Medieval Gunpowder Research Group

Firepots and Fire Arrows

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Introduction
The Ho Group, dedicated to the investigation of medieval gunpowder, met in August 2009 to continue the work started in 2008 experimenting with medieval and early modern incendiary devices. The aims of the meeting were, first, to continue working with fire arrows and the means to ignite them and to investigate and second to attempt a reconstruction of the fire pots as described by Biringuccio in his book *Pirotechnia*.

Fire arrows
In 2008, the Ho Group had tried to make fire arrows in three different ways from the recipes given by Johannes Bengedans in his *Firework Book* of the 1440s. Of the three recipes tried only one was found to work and it was this recipe and method which we decided to try again.

> *Take some fustian or linen and make a small bag - 1 big inch wide, 3 fingers long. Take 5 pound good saltpetre and apply 2 pounds of sulphur. Add 1 pound finely crushed coal, 2 lod camphor and 1 lod amber. Mix it all with alcohol. Fill the bag and press it tight together. Take the iron tip and press it through the bag. The bag is secured with string.*
> *Take 2 pound sulphur, 1 pound resin and ½ pound normal pitch. Let it melt over the fire – put the arrow into it.*
> *When firing the arrow, the bag should be opened a bit on the front and set on fire.*

A 5:2:1 mixture of fine gunpowder was made following this method but omitting the camphor and the amber, both of which were in such small quantities as to be virtually non-existent. Small cloth bags were made, filled with powder, the arrow pushed through them and the ends of the bag secured to the arrow with string. String was then wound spirally round from end to end the bag pulling it tightly to compress the powder. Finally a mixture of sulphur, pine resin and pitch in the ratio 4:2:1 (2:1:½), was heated till molten and used to coat the bag of powder as described in the original text. On cooling this formed a hard, black coating.

The problem was just how to ignite the head at the point of impact at the target. Experiments in 2008 had shown that the contents of the bag burned very powerfully and relatively quickly so that it was necessary that it was not ignited till it reached its target indicating that some from of fuse was necessary. If the instructions from Bengedans were followed the arrow burned through before it reached its target. Some form of fuse was needed. Other recipes in Bengedans suggested that the arrow was ignited with a small coal but again this would have resulted in the arrow igniting prematurely.

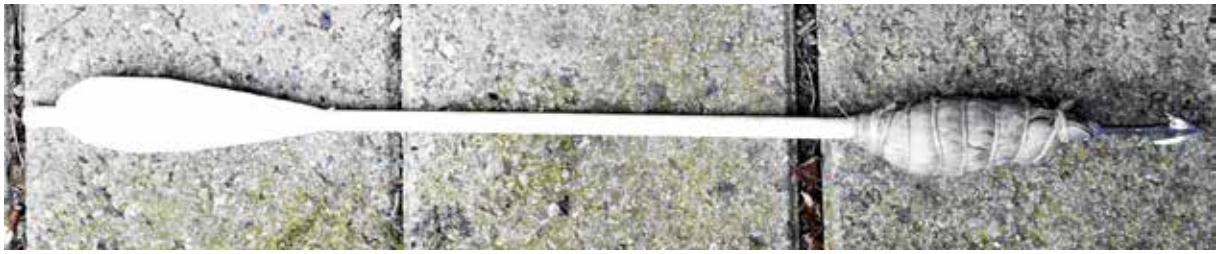
After some discussion we decided to use a tried and tested fuse method – soaking a cotton cord in a solution of saltpetre. This technique is described very well in the *Pirotechnia* of Biringuccio:

> *…a good thick fuse of twisted cotton that has been boiled in vinegar, sulphur and saltpetre, then wrapped and covered well with good gunpowder and dried in the sun*

We used a cotton cord approximately 5mm in diameter and soaked this in a solution of saltpetre in vinegar. Though Biringuccio does not specify the amounts, we made up a super saturated solution of saltpetre – essentially adding more saltpetre than will actually dissolve. The cord was immersed for about 10 minutes and then hung out to dry. Two separate types were made – one just soaked in the saltpetre and another soaked in saltpetre and then rolled in fine blackpowder while still wet. Once dry they were tested to see how they burned. On applying a

light to the example rolled in blackpowder the coating burned very quickly while that without the coating burned at a relatively slow and consistent rate. It was felt that the very fast burning of the coated fuse would result in premature ignition of the arrow head so that in all the tests subsequently carried out we used the uncoated fuse.

A fire arrow from Johannes Bengedans



Our copy of the Bengedans arrow with the bag full of powder attached

Detail of gunpowder bag tied with string

We then mixed sulphur, pine resin and pitch together in the ratio 4:2:1, heated it till molten and coated the bag of powder as described in the original text. On cooling this formed a hard, black coating.

The completed fire arrow

Firing trials

The arrows were fired from a simple, modern crossbow mounted on a stand. A slit was made in the front of the bag of powder and a short piece of the fuse inserted. The fuse was lit and the arrow fired. The first shots had a range of just over 30 metres, though this would, of course, be dictated by the crossbow being use. We also tried firing at a simple wooden target set at 20 metres and 15 metres range.

The arrow set onto the crossbow

Setting light to the fuse

The arrow struck the target but it was usually several seconds before the fuse burnt down and the incendiary in the arrow caught fire. The mixture then burned very fiercely, the hard outer coating forcing the flames forwards towards the target making an extremely effective weapon – the intense flame would set light to whatever it had struck.

The flame from the burning incendiary was directed towards the target by the hard coating around the arrow

Although it is impossible to be sure that we had reproduced a medieval fire arrow accurately we felt that we had, at the very least, understood the basic parameters.

- The incendiary mixture was based on a gunpowder recipe
- The hard, outer layer ensured that the full effect of the incendiary was directed at the target
- The arrow did not burn in flight but used a short length of fuse
- The burning time for the mixture was between 5 and 100 seconds

The test firings are summarised below.

Test results

Arrow number	Weight of powder bag - grams	Range metres	Notes
1A	110	35	Test firing and fired unlit Fired unlit – into the wind – not at a target. Spun slowly in flight and quite erratically. Result on the bag was that the coating broke up at the front and it was loosened and moved forward along the arrow about 1 cm
1B	110	37	Arrow buried in ground – it almost stopped smouldering but then burned throwing a jet of flame forward
2A	85	38	Fuse went out – coating cracked on impact
2B	85	39	Arrow started to burn as it left the ballista and burned during flight
3	150	33	Fired with fuse alight – did not burn till a few seconds after landing. Then burned with jets firing forward – lots of sparks and smoke
4A	115	37	Fired with 5 cm fuse but the fuse went out and did not burn. Coating slightly cracked
4B	115	38	Fired again but again did not light
4C	115	14	Fired again but it ignited while still on the ballista and continued burning. Burned very fast – bag ended up at rear of arrow
5A	145	34	Fired – spun with distinct wobble but failed to ignite – fuse had gone out
5B	145	34	Fired again – fuse unbraided a little – ignited almost immediately on impact with a big WOOF and burned very fast
6A	114	20	Arrow hit the ground in front of the target and bounced to hit target at bottom. Seal broke and bag moved forward
6B	114	20	Arrow was alight when it left ballista and missed target completely going to left. Bag burned for quite a long time
7	125	15	Flight erratic but hit target and burst into flame throwing jets forward and burning for several seconds.
8	110	15	Ignited on ballista at point of firing. Jets of flame thrown forward
9	120	15	Burned really well after embedding itself in the target

Firepots

The second group of experiments were an attempt to reconstruct fire pots. Biringuccio describes how these were made:

> *Take the number of vessels that you have to make – it does not matter whether they are raw or baked as long as they are well freed from the moisture of the clay – and fill them a little more than half full with coarse gunpowder which has mixed in it pounded Grecian pitch and at least a third of crushed sulphur. The pour in a covering a dito thick of strained pig fat mixed with powder. This keeps it from falling out when it is thrown and keeps the fire slower until it reaches the enemy. When this has been made, open up the pig fat a little at one side when you wish to throw it and put in a little fuse or a little good powder and apply fire, holding it in your hand until you see that the fire has taken hold well. Then throw it, choosing your time.*

In the accompanying illustration of the fire pots he is describing, the fuse to ignite them is clearly visible. Intriguingly it is also clear that a fire pot could be thrown using a sling.

In addition to this description and illustration we have some surviving fire pots in the collection in Veste Coburg in Germany. These are now empty and have four loops in which are preserved pieces of fuse.

Fire pot from Coburg (Kunstsammlungen der Veste Coburg, Bavaria, Germany)

For our experiments we decided to copy the pots from Coburg and try to fill them with the mixture given by Biringuccio. We carried out a number of trials as it was unclear just how the mixture was made up. Was the sulphur to be mixed with the gunpowder and pitch or was the gunpowder and pitch mixture separate, filling half the pot, and the sulphur on top of that? Just how much powder should be mixed with the fat?

The first experiments used coarse gunpowder mixed with pitch, crushed to the size of peas, and crushed sulphur. We then covered this with a layer of fat mixed with its own weight of fine, meal powder. After some discussion we tried both making the fat liquid, by gentle warming, as well as in the solid state. After a series of small scale experiments it was found that the mixture 'exploded' with a ball of flame and lots of smoke but that the overall effect was quite ineffective. We also tried using a small pot half filled with the powder/pitch mixture and then adding sulphur on top but this did not work at all.

After some discussion we tried a mixture of meal powder, pitch and sulphur covered with a layer of fat. We also added a thin layer of the main mixture on top of the fat instead of incorporating it into the fat. This worked very well indeed burning relatively slowly. Finally as a check we substituted a coarse powder and found that this burnt very quickly.

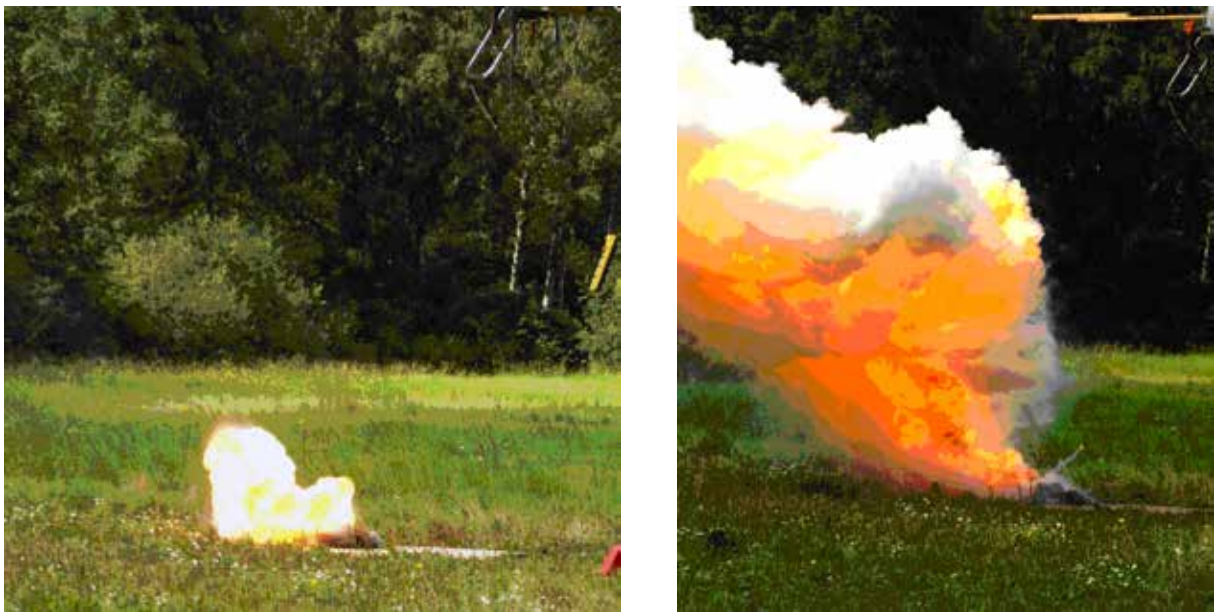
For our trials we made up pots consisting of a mixture of 500g meal powder, 1000g pitch and 250g sulphur covered with a layer of fat with a thin layer of the same mixture.

Firing trials

For safety reasons we set up a rig which held the pot at about 5 metres above the ground. Using a remote trigger the pot then fell to the ground.

The rig used to drop the fire pots

All the trials were successful but the mixture seemed, to us, to burn too quickly – in just a second or two. Biringuccio implies that the mixture should burn quite slowly – 'apply fire, holding it in your hand until you see that the fire has taken hold well. Then throw it, choosing your time.' Certainly as an incendiary it would very little damage except to its immediate surrounding and that, unless where it landed was very flammable, its effects would not be great.



When the fire pot hits the ground it burst into flame but this only lasted for a few seconds

Test results

Firepot number	Fuse	Notes
1A	3 pieces of slow match	Dropped onto a wood panel and did not break
1B	3 pieces of slow match	Dropped again with the same fuses onto stones Broke and burst into fire – burned very quickly with a lot of smoke – spread 1.7 x 1.3m
7	3 pieces of slow match	Dropped from 4.5 m Burnt relatively slowly with a great deal of flame
6	Electric ignition	Dropped from 4.5 m Top layer was burning when it was dropped Lots of orange flame and little smoke
5	Electric ignition	Dropped from 4.5 m Top layer was burning when it was dropped. Pot did not break – like a flame thrower
4	Electric ignition	Dropped from 4.5 m Top layer was burning when it was dropped. Burnt with prolonged orange flame
2	2 pieces of slow match	Small orange ball of flame and large FWOOF
	2 pieces of slow match	Dropped from a low height (approx 3.5m) and did not break
	2 pieces of slow match	Burned very fast with large whitish cloud of smoke

Conclusions

Our experiments with fire arrows leave us to believe that we have managed to come close to replication of medieval fire arrows.

The results with fire pots were less satisfactory and the Group felt that their replication was not accurate. In particular the mixture burned too quickly and some work is needed to slow the burning rate to make a more potent and effective weapon.

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