (e) The apparent specific gravity of your stars in gm/cc equals Mstars divided by Vstars. If the mass and volume of your cores are negligible compared to the mass and volume of composition in the star, this is also the specific gravity of your composition. If your cores are relatively large or heavy, you should measure their mass and volume using the procedure outlined above. The specific gravity of your composition is then (Mstars – Mcores) divided by (Vstars – Vcores).

References

(1) D. Bleser, *Round Stars & Shells*, American Fireworks News, Dingmans Ferry, PA, 1988.

(2) T. Shimizu, *Fireworks from a Physical Standpoint*, Part III, pg 143, Pyrotechnica Publications, Austin, TX, 1985 (English Translation by A. Schuman)

(3) T. Shimizu, *Fireworks: The Art, Science and Technique*, Pyrotechnica Publications, Austin, TX, 1988.

Workman's Comp Corner

by Mike Workman

Featured is this issue: Bill Bahr's Crossette Formulae

In February of this year, the Crackerjacks had a Pyro-outing in which Bill Bahr presented a seminar on crossette comets. For those of you who aren't aware, the Crackerjacks are an organization similar to the WPA but they are located on the East coast. Presently, our PGI president is also the president of the Crackerjacks. Good ol' Snerd (Harry Gilliam of Skylighter) is the Vice President of the Crackerjacks. Tom Handel, the Crackerjacks VP of Publications, has kindly agreed to send me their Newsletter (The Passfire) in exchange for ours. The March edition contained some interesting crossette formulae, a few of which were new to me. Bill's formulae are listed below, where the proportions are give in parts by weight (not percent).

Gold Glitter

Potassium Nitrate	51
Charcoal (Air Float)	19
Antimony Sulfide	12
Atomized Aluminum (12 μ)	9
Barium Carbonate	5
Dextrin	4
Boric Acid	7
Magnalium (50:50, 60 mesh)	2.5

White Glitter

Potassium Nitrate	50
Charcoal (Air Float)	13
Sulfur	9
Antimony Sulfide	16
Atomized Aluminum (12 μ)	8
Dextrin	4
Boric Acid	7
Magnalium (50:50, 60 mesh)	2

Note: Water used to dampen these glitter mixtures may be saturated with boric acid. At 25 °C (77 °F), approx 30 grams of boric acid are required for 500 mL of water.

Tiger Tail

Potassium Nitrate	44
Willow Charcoal	44
Sulfur	6
Dextrin	6

Red

Strontium Nitrate	28
Potassium Perchlorate	24
Aluminum, American Dark	16
Aluminum, Course Flitters	15
Parlon	12
Dextrin	5

Blue

Black Copper Oxide	30
Potassium Perchlorate	22
Aluminum, American Dark	16
Aluminum, Course Flitters	15
Parlon	12
Dextrin	5
Boric Acid	5

Flash Powder for Breaking Comets

The author prefers to use a 7:3 (by wt) mixture of potassium perchlorate and dark aluminum powder to break crossette comets. Bill adds an additional part of antimony sulfide.

Note: This blue comp may heat up, especially when wet and contained or pressed. Assume that it will be a problem and take all necessary precautions: (i) only produce small quantities; (ii) dry and store product in cool, isolated areas; and (iii) watch carefully for signs of decomposition.

The Pyrotechnic Bee

by Steve Majdali

What are bees? A bee (in the pyrotechnic sense) is a small device that spins and propels itself, usually with a distinct "zing"or buzzing sound as it goes. Bees are typically used as an insert in a shell, mine or shot from a candle. They are easy to make but labor intensive. Pressing is the preferred method of assembly but they may be effectively produced by simple hand ramming using a drift and mallet.

Materials:

Tubes: short, thick-walled, convolute tubes are used. Typical size is 5/16" ID x 9/16" OD x 1" long.

Clay: dry, powdered fireclay or similar material is used to plug the ends.

Black match: usually a specially made material about 3/32"diam. used to convey fire to the composition. Visco safety fuse may be used if cut short and properly primed.

Composition: as per the following section.

Composition:

Either commercial meal powder or a fast-burning hand mixed black powder. If the hand mixed powder lacks power, a percentage of FFFg rifle powder can be substituted for part of the total mixture.

hand mixed black powder (parts by weight percent)

	1	2	3
KNO_3	75	75	53
Airfloat Charcoal	15	12.5	10
Sulfur	10	12.5	7
FFFg	–	–	30

Tools:

A flat plate of steel, brass or aluminum with a minimum thickness of 3/4". A flat-ended rammer of brass or (non-sparking) stainless-steel is used to consolidate the charge of clay or composition in the tube. A scoop is useful to charge the tube between presses.

Method of Assembly:

The first step in manual assembly is to place the tube, open end up, on a ramming (press) block or plate. Next, charge the tube with enough clay and press with heavy pressure to leave a 1/8"-3/16" plug. Using the rammer as a gauge, mark the outside of the tube where the clay and composition meet. Now press small increments of composition with heavy pressure, taking care not to rupture the casing, till the composition is about 1/4" from the top end of the tube. Fill the remainder of the tube with fireclay and press to finish.

The device needs two 3/32" thrust ports to function properly, one drilled through the bottom, center of the first clay plug and slightly into the composition. The next through the tube, just above the first clay plug, tangential to the composition so as to cause a spinning motion during the burn. This second port takes the special match for ignition of the device. A small dab of prime may be used to secure the match if necessary.

CAUTION: If titanium or any metal is added for variety, a real danger of ignition during the drilling phase exists. For safety, be certain NO metal is used in the first increment or two. Also, no more than 2% to 5% titanium should be used. More than this increases the risk of ignition during assembly, especially when pressing with heavy pressures.