A Treatise

on

Gunpowder

By

Frederick Drayson

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Containing an exact description of every building and utensil and of every process followed in refining nitre and sulphur, charring wood, manufacturing them into gunpowder, regenerating damaged gunpowder and extracting saltpetre from unserviceable gunpowder at the Royal Gunpowder Manufactories with a plan geometrical section and Perspective views of the interior of each building and a Drawing of the utensils used therein; also containing observations and remarks upon each building and proofs showing when and what improvements may be made in the same and a Report upon the Royal Gunpowder Manufactory of Waltham Abbey with plans for its repair extension and improvement.

By

Frederick Drayson

written for the

Honorable Board of Ordnance

by their authority dated

13th August 1830

For the sake of clarity and in order to treat upon each subject separately this work is divided into three parts.

Part 1st Contains the descriptions of the different buildings and utensils and of the processes followed in refining saltpetre and sulphur, charring wood and manufacturing them into gunpowder regenerating damaged gunpowder and extracting saltpetre from that which is unserviceable.

Part 2nd Contains the observations and proposed improvements in the different buildings, utensils and processes described in the first part.

Part 3rd Consists of a report of the present state of the Royal Gunpowder Manufactory of Waltham Abbey, with plans for its repair, extension and improvement.

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Royal Gunpowder Manufactory of Waltham Abbey

A Treatise on Gunpowder

Part the First

On the Component Parts of Gunpowder.

Gunpowder is an explosive propellant compound composed of saltpetre, charcoal and sulphur.

Saltpetre or nitre is a combination of nitric acid with vegetable alkali but is never found pure, being contaminated with other salts and earthy matter and is totally unfit for gunpowder until it has been refined.

Charcoal and sulphur are simple combustible substances the former consisting of the woody fibres of willow, alder or any other vegetable matter, the volatile part being driven off; the latter is a production of nature chiefly abounding in volcanic countries and in manufacturing these ingredients into gunpowder at the Royal Gunpowder Manufactory of Waltham Abbey they undergo the following processes.

Process of Refining Saltpetre or Nitre

The buildings in which this operation takes place are called Nitre refineries. There are two Nitre Refineries at Waltham Abbey, one capable of refining 640 and the other 320 tons of nitre per annum by the process after mentioned. Each refinery consists of a boiling house, a crystallising house, and a melting house, the following explanation of the buildings relates to the latter refinery and the description of the process will apply to either.

The Boiling House is the first building used in this process, and is built of brick similar to the drawing numbered 1, using louvered vents in the roof to let off the steam and tanks under the floor for receiving the liquors poured from the different crystals. In this building there are 2 copper boiling pans marked A, for boiling the grough saltpetre and crystals from the first and second boilings, 2 cast iron evaporating pans marked B, for boiling the liquor poured from the three crystals, a cast iron boiler called the foul pot marked C, for boiling the refuse salts and water from the first evaporating pan, and a small copper for hot water marked D.

Utensils used in the Boiling House and shewn in the drawing numbered 3.

A, A copper boiling pan capable of holding 540 Gallons of water, it is used for boiling the grough saltpetre and the first and second crystals.

B, A cast iron evaporating pan capable of holding 280 gallons of water, it is used for boiling the liquor poured from the 3 crystals.

C, a cast iron boiler called the foul pot capable of holding 370 gallons of water, it is used for boiling all the foulest liquors.

a, A false bottom made of deal 1½ inch thick, with an iron ring round both sides to toughen it, perforated with a number of small holes 4 inches apart , and half an inch in diameter. This false bottom is placed there to prevent the grough saltpetre and crystals that are put in upon it, from burning to the bottom of the copper boiling pan A.

b, A skimmer used for skimming the liquor in the copper boiling pans A, it is made with an iron ring about 1½ inch deep, having one side covered with cloth in the form of a sieve.

c, A copper pump 5 feet long with a 6 inch bucket, it is used for pumping the liquor out of the copper boiling pan A, into the trough d.

d, A deal trough 4 feet 8 inches long, used for conveying the liquor from the copper pump c, to the filtering trough e.

e, A filtering trough and stand 8 feet 8 inches in length, 1 foot 2½ inches in width, and 10½ inches in depth, having four brass cocks and two filtering bags made of Russia duck attached to each cock.

f, A copper pouring pan capable of holding 2 7/8 gallons, into which the liquor runs from the filtering bags, and in which it is carried to the crystallising house, and poured into crystallising pans.
g, A copper pump 18 feet long with a 6 inch bucket, it is used for pumping the first, second, and third liquors out of their respective tanks into the cast iron evaporating pans B.
h, A copper jet for jetting the liquors out of the evaporating pans B, and the foul pot C, into filtering bags.
i, A copper skimmer with small holes in it, for skimming the liquor in the foul pot C.
j, An iron scraper for removing the saltpetre from the tops of the different ?????
k, An iron chisel for chipping the saltpetre from the bottom of the foul pot C.
l. A copper _____ pan capable of holding 15 gallons of water, and in which the different utensils are washed.
m, ____ ____ ___ for dipping water.
n, ____ _____________

The Crystallising House is a brick building with louver vents in the roof, in this building there are a number of draining troughs, and upon each trough are placed three crystallising pans; at one end of each row of troughs and under them is a smaller one, sometimes called a gutter, for conveying the liquor into small tanks for depositing foul matter after it is poured from the crystals. The tanks have attached to them copper pipes, which are placed within deal troughs, and carry the liquor into the large tanks in the boiling house, from whence it is pumped into the evaporating pans. This building is paved with stone, and on the North side are louver vent windows to keep it cool.

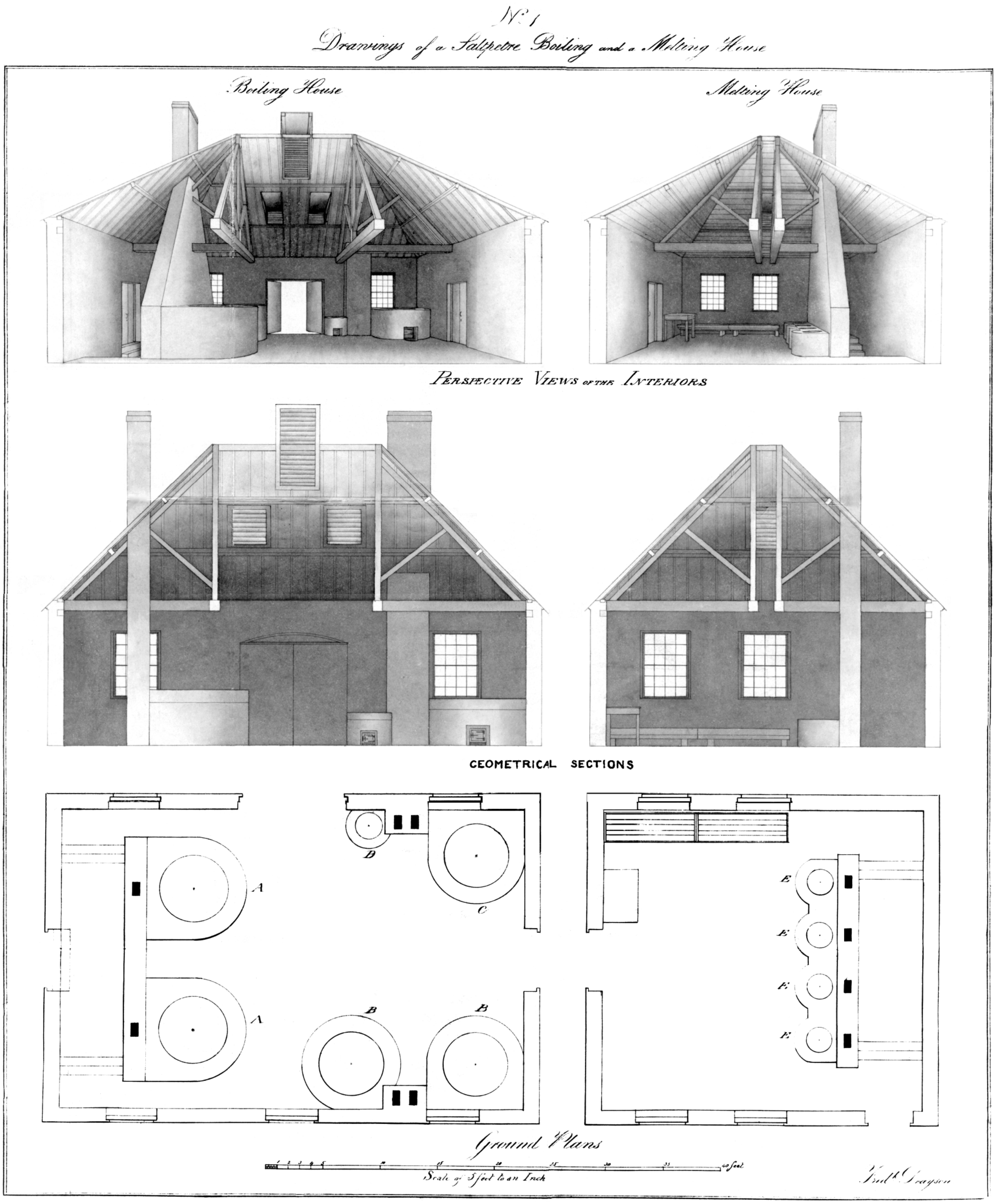
Utensils used in the Crystallising House and shewn on the drawing numbered 3.

p, A crystallising pan 2 feet 6 inches in diameter, 12 inches deep, and capable of holding 12 gallons of water. When the liquor is brought from the boiling house, it is poured into these pans to crystallise.
q, A deal cover made of ¾ inch deal, a cover is put over every crystallising pan to prevent dirt falling into the liquor and to keep it from cooling too quickly.
r, A deal draining trough 8 feet 8 inches long, 2 feet 5 inches broad and 5 inches deep in the centre, having a hole in one end through which the liquor poured from the crystals runs into the small trough or gutters, to the tanks.

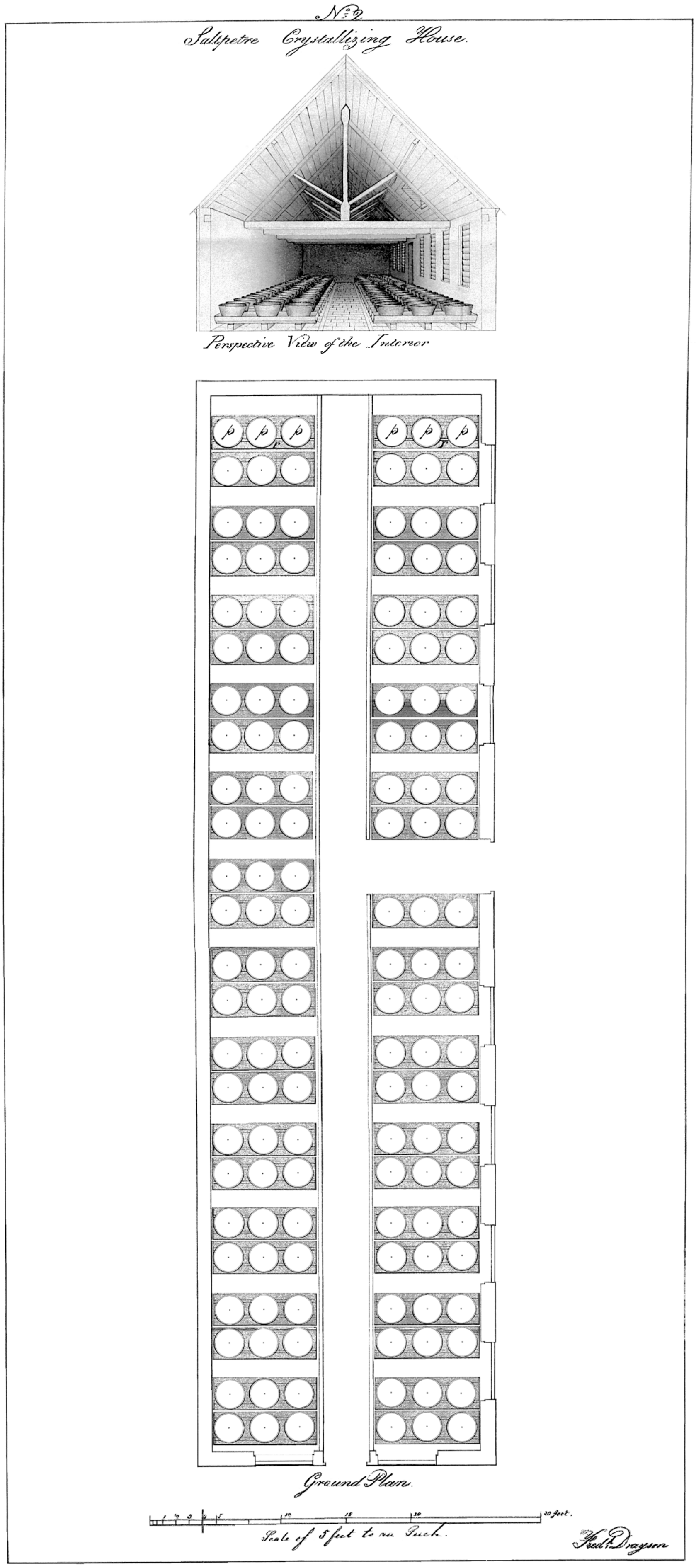
The Melting House is the last building used in this process and is built of brick with louver vents in the roof. It contains four cast iron melting pots marked E, for melting the refined saltpetre; the bars of the furnaces under them, are of cast iron three inches thick, they are placed half an inch apart, 5 bars form a set and weigh 2 Cwt 1 qu. The flues around the melting pots are 6 inches wide.

Utensils used in the Melting House and shewn in the drawing numbered 3.

E, A cast iron melting pot capable of holding 3½ Cwt of Nitre.
s, A small ladle for skimming the melted saltpetre.
t, A copper jet for jetting the saltpetre out of the melting pots E, and pouring it into the copper moulds u.
u, A copper mould into which the melted saltpetre is poured to cool and which forms it into cakes weighing about 36 lbs each.

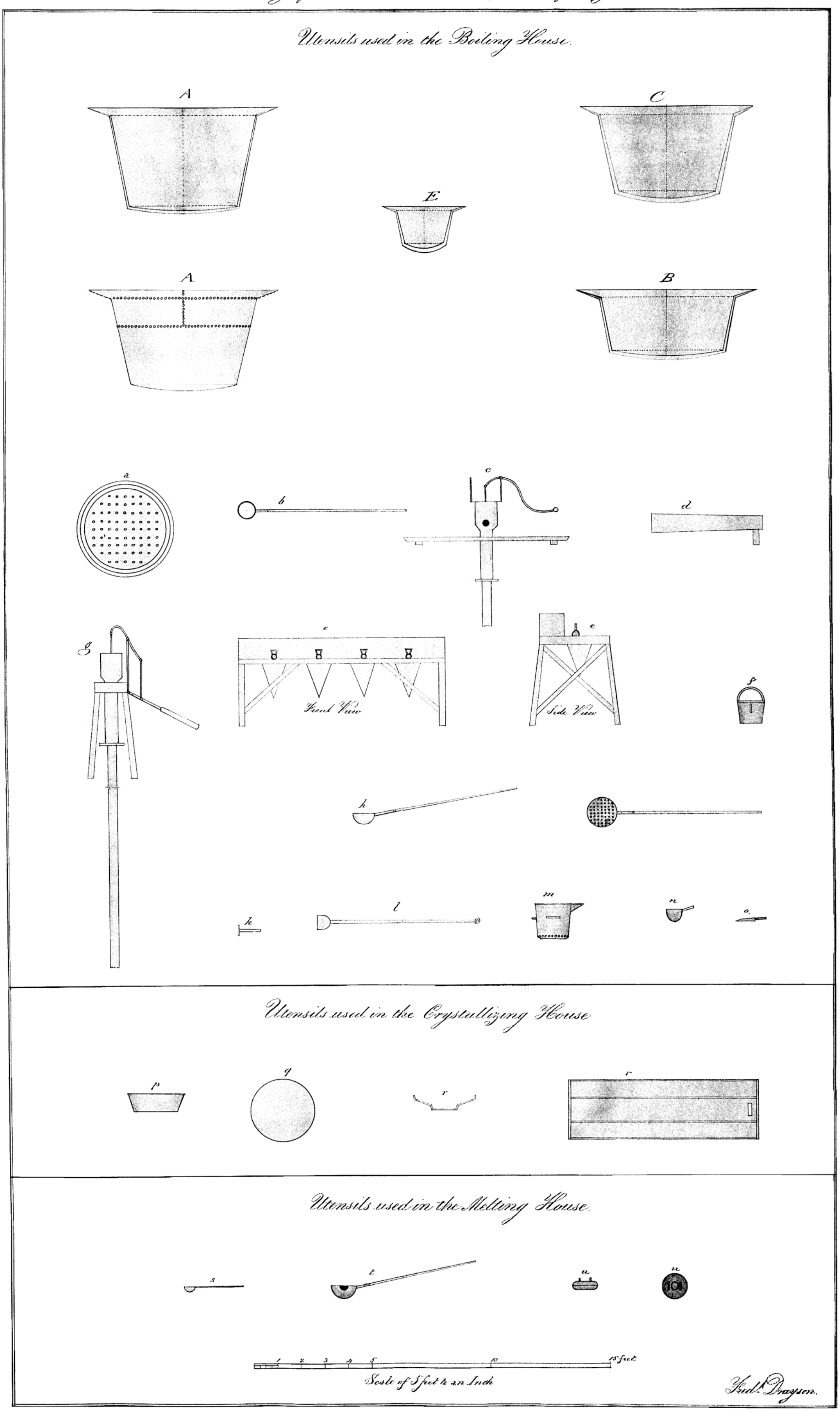

Nº 1
Drawings of a Saltpetre Boiling and a Melting House
Boiling House
Melting House
Perspective Views of the Interiors
Geometrical Sections
A
A
B
B
C
D
E
E
E
E
Ground Plans
Scale of 5 feet to an Inch

Drawing 1


No. 2
Saltpetre Crystallizing House.
Perspective View of the Interior
Ground Plan.
Scale of 5 feet to an Inch.
30 feet.
Fred. Drayson

Drawing 2

No. 3
Drawing of the Utensils used in a Saltpetre Refinery



Drawing 3

In the process of refining saltpetre the false bottom is put into one of the copper boiling pans A, and the boiler is filled with pure spring water and grough saltpetre, in the proportion of Ten gallons of water to one Cwt of nitre; the false bottom as before stated prevents the saltpetre from burning to the bottom of the copper whilst it is dissolving. The solution is made to boil in about 3 hours; a man attends the copper, and takes off the scum with the skimmer b, and puts it into a bucket which is placed upon the edge of the boiler, over which is thrown two or three saltpetre bags, so that any liquor which is taken up with the scum may drain through into the copper. This scum consists of earthy matter and about one bushel of it is generally skimmed from the liquor during the first boiling of the saltpetre. After the solution has boiled very fast for about one hour, near 100 gallons of pure water are put into the copper at a rate of 1 ½ gallons per minute, this is done to make the scum rise more freely and to clear the liquor. The solution is made to boil away fast for about 5 hours, and during that time about 5 bushels of scum are removed; at the end of that period it is pumped out of the boiling pan with the pump c, into the trough d, which carries it into the _____ _____ filtering trough e, only one of the brass cocks in the filtering trough is first set running into the filtering bags attached; from which it runs into the pouring pans f, and all the bags have a little white sand thrown into them to assist in clearing the liquor, and to keep them from clogging. If the liquor does not run clear into the pouring pans it is returned into the filtering trough until it does; the other cocks are then set running and the liquor is in like manner returned to the filtering trough until it runs clear from them also; it is carried in the pouring pans f, to the crystallising house, and about eleven gallons are poured into each crystallising pan, a cover is put over every pan that the liquor may cool slow, otherwise the saltpetre would not adhere to the sides, but would form itself into small crystals all over the pans, & when the liquor was poured a great proportion of them would fall into the draining troughs, which cannot be kept very clean and therefore would require boiling again to clear them of the impurities they thus acquired, The liquor stands to crystallise 36 hours then it is poured off from the crystals formed and runs back into the tanks in the boiling house for further reduction; the pans are set on edge to drain, and the crystal are rinsed with a little cold water. Every crystallising pan produces on average 80 to 100 lbs of crystals, and the saltpetre is now considered as single refined.

The crystals produced from the foregoing process are taken back to the <boiling house> and the other copper boiling pan A, is filled with them and spring water in the proportion of one cwt of crystals to ten gallons of water. <It is> made to simmer or boil gently for 5 hours, and any scum that <rises to the surface> is taken off & put into the first pan, but very little remains _______ ________ __ and no additional water is put into the copper during <this boiling as it was> during the first boiling. The liquor is pumped out of the boiler and filtered in the same manner as before, and taken to the crystallising house, when the same process is followed as in the first crystallisation.

The same process is followed in the third or last boiling as in the second.

The liquor which is poured from the first crystals returns back into the tank appropriated for it in the boiling house, and 280 gallons at a time are pumped into one of the cast iron evaporating pans B, the liquor is made to boil very fast for 6 hours, during which time about 6 bushels of coals are consumed, and the scum which rises to the surface is taken off and thrown into the foul pot C, it is reduced to about 50 or 60 gallons, and is jetted out of the evaporating pan with the copper jet h, into two double filtering bags attached to small frames, runs through them into the pouring pans f, is taken to the crystallising house and poured into the crystallising pans; after standing three days the liquor is poured from the crystals that formed, and runs into tubs at the ends of the draining troughs, and is afterwards poured into the foul pot C. The crystals produced from this operation are considered as grough saltpetre and are put with it into one of the copper boiling pans A, to recommence the original process.

The same process is followed in reducing the liquor poured from the second and third crystals, and those that are produced are considered as single refined saltpetre and are put with it into one of the copper boiling pans A, and the liquor poured from them goes back to the first evaporating pan B, and it is reduced with the liquor from the first crystals.

Into the foul pot C, are put from time to time all the foulest liquors, the sweepings of the different houses, and the water in which the different utensils are washed, and whenever it is full the liquor is reduced in the same manner as that in the two evaporating pans, in accomplishing which, from its great impurity, between 6 and 7 bushels of coals are consumed. It is the jetted into filtering bags upon the small frames, runs through them into pouring pans, is taken into the crystallising house, poured into crystallising pans, and stood to crystallise for three days, at the end of that period the liquor is poured off from the crystals formed, and is put again into the foul pot C, to be further reduced. When a sufficient quantity of crystals have been produced from the liquor reduced in this pot, about 20 Cwt of them are put with one hundred gallons of water into one of the evaporating pans B, is attended in the same manner as the liquors from the three crystals, and is called a rework. The crystals produced from this operation are considered as grough saltpetre.

Thus it may be seen that in refining saltpetre, after every boiling the crystals are advanced one step; whilst the liquor poured from them retrogrades in the same proportion.

The crystals produced from the third boiling are brought into the melting house in the crystallising pans, and the produce of four of them being about 380 lbs, is put into each of the cast iron melting pans E; the fires are then lit in the furnaces, and the saltpetre is melted and brought to a heat of not less than 800° of Fahr. When it is
sufficiently hot to set fire to paper, the fire in the grate is allowed to go out and the nitre is occasionally skimmed with the ladle s; as soon as it begins to congeal on the surface it is jetted out of the melting pots with the copper jet t, and poured into the copper moulds u, and is thus formed into cakes of about 38 lbs each. The heat to which the saltpetre is exposed during this operation wholly depends upon the practical experience of the workmen and therefore is liable to much variation. The expense of erecting buildings similar to the foregoing would be as follows.

	£
Boiling House …………………………………..	1800
Crystallising House ……………………………..	1200
Melting House …………………………………..	800
A Storehouse for the refined Nitre ……………….	300
Total	£ 4100

According to the foregoing process, this refinery is capable of refining 400? tons of grough saltpetre per annum, the produce of which in refined <nitre is> 320 tons making a loss of 20 per cent consisting of the foul salts and earthy matter. The expense of producing 320 tons of refined nitre would be £1119 detailed as under.

		Per ton	Per bbl of gunpowder	
Interest upon £4100 the first cost of }	£	£ s d	s d	
the buildings at £4 per cent per annum}	164, or	-..10..3,	or -..4x	‘4732142+
The daily pay of 10 men ------------	395, or	1.. 4..8½,	or -..9¾	‘6763392+
180 chaldrons of coal -------------	360, or	1.. 2..6,	or -..9x	‘1607142+
keeping the buildings and utensils in repair	200, or	-..12..6,	or -..5x	‘0892857+
Total	£1119, or	3.. 9..11¼,	or 2..4..	‘3995533+

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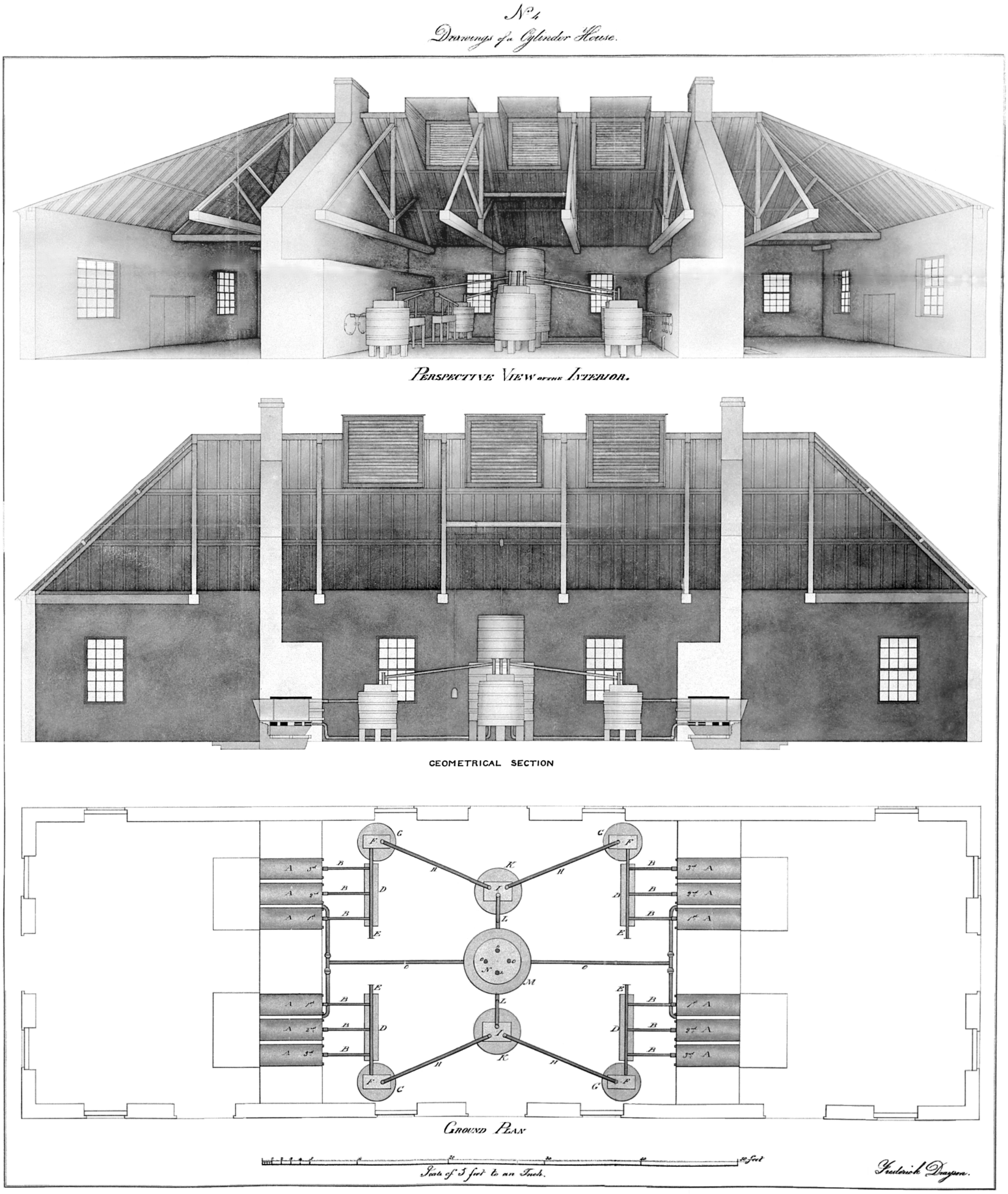
Process of Charring Wood

The buildings for preparing the charcoal, called the Cylinder Houses are located at Faversham, a distance of 60 miles from Waltham Abbey and _____ ______ ____ to this manufactory; but charcoal being the ingredient second in importance to nitre is now brought under consideration. The Cylinder House was formerly a saltpetre boiling house, but was ____________ it is a brick building 100 feet in length and 33 feet in breadth, the roof is tiled. It contains 4 sets of cast iron cylinders with tubs and gasometers for retaining the tar, acid, &c, extracted from the wood during the process of charring, as shewn in the plan of the drawing numbered 4. Every set consists of 3 cylinders marked A, which are each 6 feet 6 inches long, 2 feet 3 inches in diameter, and one inch thick; the chamber in each cylinder in which the wood is charred is 3 feet 6 inches in length. In one end of each cylinder there are 4 pipes or horns, which extend about 1 foot 9 inches from the chambers; the upper horn of each cylinder is left open for the escape of the elements composing tar, acid, &c, driven from the wood; the others are closed with dumb bosses and the space between them filled with brickwork. The horns remaining open have copper pipes affixed to them marked B, about 3 ½ inches in diameter, which run horizontally for a distance of 5 feet, when they meet with and are each joined to another pipe placed perpendicularly marked C, the lower ends of these perpendicular pipes are placed in a tub or trough marked D, nearly full of tar and acid, the upper ends are fixed into another pipe laying upon them marked E, the end of which towards the centre of the building is closed, the other end enters a tub reversed? called a gasometer marked F, which is fixed in another larger tub marked G, one end of a second pipe marked H, also enters the gasometer F, and the other end is fixed into the second gasometer marked I, in the large tub K, a third pipe marked L, is also fixed in the gasometer I, and passes down between the tubs K and M underneath and through the bottom of the large tub, and rises up above the tar and acid, into the principle gasometer marked N. It has been before stated that there are four sets of cylinders, each set has a gasometer F and tub G the pipes from two of these gasometers enter into each of the gasometers I, as shewn in the plan of the drawing, and only one pipe passes from each of the latter gasometers under and through the bottom of the tub M, into the principal gasometer N. Two pipes marked o, have one of their ends open and above the surface of the tar and acid in the principal gasometer N, and also passes through the bottom of the tub M and along the floor of the building until they arrive within about 6 inches of the walls connected with the cylinders; each pipe here divides into two branches and one branch enters into the furnace for each set of cylinders; each branch has a cock so that the gas from the principal gasometer N may be turned into those furnaces only, which are at work. The furnace is situated under and between the first and second cylinder; the flue passes under the second and third cylinders, over the tops of all of them following the circle? of each cylinder, and from thence the smoke enters a large space formed by the arch over the three cylinders which is a semicircle and is conveyed beyond the roof of the building by a chimney 1 foot 2 inches square. The flue under the cylinders is four inches deep, and is divided into four smaller ones each nine inches wide, as shewn on the geometrical section of this building. but is only two inches deep over the tops of the cylinders, and is not divided into smaller ones but it is under them. The under sides of the cylinders are covered with Newcastle fire shoes? to preserve them from the fire. The gasometer N is balanced by a weight and may be raised or lowered by means of a pulley.

This building has a storehouse attached for receiving the charcoal, which is built of brick and paved with stone, and has also a pot or reservoir for receiving the tar.

Utensils used in the Cylinder House and shewn in the drawing numbered 5.

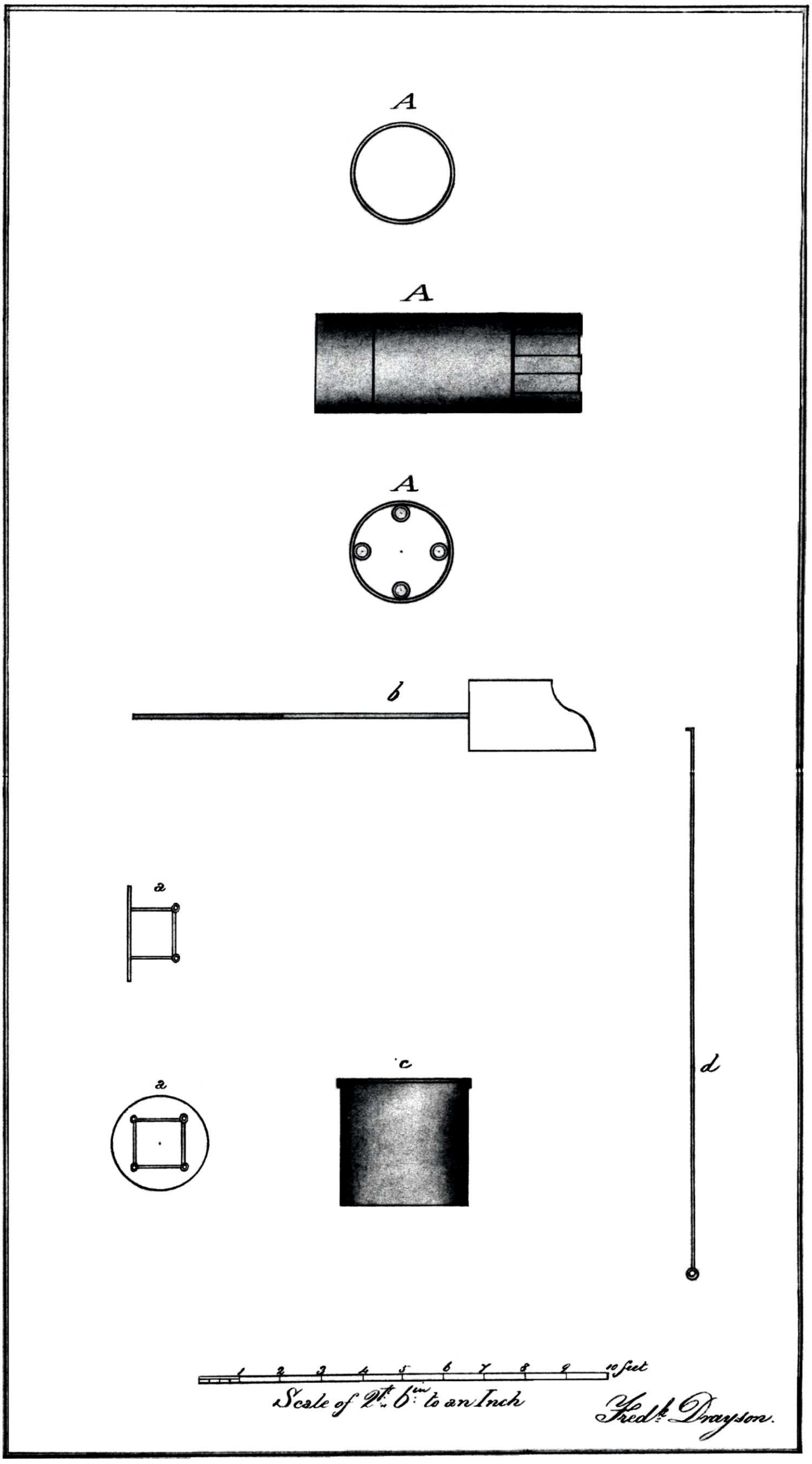
A, A cast iron retort or cylinder used for charring the wood, it is 6 feet 6 inches long, 2 feet 3 inches in diameter and one inch thick, each weighs 30 cwt and three form a set.
a, An iron stopper for closing the chambers in the cylinder.
b, An iron tip for taking the charcoal out of the cylinders.
c, An iron cooler into which the charcoal is put when it is taken out of the cylinders.
d, An iron scraper for cleaning the inside of the pipes.


No. 4
Drawings of a Cylinder House.
Perspective View of the Interior.
GEOMETRICAL SECTION
Ground Plan
Scale of 5 feet to an Inch.
Frederick Drayson.

Drawing 4

No. 5

Drawing of the Utensils used in a Cylinder House.



Drawing 5

Previous to the operation of charring, the wood is stripped of the bark, the knotty parts are removed, and it is cut into lengths of 3 feet 4 inches. About 580 lbs of wood are put into each set of cylinders to be charred at one time, the stoppers a, are then placed against the edge provided for that purpose in each cylinder and the spaces between them and the outer doors are filled in with sand. The fire is afterwards lit in the furnaces, and as the wood becomes heated, the elements of which pyroligneous acid is composed, are driven from it in a kind of steam which passes through the pipes B, C, and E, into the first gasometer F, by this time a portion of it has become condensed forming pyroligneous acid, and is deposited in the tub G, the steam then passes through the pipe H, into the second gasometer I, and more acid is deposited in the tub K, the remainder of the steam passes down the pipe L, enters the principal gasometer N, and becoming condensed therein, is deposited in the large tub M. The elements of which tar is composed are also driven from the wood, and a portion escapes through the pipes in the shape of a white smoke, which mingling with the elements composing pyroligneous acid, is condensed with them in the different pipes and gasometers and forms tar. In this manner the elements composing pyroligneous acid and tar continue to be driven from the wood during the space of 5 hours in the shape of a smoky steam which will not burn or is only slightly inflammable, at the end of that period the cylinders have become red hot, all the elements of which pyroligneous acid is composed have been driven from the wood, and the elements composing tar being now freed from the steam composing the acid, escapes in the shape of an inflammable gas, which burns fiercely if set on fire. When this is the case, the cocks in each branch of the pipes a, which had been stopped are turned, and the gas, passing through the different pipes and gasometers enter the furnaces, and is burnt. After 8 hours burning the wood has become charcoal, and if any fire remains in the furnace it is raked out, but the charcoal is left in the cylinders during the night in order to cool before it is exposed to the air. As soon as the men come to work the next morning, the outer doors are opened, the sand and stoppers are removed and the charcoal is taken out of the retorts with the tip b, and put into the coolers c, where it remains during the day as a precautionary measure to prevent its taking fire; it is afterwards put into the store. Every set of cylinders has two men to attend it, and the quantity of charcoal produced from the 580 lbs of wood with which they were loaded averages from 160 to 170 lbs, being at the rate of about 29 per cent. The tubs where the tar and acid is deposited during the operation have a small pipe near the top for carrying off the pyroligneous acid, the tar being heavier sinks and is occasionally drawn off through a wooden tap, commonly called a spicket and passed in the bottom.

One set of cylinders is capable of burning a sufficient quantity of wood to produce charcoal for 2500 barrels of gunpowder per annum and as this building contains four sets, it is capable of producing 67 tons of charcoal annually, being a sufficient quantity for 10000 barrels.

The expense of erecting a cylinder house similar to the foregoing including cylinders, tubs, gasometers &c would be £3000 and the expense of charring wood to produce 67 tons of charcoal would be £688 detailed as under.

		Per bbl of Gunpowder
Interest upon £3000 the first cost of the}	£	£ .. s .. d
building at £4 per cent per annum }	120, or	--..--.. 2¾ ’52
The daily pay of 8 men	320, or	--..--.. 7½ ’72
74 chaldrons of coals	148, or	--..--.. 3½ ‘208
Keeping the buildings and utensils in repair	100, or	--..--.. 2¼ ‘6
Total	£688, or	--..-1.. 4½ ‘048

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Process of refining Sulphur

The processes adopted at Waltham Abbey for refining sulphur are “fusion” and “sublimation”, the latter process however is seldom followed, the sulphur refined by fusion being preferred for manufacturing gunpowder.

Refining Sulphur by the Process of Fusion.

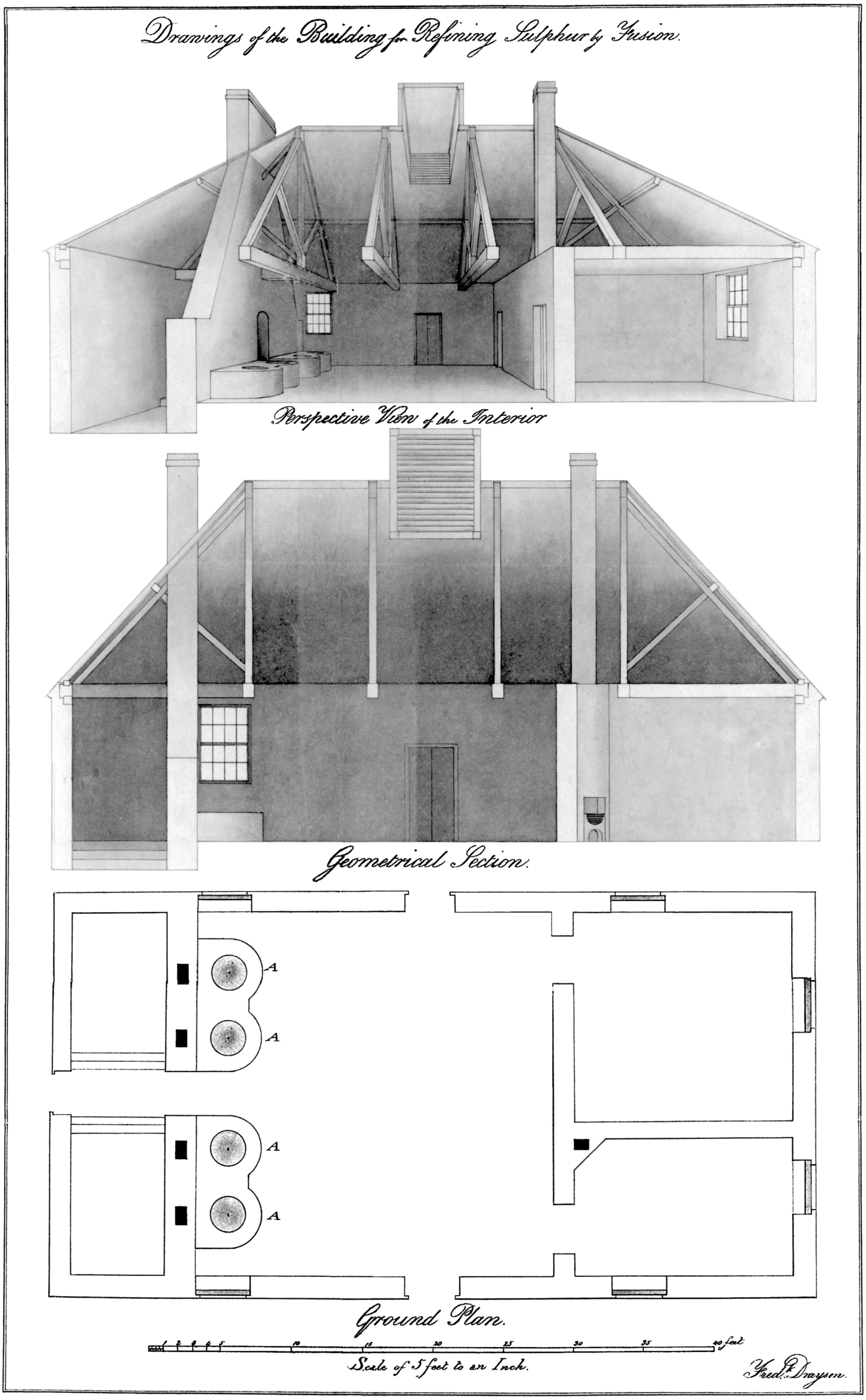
The building for refining sulphur by fusion is 55 feet long, 29 feet broad, and is built of brick, and paved with stone. It contains 4 cast iron melting pots marked A, and weighing about 10 cwt, and capable of holding 7 cwt of sulphur; the flues around them are 4inches wide, and the bars of the furnaces are similar to those in the saltpetre melting house. The building is shewn on the drawing numbered 6.

Utensils used in this building and shewn on the drawing numbered 7.

A, A cast iron melting pot capable of holding 7 cwt of Sulphur, and is used for refining the same.
a, A small brush for oiling the interior of the pot.
b, An iron stirrer for stirring the sulphur in the melting pot.
c, A rill? skimmer for taking out the lumps from the melted sulphur.
d, An iron beater for breaking the lumps taken out of the melted sulphur.
e, An iron skimmer for taking off skimmings from the melted sulphur during the first melting.
f, An iron pan for receiving the skimmings taken from the sulphur during the second melting.
g, An iron skimmer for skimming the sulphur during the second melting.
h, A copper jet for pouring the melted sulphur into cooling tubs.
i, A copper plate which is placed on the edge of the melting pots whilst the refiner is jetting the sulphur into cooling tubs.
k, A cooling tub into which the sulphur is poured to cool.
l, A weighing tub in which the sulphur is weighed.
m, An iron chisel for cutting the foulest parts from the cakes of sulphur.
n, A rake for raking the lumps from the broken sulphur.
o, A wooden beater for braking the grough and refined sulphur before it is put into the melting pots.
p, A wooden mallet for breaking the cakes of sulphur.
q, A wooden block upon which the cakes of sulphur rest whilst the refiner is cutting the foulest parts from them.
r, A wooden lid to put over the melting pots.

In this process the sulphur is broken very small before it is put into the melting pot; it is therefore first spread upon the floor of the building about one inch thick, and broken with the wooden beaters until no lumps remain. The fire is lit under the melting pot before the sulphur is put in it, and when it becomes warm, it is oiled with sweet oil with the brush to prevent the sulphurs adhering to it. When this has been done, about a shovel full of the broken sulphur is thrown into the pot, and stirred with the stirrer b, until it becomes heated to 218° of Fahr when it melts; another shovel full is thrown into the pot, and also stirred until it melts and in this manner the melting pot is filled, only one shovel full of sulphur being thrown in at a time. If the sulphur is not all melted it is lumpy, and the lumps are taken out with the rill? skimmer c, or with the skimmer g, put on the edge of the pot and broken with the iron beater d; when the sulphur begins to cool the skimming is discontinued, and in a short time an incrustation ___________ an inch

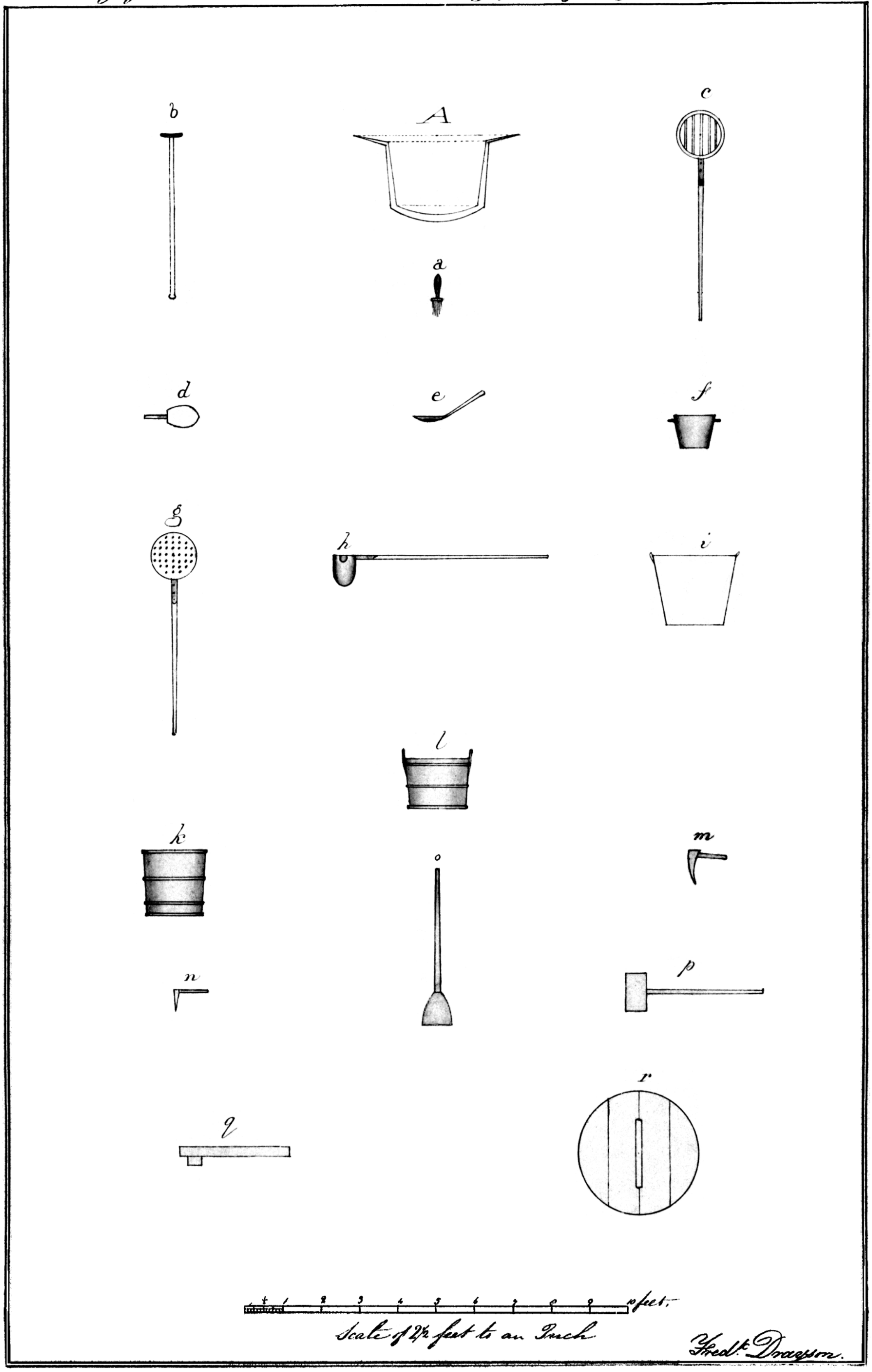
No. 6.



Drawing 6

No. 7.

Drawing of the Utensils used in the Building for Refining Sulphur by Fusion



Drawing 7

thick forms on the surface of the sulphur, and is skimmed off with the skimmer e, other ?? ____________________ _____ until most of the impurities that are lighter than the sulphur have risen to the surface, the sulphur is then jetted or poured with the jet h, into the cooling tub k, and allowed to cool. This process is called the first melting.

When the sulphur from the first melting is cold it is turned out of the cooling tub, and the contents of each tub is called a cake of sulphur. The refiner cuts off about 3 inches from the bottoms of the cakes of sulphur, which consists of the impurities that have sunk to the bottoms of the cooling tubs whilst the sulphur was cooling, and is called the "bottoms" or "sulphur vivum?", and about half an inch from the tops and sides called "cuttings", the latter is put with the grough sulphur and melted with it; the former and the skimmings cannot be refined by this process, & are put away as useless.

The cakes of sulphur are broken up for the second melting in the same manner as the grough sulphur was broken up for the first melting, also the same process is followed in filling the pot and after two meltings the sulphur is considered sufficiently pure to be used in the manufacture of gunpowder.

By this process one ton of grough sulphur will produce as follows,

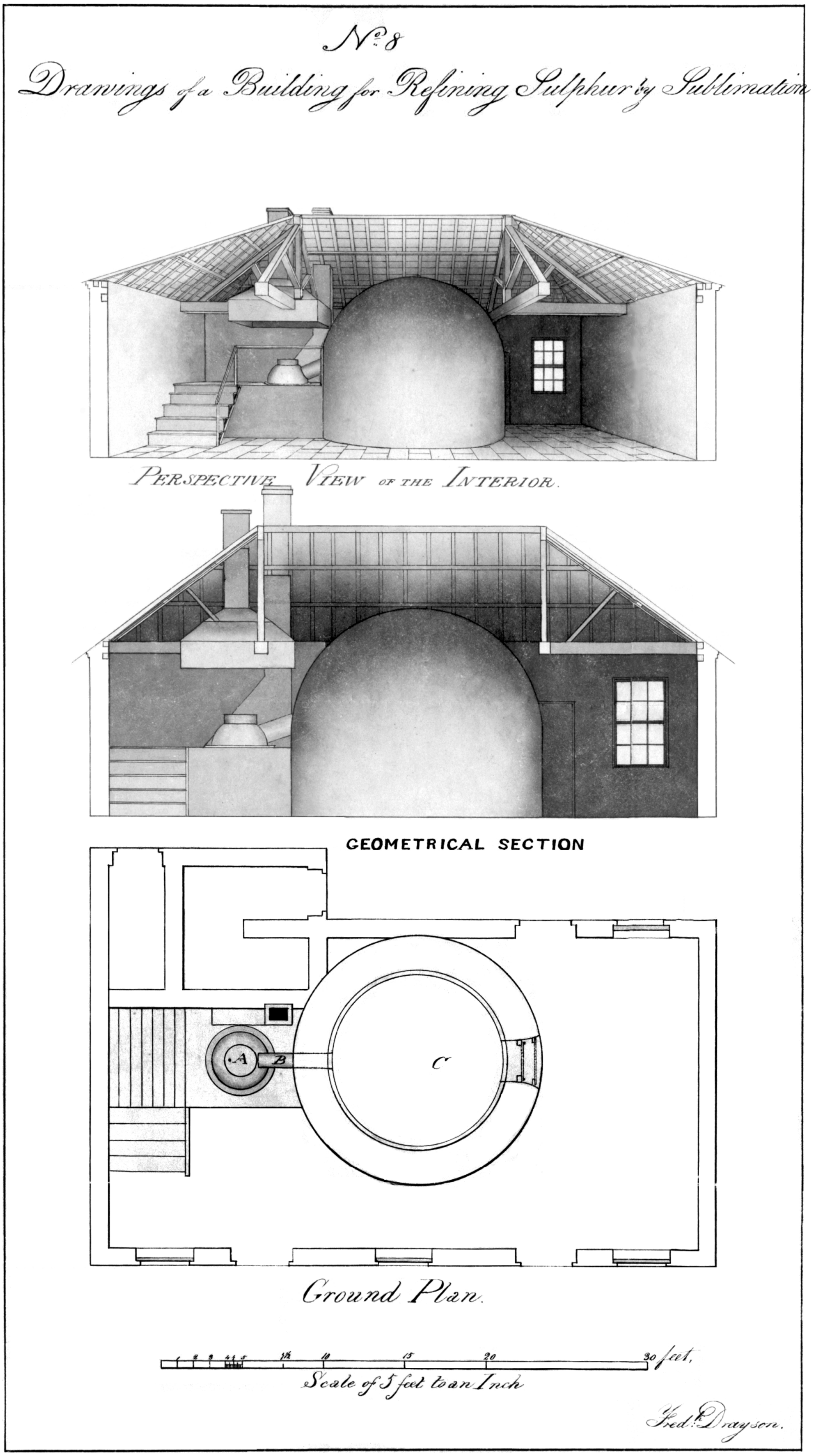
	Cwt qu lb	
Refined sulphur similar to that now used in making gunpowder}	14.. 1.. 0,	or 71 ¼ per cent,
Cuttings put with the grough sulphur to be refined }	3.. 1.. 0,	or 16 ¼ per cent,
Trimmings	1.. 0..14,	or 5 ¾ per cent,
Bottoms or sulphur vivum?_	1.. 1..12,	or 6 ¾ per cent,
Total Cwt	19.. 3.. 26,	or 100 per cent.

The expense of erecting a sulphur refinery similar to the foregoing would be £1000, and about 154 tons of grough sulphur might be refined in it per annum, from which 110 tons of refined sulphur would be produced, making a loss of 28¾ per cent; the expense of refining this quantity of sulphur would be £376 detailed as under.

	£	Per ton £ s d	Per bbl of gunpowder £ s d
Interest upon £1000 the first cost of the building at £4 per cent per annum}	40, or	-.. 7..3¼. '09+,	or -..-.. ¼ - '5584415+
The daily pay of 5 men	200, or	1..16..4¼ '45+,	or-..-.. 1¾ - '7922077+
43 chaldrons of coals	86, or	-..15.. 7½ '54+,	or-..-.. ¾ - '3506693+
Keeping the buildings and utensils in repair }	50, or	-.. 9.. 4 '36+,	or -..-.. ¼ - '9680519+
Total	£376, or	3.. 8.. 4¼ '44+,	or -..-..3½ -'6492504+

Refining Sulphur by the Process of Sublimation

The building in which this process is carried on is called a subliming kiln or dome, and is 39 feet long, 21 feet wide, and is built of brick, the roof is slated, and the floor is paved with stone. It contains a cast iron pot for melting the sulphur marked A, a brick dome for subliming the sulphur marked C, and an ???? for the escape of foul air from the pot as shewn on the drawing numbered 8. The pot is 3 feet in diameter in the lower part, and 1 feet 6 inches in diameter at the top, the upper part being oval; it is 4 inches thick at the bottom, and 1½ inches at the top; the lid is of cast iron and weighs 2 Cwt, and in it is a small hole about ¾ of an inch in diameter, through which with an iron rod the refiner occasionally ascertains how much of the sulphur is sublimed, at other times it is closed with a plug. The pipe B, conveys the sulphur in a state of vapour from the pot to the dome, it is made of cast iron, is about one inch in thickness,


No. 8
Drawings of a Building for Refining Sulphur by Sublimation
Perspective View of the Interior.
Geometrical Section
A
B
C
Ground Plan.
1 2 3 4 5 10 15 20 30 feet.
Scale of 5 feet to an Inch
Fredk. Drayson.

Drawing 8

and 1 foot 2 inches in diameter, with an elevation of about 20 degrees from the pot to the dome. The dome is 10 feet in diameter, and 10 feet in height in the interior the walls of it are 2 feet 6 inches thick, are built of brick, and are braced and ribbed with iron ½ inches thick, and 3 inches wide, and the whole of the inside is lined with yorkshire paving stone. The door of the dome is of cast iron 1½ inch thick, and 3 foot 6 inches high, it is fixed about half way through the wall of the dome, and has a hole in the upper part 2 inches in diameter, into which one end of a copper pipe is placed, the other being put into a tub of water.

The grough sulphur is not broken up before it is put into the pot in this process, as it is when refined by the process of fusion; but about 4 Cwt whether lumpy or not is put into the pot at one time, and the lid is put on and weighted with about 1½ Cwt; the door of the dome is then shut, the copper pipe is fitted into the hole in the upper part, some deal boarding is made fast to the outside of the dome, and the space between the door and the boarding is filled with sand to make it airtight. After this has been done the fire is lit under the pot and as it becomes heated the sulphur melts, and finally turns into a kind of vapour; in this state it passes through the pipe B, into the dome C, which being colder than the pot, causes the sulphur to fall to the floor in a fine powder. When much foul air is created it escapes down the copper pipe, and through the water in the tub into which the lower end of the pipe is fixed. Before the sulphur is taken out of the dome the door must be left open for 3 or 4 hours for the escape of foul air. About 4 cwt of sulphur may be sublimed in one day, in doing which about 4 bushels of coals are consumed. The sublimed sulphur is taken out of the dome with a common shovel, and if it is to be used in manufacturing gunpowder, it is melted once in the melting pots in the building shewn on the drawing numbered 6, in the same manner as in refining sulphur by fusion. The sulphur refined in the manner just described is called flowers of sulphur and one ton of grough will yield as follows:

	Cwt..qu..lb	
Sublimed sulphur in flowers	18.. 1..16, or about	92 per cent,
Refuse? earthy matter	1.. 2..11, or about	8 per cent,
Total Cwt	19.. 3..27, or	100

The expense of building a subliming dome similar to the foregoing would be £300, it is capable of subliming according to the process described, 32 tons 12cwt of grough sulphur annually, from which about 30 tons of the flowers of sulphur would be produced making a loss of 8 per cent. The expense of refining would be £134 detailed as under.

		Per ton	Per bbl of gunpowder	
Interest upon £300 the first cost of the building at £4 per cent per an^{m}	£ 20, or	£ .. s.. d -..13.. 4, or	£ .. s..d -..-.. ½	‘8571428+
Labour	60, or	2.. 0.. 0, or	-..-.. 2	‘5714285+
17 chaldrons of coals	34, or	1.. 2.. 8, or	-..-.. 1	‘8571428+
Repairs to the building	20, or	-..13..4, or	-..-.. ½	‘8571428+
Total	£134, or	4.. 9.. 4, or	-..-.. 4¾	‘1428569+

In producing rock sulphur, that is, sulphur in a solid but not in a crystallised state, a much greater degree of heat is required than in producing flowers of sulphur. The increased heat drives the sulphur through the pipe B, into the dome C, in a stronger vapour, and the dome being very hot, the sulphur melts on the floor, and remains in that state as long as a large fire is kept up under the melting pot. The sulphur may be afterwards melted in the melting pots that it may crystallise before it is ground at the composition mill, or it may be ground in its rock state.

This building is capable of producing 50 tons of rock sulphur per annum at an expense of £160 detailed as under.

	Per ton	Per bbl of gunpowder
Interest upon £500 the first cost of}	£	£ .. s .. d	£.. s.. d
the building at £4 per cent per an^{m}}	20, or	-.. 8..- , or	- .. - .. ¼ ‘7142857+
Labour	60, or	1.. 4 ..- , or	- .. - .. 1¼ ‘1428571+
30 chaldrons of coals	60, or	1.. 4 ..- , or	- .. - .. 1¼ ‘1428571+
Repairs to the building	20, or	-.. 8 ..- , or	- .. - .. ¼ ‘7142857+
Total	£160, or	3.. 4 ..- , or	- .. - .. 3½ ‘7142857+

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The nitre and sulphur having been refined and the charcoal prepared according to the foregoing processes, are considered fit to be manufactured into gunpowder, the first operation of which is the reducing each of the ingredients to a fine powder and is called the

Process of grinding the Composition.

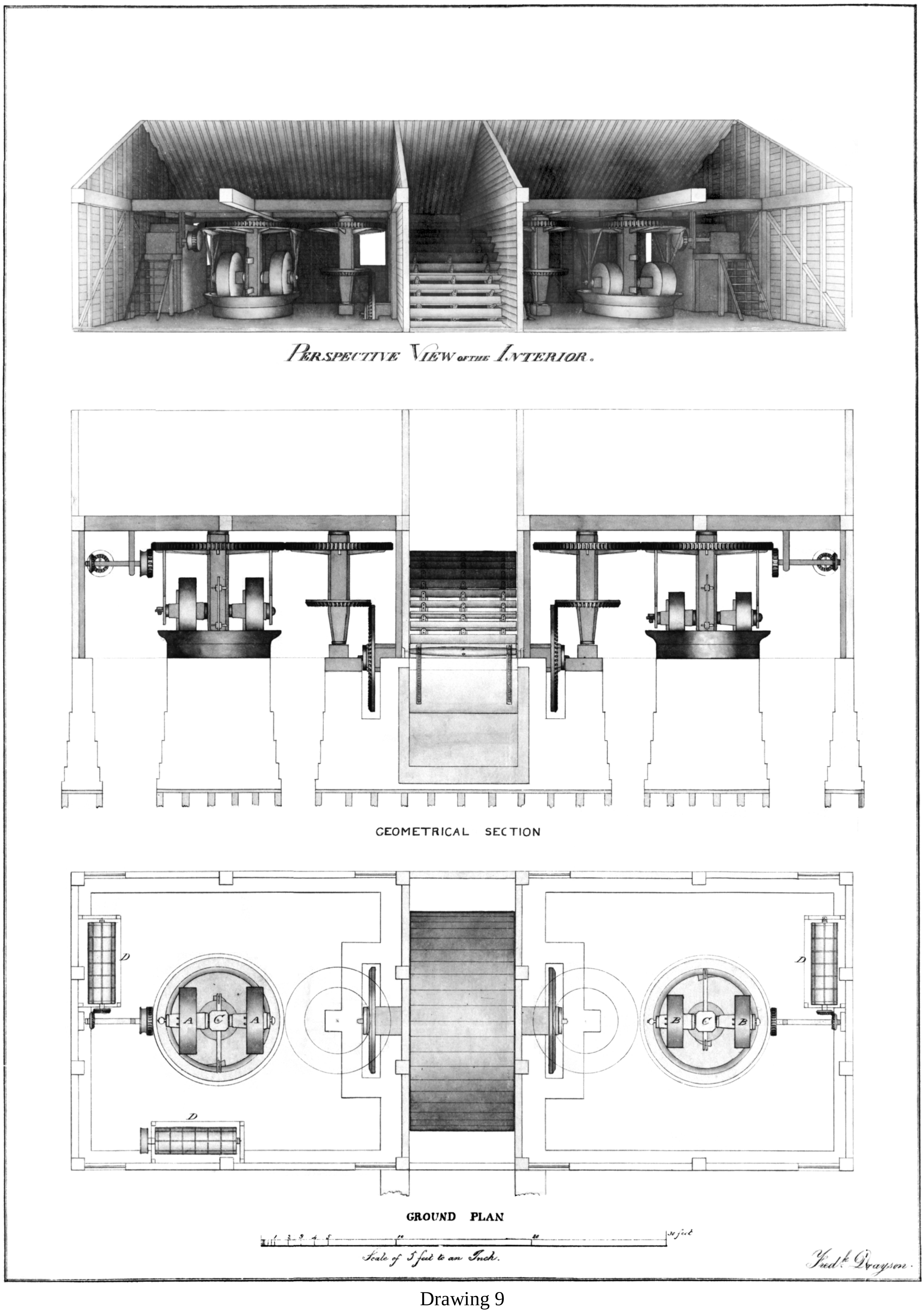
The building in which this process is carried on is called the Composition mill, it is 58 feet in length, 22 feet in breadth, is built of wood, and the foundations are of brick. It contains one pair of stones marked A, each weighing 1½ tons for grinding the nitre and charcoal separately and at different times, another pair marked B, each weighing one ton for grinding the sulphur, two stone beds upon which the stone runners revolve, and 3 reels marked D, as shewn on the drawing numbered 9. The machinery of this building is worked by water falling upon, and turning the water wheel placed in the centre of the building and marked E, each pair of stones is turned by an iron spindle which passes through the upright shaft C, and through a wooden box in the centre of each stone, and each spindle is 8 feet 6 inches in length, 4 inches in diameter, and weighs about 5 cwt. When the composition is being ground, a wooden rake is placed between the stone runners and revolves with them, being fixed to the upright shafts C, and rakes up the composition every time the stone runners go over it; two pieces of wood called ploughs are also placed between the stone runners, one on the inside of the bed and one on the outside next to the curb, these are likewise fixed to the upright shafts C, rub upon the stone bed, and keep the composition in the track of the stone runners. The reels are enclosed in deal cases, and are each 6 feet long, 2 feet in diameter, and have one end 6 inches lower than the other, the charcoal reel is clothed with brass sieve cloth of 36 meshes to the inch. The composition falls into each reel through a hopper at the upper end.

In grinding nitre about 190 lbs are thrown upon the bed stone at a time, the stone runners are set in motion at the rate of about 6 revolutions per minute, and as they run round upon the bed stone they crush the nitre to a powder, whilst the ploughs keep it in their tracks, and the rake prevents it from caking together; in about half an hour the nitre is reduced to a fine powder, it is taken off the bedstone with a common shovel, and put into the hopper attached to the __ reel; the hopper has a jiggling motion and only admits a small quantity of composition into the reel at one time; the nitre which has been ground fine enough falls through the meshes in the brass sieve cloth into the reel cases, whilst the larger pieces fall out of the lower end of the reel into a tub, and are again thrown upon the bedstone with other nitre to be again ground. The nitre which falls through the brass sieve cloth of the reels, is taken out of the reel case and sent to the mixing house.

The same process is followed in grinding the charcoal and sulphur, about 170 lbs of the former are ground at one time under the same pair of stones as the nitre, and about 180 lbs of the latter are likewise ground at one time, but under the smaller pair of stones.

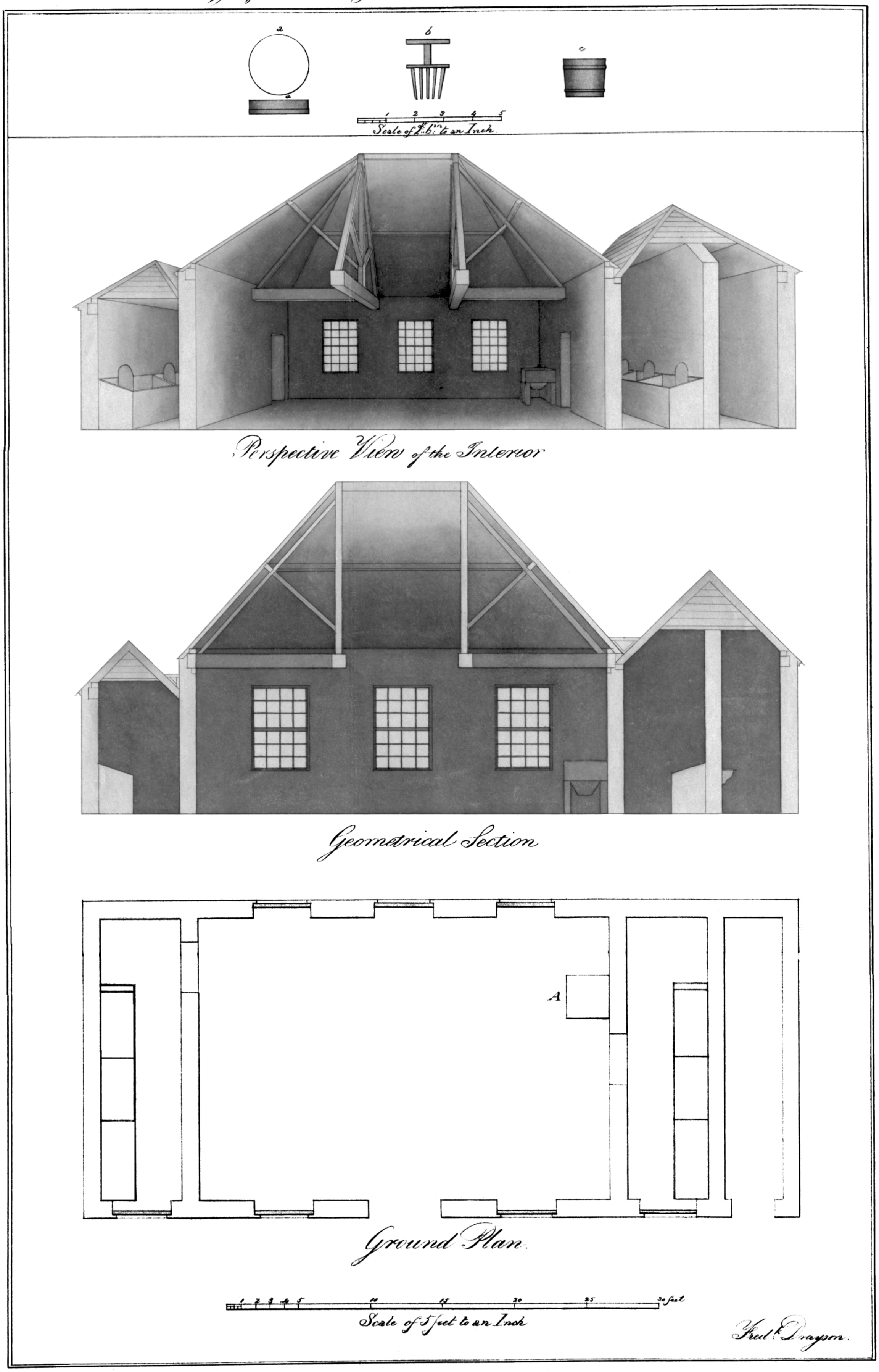
The pair of stones marked A can grind 18 cwt of nitre, or 15 cwt of charcoal per day, and the pair marked B is capable of grinding 25 cwt of sulphur in the same period. The machinery of this building requires a power equal to that of 4 horses to make the stone runners revolve at the specified rate.

No. 9
Drawings of a Water Composition Mill.



Drawing 9

No. 10
Drawings of the Mixing House and of the Utensils used therein.



Drawing 10

The expense of erecting a composition mill similar to the foregoing would be £2500, the present mill is capable of grinding composition to manufacture 8000 barrels of gunpowder annually, consisting of 276 tons, 17 cwt and 10 lbs of nitre, 11 cwt 1 qu 20 lbs of charcoal, and 35 tons 14 cwt 1qu 14 lbs of sulphur, at an expense of £450 detailed as under.

		Per bbl of gunpowder
Interest upon £2500 the first cost of the}	£	£ ..s ..d
building at £4 per cent per annum }	100, or	- .. - .. 3
The daily pay of 3 men	120, or	- .. - .. 3½ - '4
Water power equal to 4 horses	160, or	- .. - .. 4¾ - '2
Repairs to the building and machinery	70, or	-.. - .. 2 - '4
Total cost	£450, or	-.. 1 .. 1½

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Process of Mixing the Ingredients

The building in which this process is carried on is called the mixing house, it is built of brick, is 44 feet long, and 21 feet wide, the roof is slated and the floor is covered with tanned hides. Great care is necessary in this process to prevent any dirt or grit from getting into the composition, and therefore not only the men who work, but likewise any other persons when they enter this building put on slippers. This building is shewn on the drawing numbered 10

Utensils used in this building and shewn on the drawing numbered 10

a, A sieve for sifting the ingredients.
b, A stirrer or mixer for mixing the ingredients.
c, A charge tub for carrying the composition to and from the mixing house.

The nitre, charcoal, and sulphur, having been separately reduced to a fine powder, are brought to this building, and weighed into portions as below.

	lbs ..oz .. dr		lbs
Saltpetre	31 .. 8 .. 0	being in the proportion of	75 of saltpetre
Charcoal	6 .. 4 ..12 4/5		15 of charcoal
Sulphur	4 .. 3 .. 3 1/5		10 of sulphur
Total lbs	42 .. 0 .. 0	In lbs	100

The three quantities forming the 42 lbs, are then put together into a tub and stirred with the stirrer b, afterwards the mixture is put into the sieve a, and the sieve is put into the hopper marked A on the drawing of this building numbered 10; the mixture is then sifted through the sieve a, and is caught in the charge tub c, placed for that purpose underneath; is given the name of green charge, or composition and is taken to the charge magazine.

The expense of erecting a building similar to the foregoing would be £400, the present mixing house is capable of affording accommodation to mix composition for 30000 barrels of gunpowder per annum at an expense of £286 detailed as follows.

		per bbl of gunpowder
Interest upon £400 the first cost of the}	£	£ .. s .. d
building at £4 per cent per annum }	16, or	-.. - .. -. - '512
The daily pay of 5 men	200, or	-.. - .. 1½ - '4
Repairs to the building and utensils	20, or	-.. - .. ¼ - '64
Total	£286, or	-.. - .. 1¾ - '552

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Charge Magazines

A charge magazine is a brick building having a buck arched roof, and the interior is lined with wood; it is 14 feet long, 10 feet broad, and has benches on the side, upon which the charge tubs containing the mill charges are placed, as shewn on the drawing numbered 11. After the composition has been mixed at the mixing house into charges of 42 lbs it is brought to this building; and after undergoing the process of amalgamation at the gunpowder mills it is again returned to these magazines, from whence it is taken to the corning house to be processed and granulated. Every two gunpowder mills have a charge magazine attached, and the expense of erecting one is about £100.

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Process of Amalgamating or Incorporating the Composition

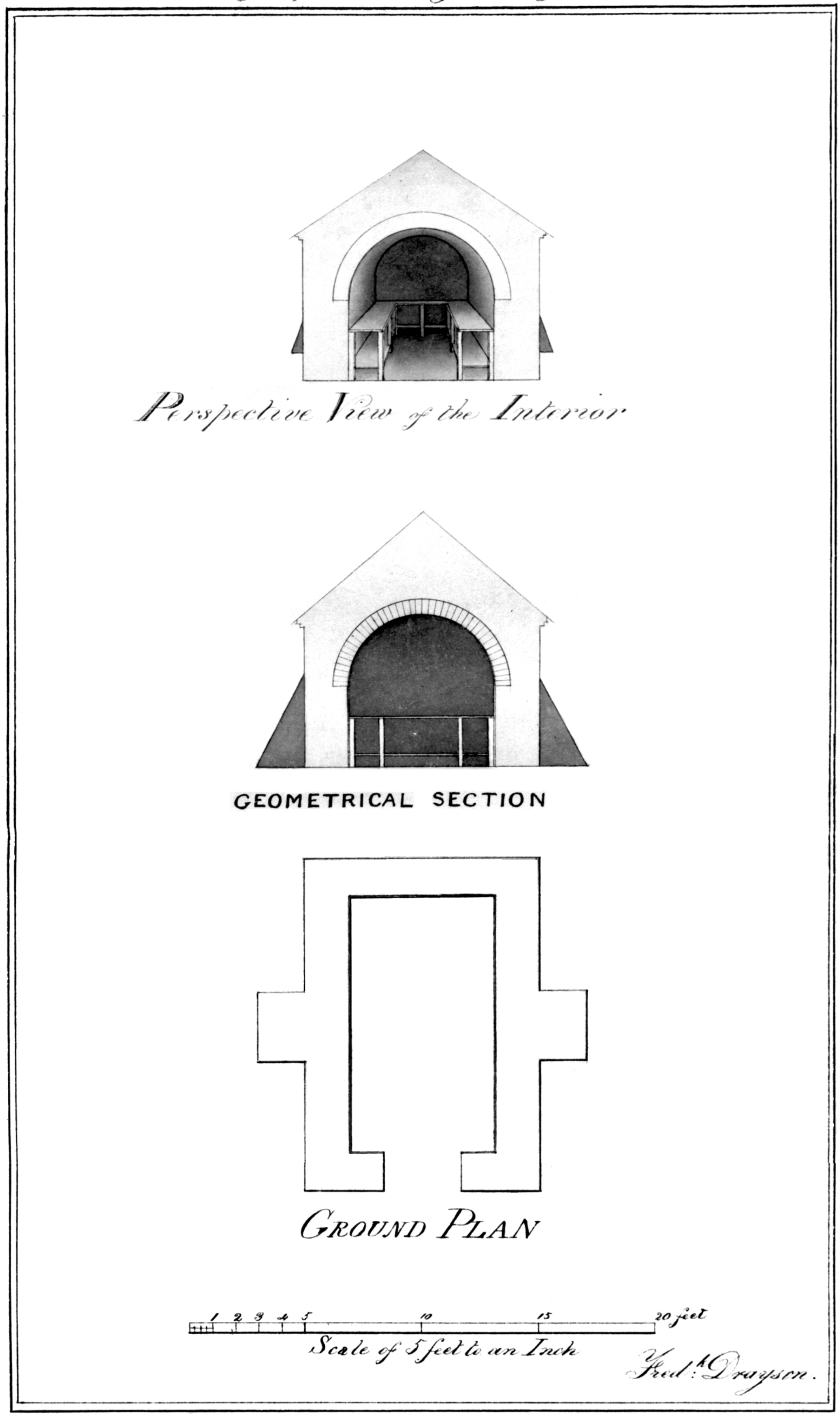
The buildings in which this operation is carried on are called gunpowder mills; they are each 58 feet long, 10 feet wide, and are worked by water, the water wheel being placed in the centre of each building, thereby dividing it into two equal parts, which are occupied by the stone runners, stone beds &c. The foundations are built of brick upon rock piles, and the water courses of stone; the framing, covering, and roofs, are entirely built of wood. The following wheels &c, compose the machinery of a gunpowder mill, and are shewn on the drawing of that building numbered 12.

The water wheel marked A, receives the impulse of the water upon its float boards, and is generally 17 feet in diameter, and 8 feet wide for a fall of 6 feet, it makes 5 1/3 revolutions per minute.

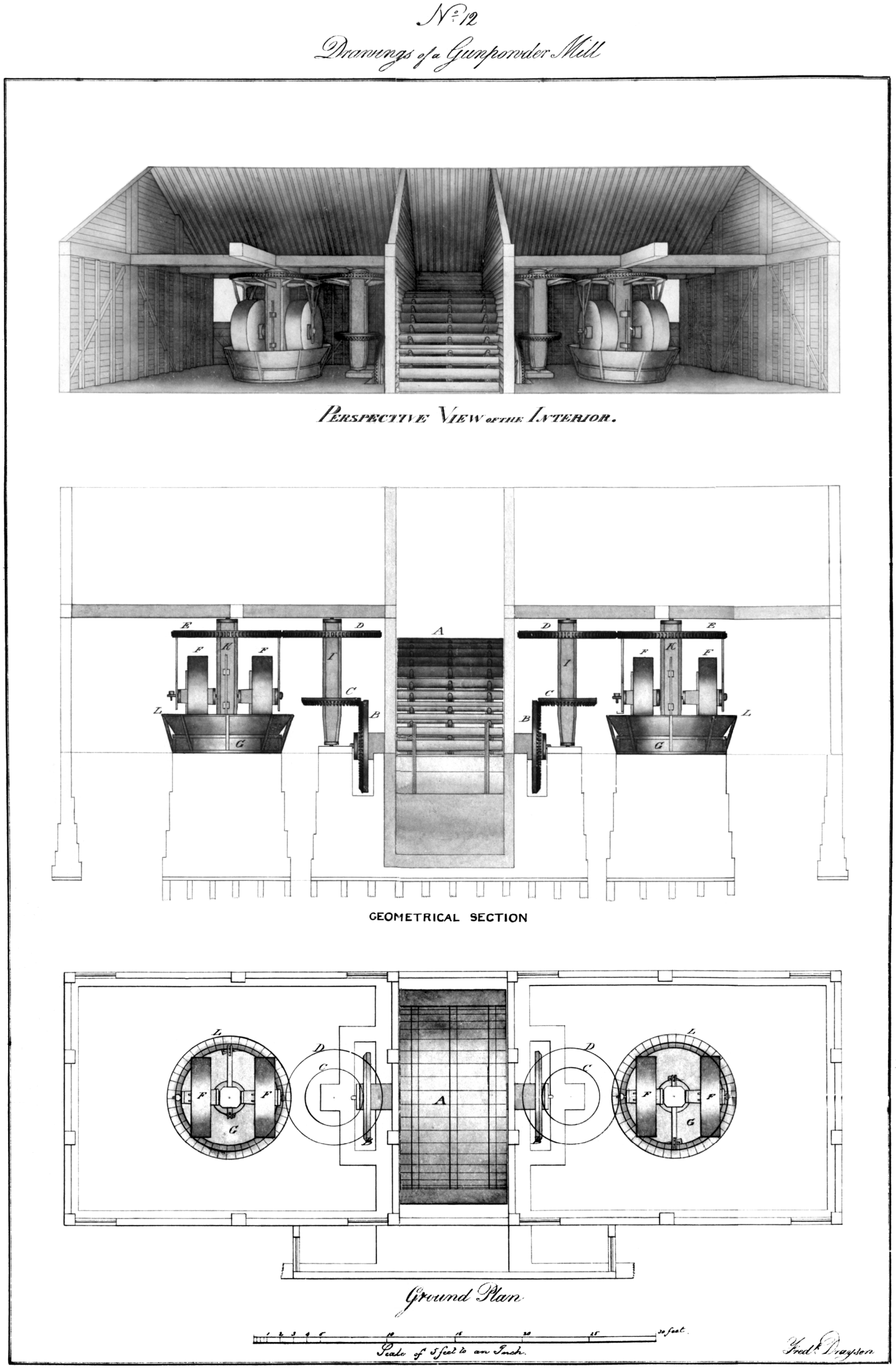
BB are 2 pit wheels 6 feet 10 inches in diameter and each has 72 cogs (in all millwrights work the wheels are calculated according to the number of cogs or teeth). These wheels are fixed upon the water wheel shaft, and make 5 1/3 evolutions per minute.
CC are 2 wallow nuts fixed upon the upright shafts I, and are turned by the pit wheels B, they are 4 ft 4 in in diameter, each has 44 cogs, and each makes 8 ¾ revolutions per minute.
DD are called the cross? wheels or the wallows, being fixed upon the same shafts; they are 7 feet 3 inches in diameter, each has 78 cogs, and each makes 8¾ revolutions per minute.
EE are called the crown wheels over the stones, they are fixed upon the shaft
K are 8 feet 1½ inches in diameter, each has 90 cogs, and each makes 7½ revolutions per minute.
FFFF are 4 circular stones, about 6 feet in diameter, 1 foot 6 inches thick and each weighs about 3½ tons. These are called the stone runners.
GG are 2 circular stones, about 8 feet 3 inches in diameter, 1 foot 2 inches thick, and each weighs about 3½ tons; they are called the stone beds are laid horizontally, and 2 stone runners run round upon each stone bed.

Some of the stone beds and runners have been procured from Numur? in Flanders, others from Ireland, and a few from Wales.

No. 11
Drawings of a Charge Magazine



Drawing 11


No 12
Drawings of a Gunpowder Mill
Perspective View of the Interior.
GEOMETRICAL SECTION
Ground Plan
Scale of 5 feet to an Inch
Fredk Drayson

Drawing 12

The stone runners F are turned by two iron spindles, one of which passes through a wooden box in the centre of each of the two stone runners upon each stone bed, and through one of the shafts K. The spindles are 8 feet 6 inches long, 4 inches in diameter, and each weighs about 5 cwt. The shafts I, and K, work into step brasses at bottom, and are fitted to the tie beams at the top by two coupling brasses. The step brasses into which the shafts K work, are fixed into wooden boxes, raised about 6 inches above the stone beds, and are surrounded by a circular piece of wood called a cheese which is about 2 feet 6 inches in diameter, 3 inches thick, and forms the inside of the track of the stone runners upon the stone beds; the curbs marked I, are fitted into grooves near the outer edge of the stone beds, and form the outsides of the tracks of the stone runners. Two pieces of wood called ploughs are fitted between the stone runners, upon each stone bed, one on the inside next to the cheese, and one on the outside next to the curb, which move round with the runners, being fixed to the shaft K, and keep the composition in their track. Every gunpowder mill has a clock, which is kept going by a lever applied to the water wheel shaft, and each revolution of the water wheel advances the clock work? by 12 seconds.

All the gunpowder mills have two stone beds, and two pairs of stone runners, which require a supply of water equal to the power of 8 horses to make the stone runners run round upon the bed stones 7½ time per minute.

Utensils used in a gunpowder Mill and shewn on the drawing numbered 13.

F, A stone runner 6 feet in diameter, 1 foot 6 inches thick, weighing about 3½ tons; it is used to amalgamate the composition.
G, A stone bed 8 feet 3 inches in diameter, 1 foot 2 inches in thickness, and weighs about 3½ tons; upon this stone the composition is amalgamated by the stone runners F.
H, An iron spindle which turns the stone runners F, it is 8 feet 6 inches long, 4 inches in diameter, and weighs about 5 cwt.
a, A copper water pot for liquoring the composition.
b, A rake for raking the composition.
c, A wooden shover for occasionally moving the composition.
d, A brush for sweeping the curb, and collecting the mill charge from under the stone runners.
e, A wooden scuppit for removing the mill charges from the stone beds.
f, A scotch or block for stopping the stone runners.
g, A charge tub for conveying the powder to, and from the gunpowder mills.
h, A piece of leather which is laid under the stone runners, whilst the mill charges are being put on, and taken off the stone bed.
I, An inside plough for keeping the mill charge in the track of the stone runners, the underside lined with fearnought.
k, An outside plough the underside of which is also lined with fearnought, used for the same purpose.
l, A copper hoe, used in taking the mill charge off the stone beds.

In this process a charge of 42 lbs is laid upon each of the stone beds to be worked at one time, and about 3 pints of water are put to each charge, this quantity however, varies according to the state of the atmosphere, more being required in dry and less in wet weather. After the charge has been liquored, it is raked over with the rake b, and spread upon the stone bed about half an inch thick; the water wheel gate is then lowered (if it is a sinking gate) and a sufficient quantity of the water in the mill head is allowed to fall upon the float boards of the water wheel as will cause the stone runners to make 7½ revolutions round the bedstone in a minute. At this seed the stone runners continue running upon the powder for the space of 3 hours during which time they make 1350 revolutions upon the stone bed; one man attends the two pairs of stones, occasionally sweeping the dust off the curb with the brush d, and moving the charges with the shover c. After 3 hours working, the mill is stopped, and the composition having become mill cake, is collected into two heaps between the stone runners; two pieces of leather similar to those marked h, are then placed upon that part of the stone bed, from which the mill cake has been cleared, and a scotch f, is placed at the edge of one of the pieces of leather to stop the stone runners, and prevent their coming in contact with the stone bed; a small quantity of water is then let upon the water wheels and the stone runners are turned on to the leathers. The powder which was under the stone runners is then collected together, and the whole of the mill cake is put into a charge tub, and returned to the charge magazine.

The expense of erecting a gunpowder mill similar to the foregoing would be £2500.

A gunpowder mill in perfect order with two pairs of stone runners, works off two charges of 42 lbs each, in 3 hours, and 14 charges in 24 hours; so that 14 x 42 or 588 lbs the quantity of composition which may be incorporated by one mill during one day and night. But if the mill works during the day only, not more than 6 charges of 42 lbs or 258 lbs are incorporated. Supposing therefore there are 300 working days in a year including Sundays, then 588 x 300 days 176400 lbs, or 1764 barrels of mill cake incorporated per annum if the mill works day and night; but if the mill works during the day only, then 252lbs x 300 days = 75600 lbs, or 736 barrels incorporated annually.

In the process of forming the grains about 2/7 of the mill cake is reduced to a fine dry powder, which must be reworked at the gunpowder mills before it can be made into grains. It is therefore reworked in quantities of 42 lbs under each pair of stones, in the same manner as new composition for 1½ hours, being half the time it was worked in the first instance; and therefore 1/7 must be deducted from the foregoing quantities of 1764 and 7 6 barrels to allow for reworking the dust which will leave a total of 1512 barrels of gunpowder incorporated per annum if the mill works day and night; and 648 barrels if it works during the day only.

The expense of amalgamating 1512 barrels of gunpowder when the mill works day and night would be £540 detailed as under.

		per bbl of gunpowder
Interest upon £2500 the first cost of the}	£	£ ..s.. d
building at £4 per cent per annum }	100, or	-.. 1.. 3¾ - '4920634+
Water power equal to 8 horses	320, or	-.. 4.. 2¾ - '1746031+
The daily pay of 2 men	80, or	-.. 1.. 0½ - '7936507+
Repairs to the building and machinery	40, or	-.. -.. 6¼ - '3968253+
Total	£540, or	-.. 7.. 1½ - '8571425+

The expense of amalgamating 648 barrels of gunpowder when the mill works during the day only would be £490 detailed as under.

		per bbl of gunpowder
Interest upon £2500 the first cost of the}	£	£ ..s .. d
building at £4 per cent per annum }	100, or	- .. 3.. 1x - '1481+
Water power equal to 8 horses	320, or	-.. 9..10½ - '0740+
The daily pay of 1 man	40, or	-.. 1.. 2¾ - '2592+
Repairs to the building and machinery	30, or	-.. -..11 - '4444+
Total	£490, or	-..15.. 1¼ - '9257+

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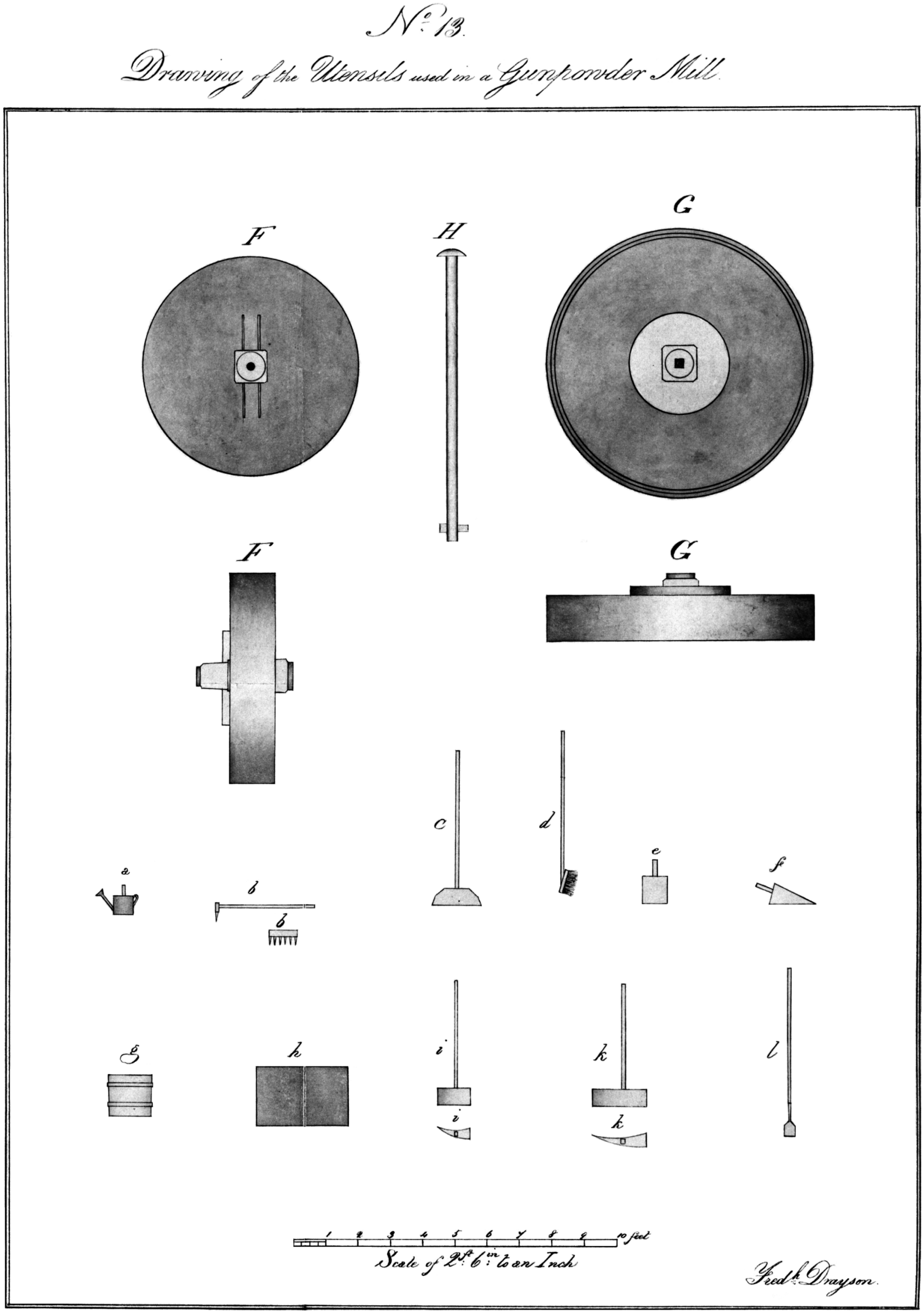
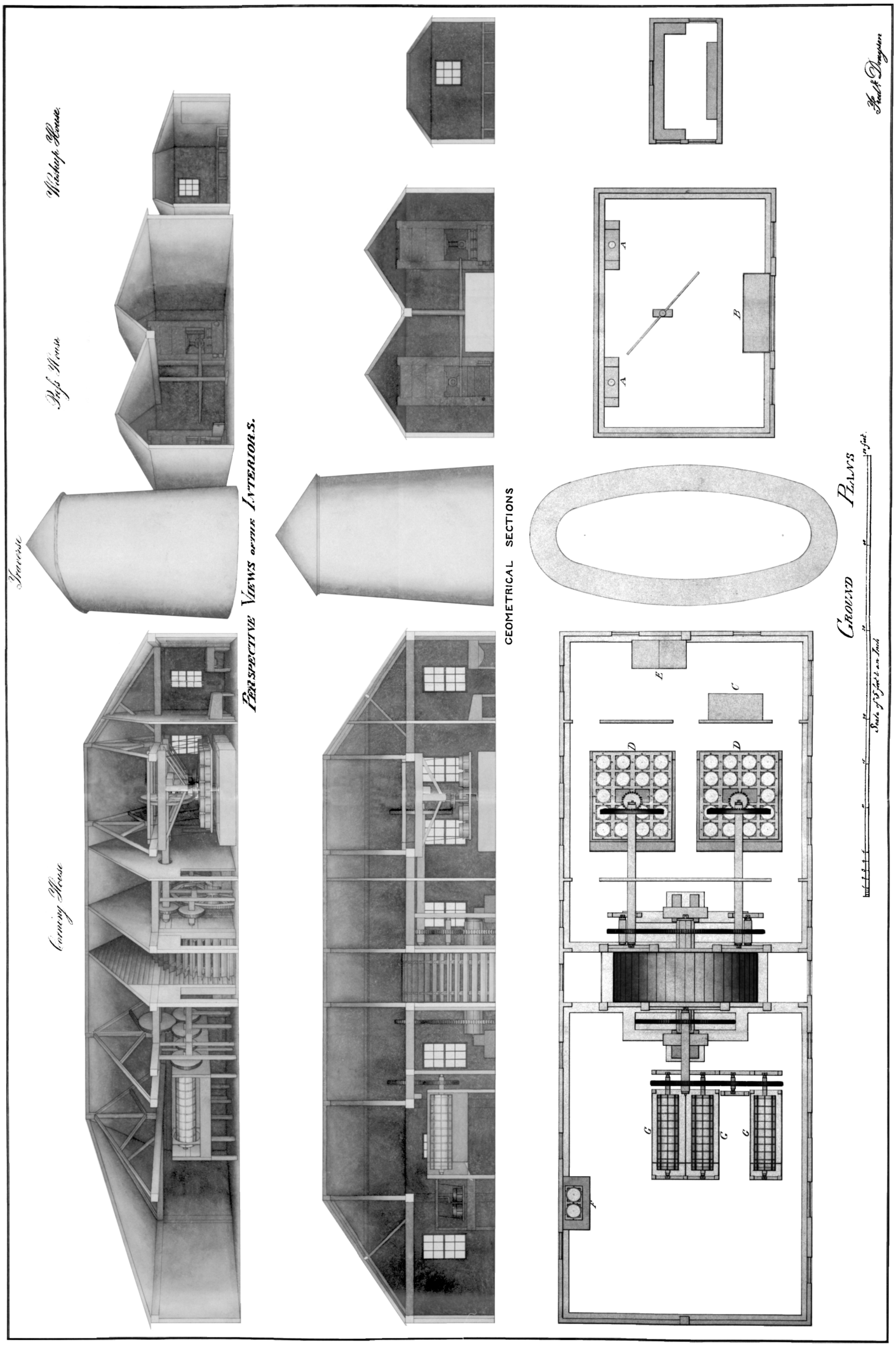

No. 13.
Drawing of the Utensels used in a Gunpowder Mill.
F
H
G
F
G
c
d
a
b
b
e
f
g
h
i
i
k
k
l
1 2 3 4 5 6 7 8 9 10 feet
Scale of 2ft. 6in. to an Inch
Fredk. Drayson.

Drawing 13



Drawing 14

Process of manufacturing Mill Cake into Grain

There are two kinds of buildings in which this operation is carried on, one having shaking frames for reducing the fine powder to grains, & the other a machine invented by the late Sir Wm. Congreve. The powder granulated by the former machines is pressed in screw presses, and that which is granulated by the latter, is pressed in Bramah's hydraulic presses.

Process carried on in a Corning house working Shaking Frames.

The buildings connected with a corning house working shaking frames are
A washup House
A Press House
A Traverse, and
A Corning House.

The Washup House is a wooden building, 14 feet long, 8 feet wide, and has a slated roof. In this building the workmen change their dresses and wash themselves after they have done their work in the Press and Corning houses.

The Press house, is a wooden building 28 feet long, and 20 feet wide, the roof is slated, and the floor is covered with tanned hides. It contains 2 presses marked A, in the drawing numbered 14, each worked by a screw for pressing the mill cake, and a breaking bin marked B, for breaking the pressed powder into small pieces called chucks, before it is put into the sieves upon the shaking frames. The presses are made of wood, the screws are of iron, and the saddles which receive the nipples of the screws, are of gunmetal, and are fixed to the wooden saddles which press the powder. The cheeks of each press are 14 feet long, 1 foot 8 inches wide, and a foot thick; they are also 3 feet 6 inches apart, and are placed upon a strong foundation of brickwork; the chambers in which the powder is pressed, are lined at the backs and sides with false cheeks about 1 ½ inch thick, and are each 3 feet 3? inches long, 1foot 8 inches wide, being rather narrower at the back part than at the front, and the bed or bottom of each chamber is about 6 inches above the floor of the building. The iron screw of the press is 6 inches in diameter, and the threads are 3/8 of an inch apart, each weighs about 4 cwt, and is turned by a lever 8 feet in length. The rule for ascertaining the amount of pressure given by the screw is as follows.

The screw must be turned once round before the resistance can be moved from one thread to another, and if it is turned by a lever, as much as the circumference of the circle described by the handle of that lever, is greater than the distance between the threads of the screw, so much does it multiply the force applied. Therefore, the distance between the threads of the screws of the presses in the press house being 3/8 of an inch, and the length of the lever applied to turn them being 8 feet, the circle described by the handle of the lever where the power is applied, is 603 inches, or 1608 times greater than the distance between the threads and consequently the power of a man at the end of the lever is multiplied 1608 times. The capstan is also used in this building, and is 9 inches in diameter, the lever applied to turn it is 6 feet in length, and consequently multiplies any force applied to it 16 times.

The breaking bin is 9 feet in length, and 2 feet 9 inches broad, and for the purpose of better resisting the blows of the mallet, the bed upon which the pressed powder is beaten is made of pieces of elm or beech, glued together with the ends of the grain upwards.

Utensils used in the Press House and shewn on the drawing numbered 15.

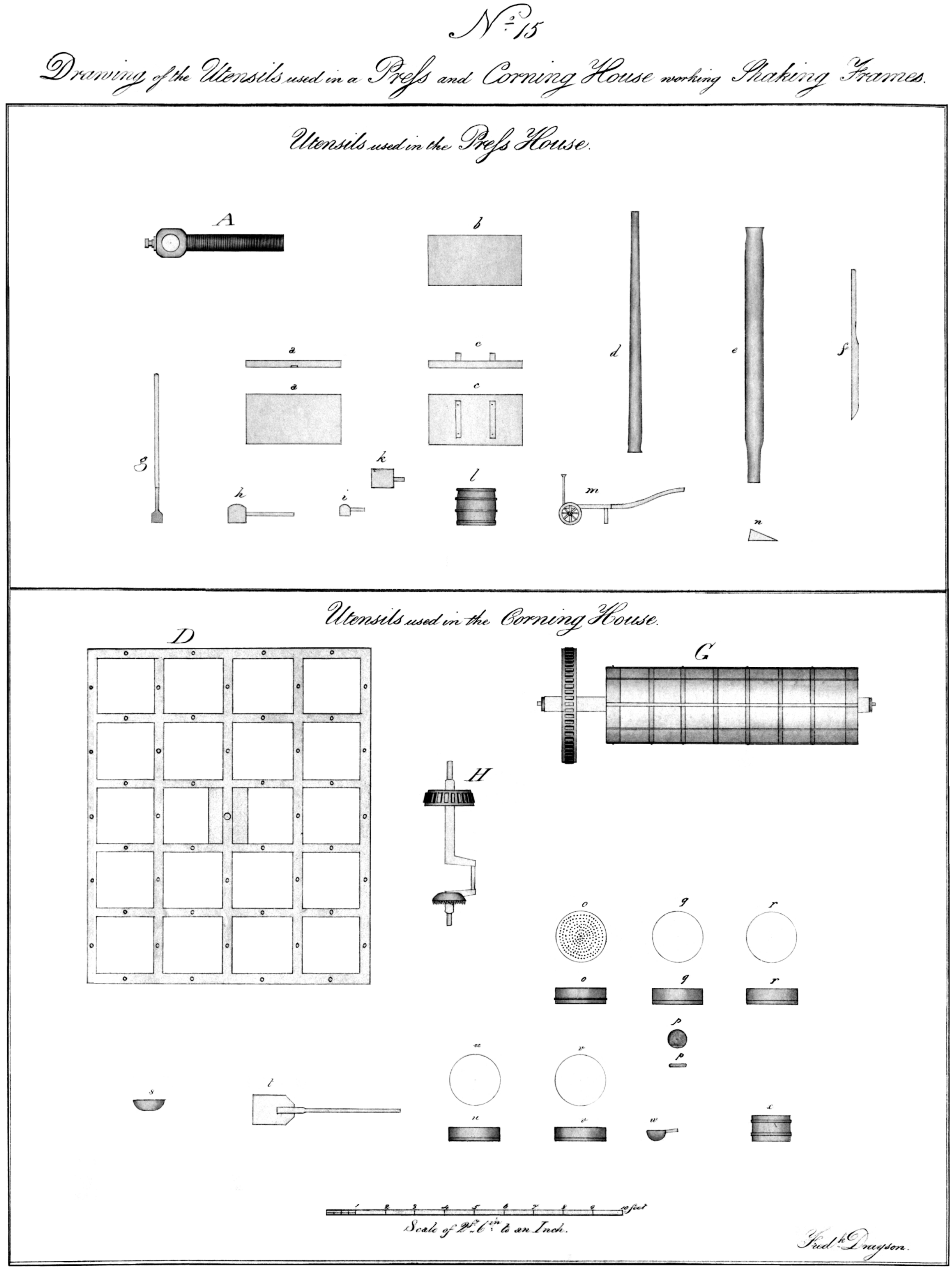
A, A screw for pressing the mill cake, it is about 4 feet long, 6 inches in diameter, the threads are 3/8 of an inch apart, and it weighs about 4 cwt
a, A false bed for the press, the upper side is lined with sheet copper.
b, A copper plate about 1/16 of an inch thick, used for separating the mill charge

in the press.
c, A wooden block called a follower, which is laid upon the mill charges when they are in the press.
d, A wooden lever for turning the press screw.
e, A large wooden lever for turning the press screw.
f, A small lever for unloading the presses.
g, A copper hoe with a wooden handle, for separating the press cakes from the copper plates, and cleaning out the chambers of the presses.
h, A large wooden mallet for breaking the press cakes into chucks upon the breaking bin.
i, A small wooden mallet for breaking those chucks still smaller.
k, A wooden scuppit for removing the broken press cake from the breaking bin, and putting it into tubs.
l, A tub or barrel for conveying the broken press cake from the press house to the corning house.
m, A barrow for conveying the tubs containing the broken press cakes from the press house to the corning house.
n, A wedge used in unloading the presses.

The Traverse is a brick building of an oblong form about 35 feet in length, and 16 feet in breadth, the walls are 3 feet thick at the bottom, the outer sides gradually sloping from the base to the summit, the thickness at which is 1 foot 6 inches, the inner sides are built up straight, and the inside is filled with earth; pieces of bond timber are laid across it at different parts to keep the walls from bulging. Should either the press or corning house explode, the traverse is intended to break off the flame, and prevent its setting fire to the other.

The Corning House is a wooden building 79 feet long, and 28 feet broad, the roof is slated, part of the floor is covered with tanned hides and the remainder with painted canvass. It contains 2 shaking frames marked D, in the drawing numbered 14, for reducing the broken press cakes to grains, and 3 reels marked G, for glazing the large grains; there is also a separating bin and hopper marked E, a bin for receiving the chucks from the press house marked C, and a small frame marked F for granulating a small quantity of each mill charge before it is pressed. The shaking frames are made of wood, are each put in motion by an iron crank having a throw of 9 inches and weighing about 2 cwt; and are supported by ropes at the corners, which are tied to the beams above. Upon each frame there are 36 sieves, 18 of which have their bottoms made of parchment with a number of small holes punched therein, and the remaining 18 have their bottoms made of reel cloth of 24 meshes to the inch; the parchment sieves are put into the others so as to form a double sieve, and in each of the former therefore 2 pieces of lignum vitae wood, called runners weighing 2 lbs each, whose forms are sections of a spheroid flat at top and bottom. The reels are each 8 feet 6 inches long, and 2 feet 6inches in diameter; they are covered with cyphrus silk, or reel cloth of 24 meshes to the inch, and are enclosed in wooden cases to prevent the dust from floating about the building during the operation of glazing the large grain. The whole of the foregoing machinery requires the water power to work it equal to that of 4 horses.

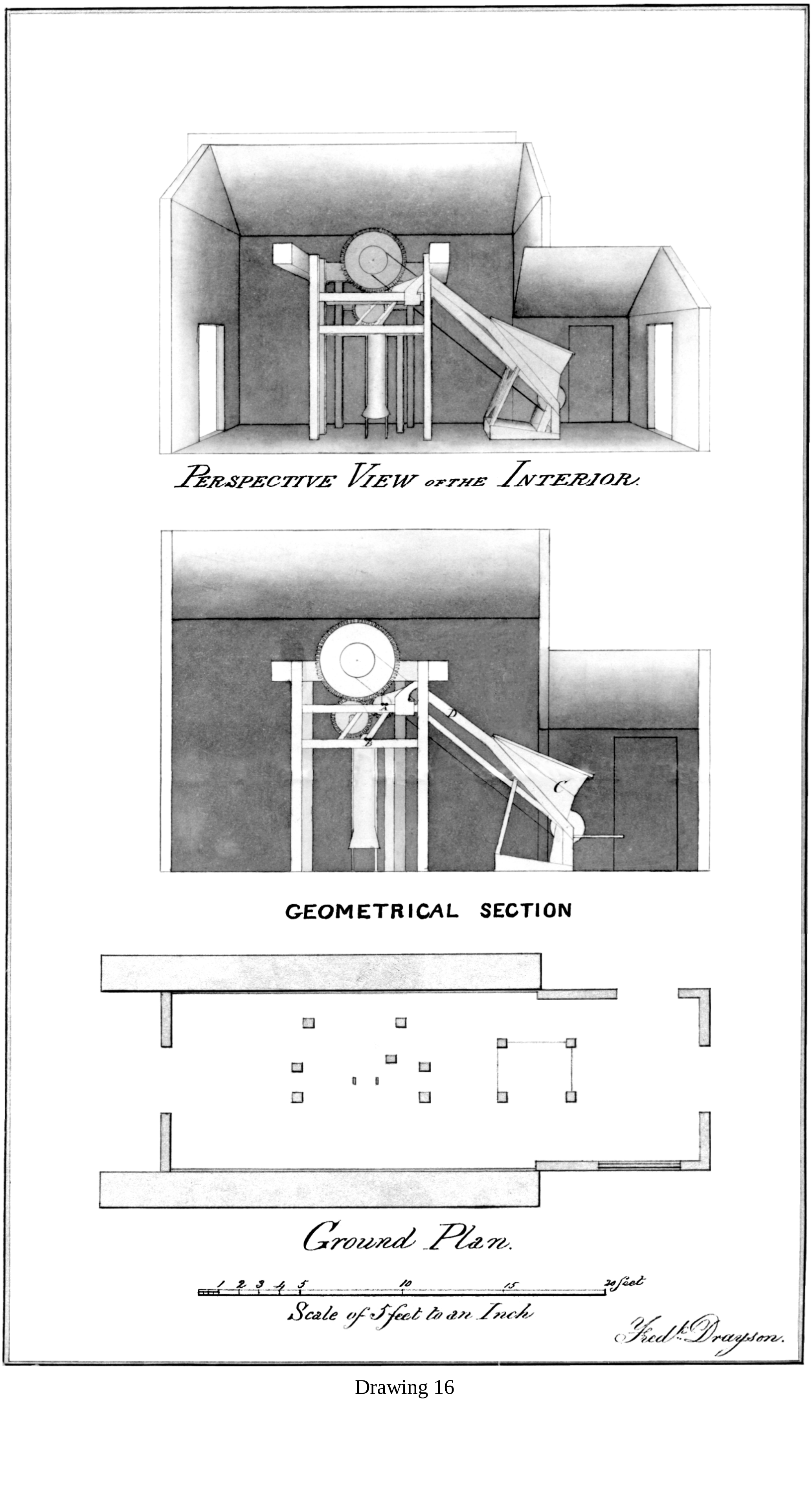
These buildings do not stand close to the river, upon the banks of which they are built, but there is sufficient space between for the workmen to go from one building to the other; this space is boarded, and is called the platform, and when the powder is brought to, or taken from these buildings pieces of tanned hide are laid upon it, so that the powder barrels do not come in contact therewith.


No 15
Drawing of the Utensils used in a Press and Corning House working Shaking Frames.
Utensils used in the Press House.
Utensils used in the Corning House.
D
G
H
Scale of 2Ft. 6In. to an Inch.
Fredk Drayson.

Drawing 15

No. 16.

Drawings of the Building for Breaking Mill Cake.



Drawing 16

Utensils used in the Corning house and shewn on the drawing numbered 15.

D, A shaking frame made of wood, upon which the sieves are placed, for reducing the press cake to grain.
G, A reel for glazing the large grain, it is lined with reel cloth, or cyphrus silk of 24 meshes to the inch.
H, An iron crank and nut for turning the shaking frames, the crank has a throw of 9 inches, and weighs about 2 cwt.
o, A sieve having the bottom made of parchment with a number of small holes punched in it of about 1/8 of an inch in diameter, in these sieves the chucks are broken into grain by the lignum vitae runners.
p, A lignum vitae runner, it is about 5 inches in diameter, one inch thick and weighs 2 lbs.
q, A sieve having the bottom made of reel cloth of 24 meshes to the inch, which lets through the grain and dust, and retains the large grain; this sieve is first put upon the shaking frame, and the sieve o, is put into it.
r, A sieve for separating the dust from the fine grain, the bottom is made of cyphrus silk of 60 meshes to the inch.
s, A bowl with which the broken press cake is thrown into the parchment sieve.
t, A scuppit for loading the sieves r, with dust and fine grain.
u, A sieve for separating the chucks from the large grain, at the separating bin, the bottom is made of brass sieve cloth of 8 meshes to the inch.
v, A sieve for separating chucks from the fine grain at the separating bin, the bottom is made of brass sieve cloth of 24 meshes to the inch.
w, A copper bowl used for putting large or fine grain into the separating sieves u, and v.
x, A tub for receiving the dust from the reel cases.

In the operation of pressing the mill cake, the false bottom or bed a, is first put into the chamber of the press, and the door is fastened; 2 mill charges weighing 84 lbs are then put into the chamber upon the false bed a, and the larger pieces are broken with the large mallet h, one of the copper plates b, is then laid upon the powder in the press, and 84 lbs more of mill cake are put in upon the copper plate, and in this manner 504 lbs of mill cake are put into the chamber of the press, a copper plate being laid between every 84 lbs. The follower c, is laid upon the last 84 lbs and a number of blocks are placed upon the follower c, between that and the wooden saddle of the press. The screw supporting the wooden saddle is then lowered as far as two men can turn it with the lever d, after which the large lever e, is put through the eye of the screw, turned by a rope from the capstan, and the screw is further lowered, as far as one man can turn the lever, with the aid of the capstan, and by this means the powder receives a pressure of 574 tons upon the whole surface of the chamber, which is equal to 106 tons upon each superficial foot; when the mill cake is first put into the press, it fills the chamber about 1 foot 10 inches high, but after it has received the foregoing amount of pressure, it is reduced to about one foot thick, and each portion of 84 lbs has become what is termed a press cake, varying from 1 ¾ to 2 ¼ inches thick.

In unloading the press, the screw is raised to its original position, and the blocks are taken off the follower c, the door of the press is then opened and one end of the lever f is put under the centre of the false bottom a, where there is a notch for that purpose, and the press man stands upon the other end, and sways the whole of the powder up and down, until it is loosened from the sides of the press; after the powder has been raised about 3 inches from the bottom of the press, the wedge n, is put underneath the false bottom a, the lever is then put between the powder and the back part of the press to force the powder out of the press chamber. When this is accomplished the cakes are set up edgeways, for they all come out of the press together, and are separated by 2 or 3 smart blows from the wooden mallet; about 40 lbs of the press cake is laid upon the breaking bin at a time, and it is broken with the wooden mallet k, into pieces about ¾ of an inch square, and afterwards with a small mallet I, until there are no pieces larger than a hazel nut. This operation of breaking the press cake produces as follows.

Of chucks, pieces too large for grain		63 per cent
Large grain and fine grain		24½ per cent
Dust		12½ per cent
	Total	100

The whole of the chucks, grain, and dust, however, are collected together, taken to the corning house, and thrown into the bin marked C. The water is then let upon the float boards of the water wheel, and the shaking frames are put into motion so that the cranks make from 50 to 55 revolutions per minute, about 1½ lb of the broken press cake is thrown into each of the parchment sieves on the shaking frames with the bowl s, and the lignum vitae runners p, break it into pieces small enough to fall through the holes in the parchment sieves into those under them, which retain the large grains called common powder, whist the fine grains and dust, fall through the lower ones also, and are caught upon the smacks on the bins underneath. When the cranks move with too great velocity, the runners attach themselves to the sides of the sieves, and produce little effect, and when a much less degree of velocity is produced, the blows given by the runners are not of that sharp kind from which a fine strong bodied gunpowder would be produced. When the broken press cake is thrown into the sieves, that portion which was reduced to dust upon the breaking bin, floats about the building by the action of the frames, creating those clouds of dust which render this process so extremely dangerous. The sieves are kept supplied with broken press cake from the chucks and every 15 minutes the frames are stopped in order to ascertain if the bearings of the cranks have become heated. In about an hour 50 lbs of the broken press cake may be reduced to grain; the frames are then stopped, the parchment sieves are taken out of the lower ones, and the frames are again made to work a few times to clean the large grain of dust, after which it is collected from the several sieves, and put into the separating bins, to have any chucks that may be with it, separated from it; eight sieves similar to the one described are then put upon each of the shaking frames in place of eight which are taken off, the fine grain and dust are collected together into the troughs by the sides of the bins under the shaking frames, and are put into those sieves; the frames are again set in motion, and the dust separated from the fine grain, falls upon the smacks, and the grain remains in the sieves; afterwards the frames are stopped, the fine grain is collected into barrels and taken to the separating room, the dust is taken into the reel room, weighed into charges of 42 lbs, and sent to the gunpowder mills to be reworked into mill cake.

After the fine grain has been brought into the separating room, it is taken to the separating hopper, and run through the sieve v, if there are any chucks, they are separated from the grain and are thrown into the bin C, the fine grain falls thro’ the hopper into barrels, and is afterwards taken to the dusting sieve. The large grain is also run through the sieve u, to be separated from the chucks, and is afterwards taken to the reel room to be glazed.

In the process of glazing, about 2 cwt of the grain is put into each reel at one time, and these machines are made to turn upon their own axis about 10 times per minute for one hour, this operation breaks off the sharp angles and soft parts of the grain, and gives it a bright appearance. At the expiration of one hour the doors at the ends of the reels are opened, and the ends of the reels are lowered about 6 inches so that the powder falls out into barrels, and when a number are so filled, they are sent to the receiving magazine again, from which they are taken to the stoves to be dried.

The produce of each pressing containing 504 lbs of powder is as follows,

As large grain, or common powder	250 lbs or 49 38/63 per cent
Fine grain, or musket powder	100 lbs or 19 53/63 per cent
Dust	154 lbs or 30 35/63 per cent
Total	504 lbs or 100

The number of men employed in these buildings when they are in full work, are

Foremen, superintending the work	1
Press men, pressing the mill cake	1
Breaking the press cake into chucks upon the breaking bin } and occasionally assisting at the presses and shaking frames}	4
Separating chucks from the large and fine grains and } occasionally assisting at the shaking frames }	1
Attending the shaking frames	1
Boatmen conveying the powder to and from the buildings	2
Total	11

who press and granulate 5 pressings containing 2520 lbs of mill cake per day, and from it produce about 1750 lbs of grain, the remaining 770 lbs being reduced to dust; of this 770 lbs of dust, about 50 lbs are totally lost by floating about the building, settling upon the machinery, and escaping out of the windows, leaving only 720 lbs which can be taken to the gunpowder mills to be reworked as already shewn.

The expense of erecting similar buildings to the foregoing would be as under,

	£
Washup house	100
Press house	870
Traverse	700
Corning house	3030
Total	4700

These buildings are capable of manufacturing 5000 barrels of gunpowder into grain per annum, at an expense of £1890 detailed as under.

		Per bbl of gunpowder	
	£	£.. s.. d	
Interest upon £4700 the first cost of } the building at £4 per cent per annum}	188, or	-.. -.. 9x	‘096
One foreman superintending the work	78, or	-.. -.. 8½ -	‘976
The daily pay of 10 men	480, or	-.. 1..11x	’16
Water power equal to that of 4 horses	160, or	-.. -.. 7½ -	’72
Reworking the dust	374, or	-.. 1.. 5¾ -	‘808
Value of the dust totally lost as powder} by settling upon the machinery and } escaping out of the windows }	360, or	-.. 1.. 5¼ -	’12
Repairs to the buildings and utensils	250, or	-.. 1.. x	
Total	£1890, or	-.. 7.. 6½ -	’88

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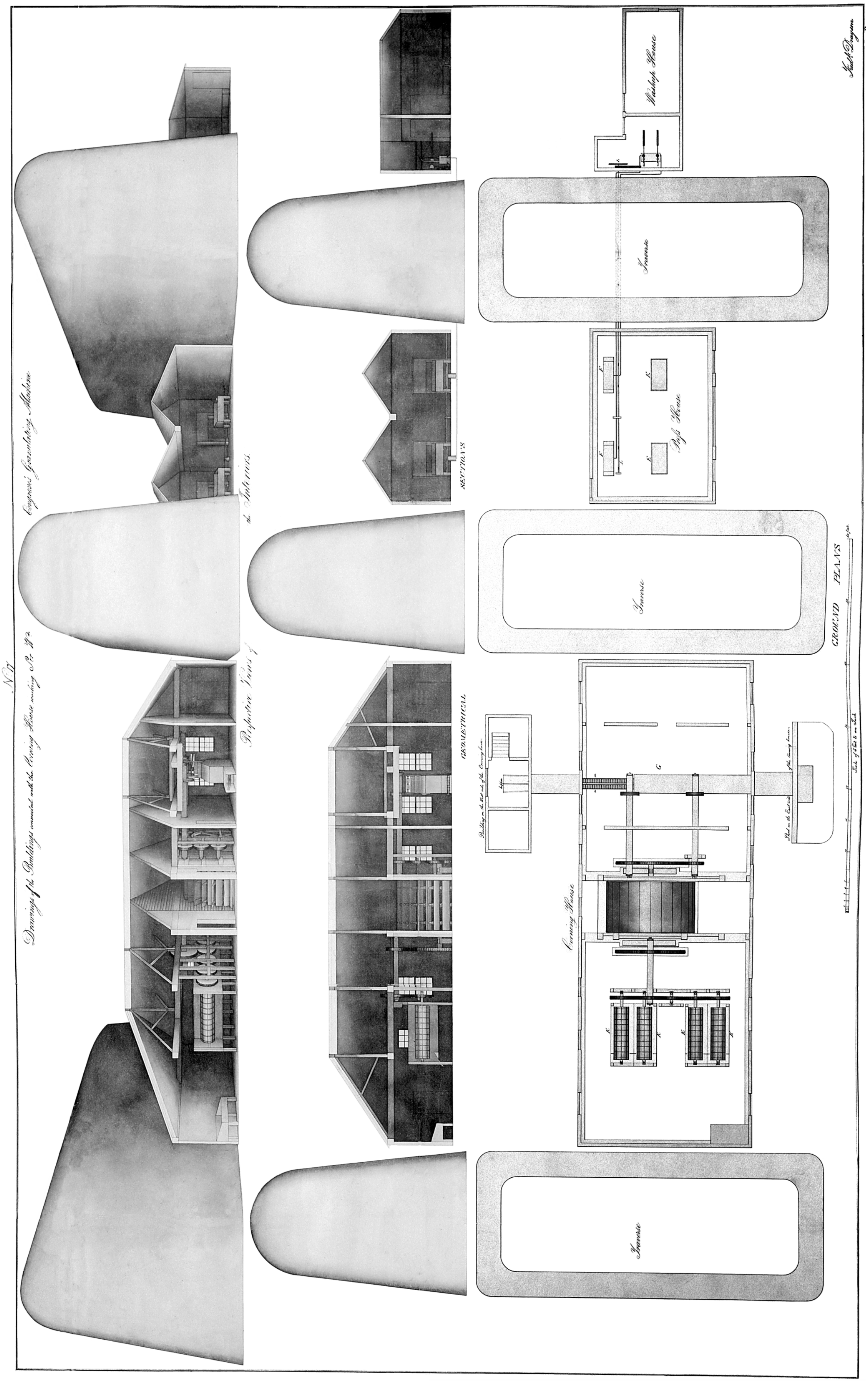
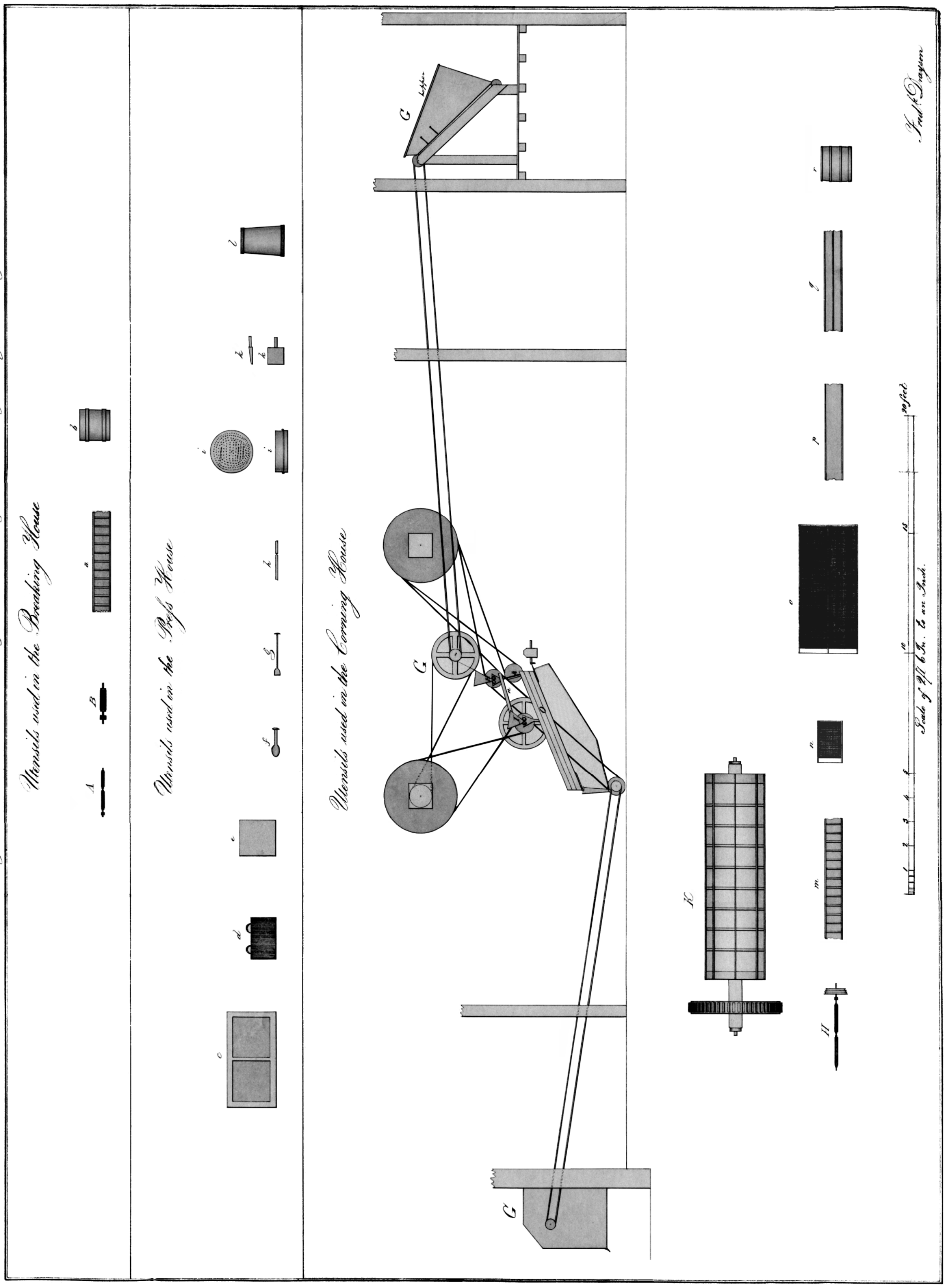

GEOMETRICAL
SECTIONS
GROUND PLANS
Corning House
Traverse
Traverse
Traverse

Drawing 17


No 18
Utensils used in the Buildings connected with the Corning House working Sir Wm Congreve's Granulating Machine
Utensils used in the Breaking House
Utensils used in the Press House
Utensils used in the Corning House

Drawing 18

Process carried on in the Corning House working a Machine
invented by the late Sir Wm. Congreve.

The buildings connected with this corning house are

A building containing a breaking machine for reducing mill cake to dust,
A washup house,
Three traverses,
A press house, and
A Corning house.

The building containing the breaking machine is distinct from the corning house; it is 26 feet long, 9 feet wide, has a boarded roof, and the floor is covered with tanned hides; two of its sides are built of brick, and the remainder of wood, similar to the drawing numbered 16. The breaking machine consists of 2 pairs of gunmetal rollers, with sharp cutting teeth, and one pair is placed about 1 foot 6 inches above the other. The upper pair marked A, are placed ¼ of an inch apart, are 7 inches long, 3 inches in diameter, and the teeth are 3/16 of an inch in length; the lower pair marked B, are placed about 1/8 of an inch apart, and are 1 foot 10 inches long, 1½ inch in diameter, and the teeth are 1/8 of an inch in length. The rollers are supplied with mill cake from the hopper marked C, by a band made of web cloth, and in the upper part of the hopper there are copper flaps, which only allow one thickness of mill cake to be dropped between the rollers at one time. This machinery is worked by water, and requires a power equal to that of one horse.

Utensils used in this building and shewn on the drawing numbered 18.

A, One of the upper pair of gunmetal rollers.
B, One of the lower pair of gunmetal rollers.
a, A piece of the band which supplies the rollers A and B, with mill cake from the hopper C.
b, A barrel for carrying the powder to the press house.

The Washup House is a wooden building 25 feet long, 9 feet wide and the roof is slated. It is divided into two parts, one of which is used by the men as a washing house, and the other contains the pumps and cisterns for working the hydraulic presses in the press house; the pipes through which the water is injected into the large pistons of the presses, passing through the brick traverse which is between the washup house and the press house; the floor of this part of the building is covered with tanned hides.

The Traverses are of a rectangular form, the corners are slightly rounded off and the tops are turned with brickwork, they are each about 60 feet long, 20 feet wide, and 40 feet high; the outsides are built of brick, and the interiors are filled with earth, and thus form a solid mass, and pieces of bond timber tie the walls together, and prevent them from bulging. One is situated between the washup and press houses, another between the press and corning houses, and the third at the other end of the corning house.

The Press House is a wooden building 28 feet long, and 20 feet wide the roof is slated and the floor is covered with tanned hides. It contains two bins marked E on the drawing numbered 17, a hopper, and 2 presses marked F, each worked by one of the Brahmah's hydraulic pumps. The power of these hydraulic pumps is much less than the power of a screw, but the powder is pressed in thinner cakes, and therefore is about equal in density to that which is pressed in thicker cakes in the screw presses.

The power of hydraulic pumps depends upon the sizes of the injecting pipe and the working piston, and the length of the pump handle or lever, the amount of pressure given to the powder in these presses may therefore be ascertained as follows.

The injecting pipe is one inch in diameter, the working piston is 10 inches in diameter or 100 times as large as the injecting pistons, the pump handle is 16 times longer in the long fulcrum, than it is in the short fulcrum, multiplying any weight applied to the end thereof 16 times, and two men usually work it, whose united weights may be calculated at 24 stone or 336 lbs.

Therefore 1x100x16x336 will give 537600 lbs or 240 tons. The friction or resisting power is equal to 1/8 of the whole pressure, deducting which from the before mentioned 240 tons, will leave 210 tons as the total amount of pressure applied to the powder in each press.

Each press has 2 boxes together equal to a surface of 4 ½ feet, which are worked into and out of their places by a pinion upon a revolving spindle, that operates upon a rack at the bottom of the boxes; the spindle passes in front of both presses, and through the traverse into the washup house, & is marked L.

Utensils used in the Press House and shewn on the drawing numbered 18.

c, Two press boxes made of 2 inch oak plank, two of their sides may be removed and the other two are fast.

d, A comb, rack, or guide, put down the sides of the press boxes, to keep the copper plates at equal distances apart, whilst the powder is being filled into the space between them.

e, A copper or gunmetal plate 1 foot 8 inches long, 1 foot 6 inches wide, and 1/8 of an inch thick, used for separating the powder into thin layers, or cakes, whilst it is being pressed in the press boxes. Each box has 2 sets of plates, 32 to a set, and each plate weighs 18 lbs, but only one set is used at a time.

f, A wooden mallet, }
g, A copper chisel, } used in separating the press cake from the copper plates.
h, A copper knife, }

I, A sieve for separating chucks from the broken mill cake, the bottom is made of parchment, in which are a number of small holes ¼ of an inch in diameter.

k, A copper scuppit for receiving sweepings.

l, A tub made from a willow tree, the inside being hollowed out, it has a copper hoop round it at the top and bottom to keep it from splitting, and it is used for carrying the pressed powder from the press house to the hopper in the building on the west side of the corning house.

The Corning House is a wooden building 79 feet long, and 28 feet wide, the roof is slated, and the floor is covered with tanned hides. It contains a machine for granulating the press cake marked G, and four reels for glazing the large grain marked K. On the west side is a temporary building containing a hopper supplying the granulating machine with press cake; and on the east side is a small shed, into which the powder is carried upon bands from the granulating machine. The granulating machine consists of two pairs of gunmetal rollers with sharp cutting teeth, and one pair is placed above the other, they are turned by catgut bands, and make 120 revolutions per minute. Each roller is 2 feet 6 inches in length, and 1½ inch in diameter; the teeth of the upper pair are 1/8 of an inch, and those of the lower pair are 1/16 of an inch long; these cutting teeth however, do not extend the whole length of the rollers, but are divided into rows about 1/8 of an inch wide, by grooves of the same dimensions, and the teeth of one roller are opposite to the grooves in the other; the upper pair of rollers are 1/8 of an inch and the lower pair are 1/16 of an inch apart. Under the upper pair of rollers there are two small screens covered with brass wire cloth of 8 meshes to the inch; and under these and also under the lower pair of rollers, there is a nest of screens for separating the grains as they fall from the small screens and from the lower pair of rollers; the uppermost screen is covered with brass wire cloth of 8 meshes to the inch, the second with wire cloth of 24 meshes to the inch, the third with wire cloth of 48 meshes to the inch, and under this last screen is a board for catching the dust; these and the two smaller ones are fastened together, and have a slight inclination so that the grain and dust may drop off the lower ends, and the whole receive a joggling motion from a small wheel with 2 nogs?. There are two bands from the building on the west side of the corning house to the granulating machine, and three bands from hence to the shed on the west side; the chucks and large grain are carried away on separate bands, and the fine grain and dust upon the same band, which is divided into two parts, by a strip of leather sewn down the middle. The reels are similar to those in the corning house working shaking frames.

Utensils used in the Corning House and shewn on the drawing numbered 18.

G, A section of the rollers, screens &c of the granulating machine.
H, A gunmetal roller with sharp cutting teeth for cutting the press cake into grain.
K, A reel for glazing the large grain.
m, A piece of band for carrying the press cake from the hopper in the building on the west side of the corning house to the gunmetal rollers of the granulating machine.
n, A small sieve placed under the upper pair of rollers.
o, One of the sieves for separating the different sized grains from each other, as they fall from the gunmetal rollers of the granulating machine.
p, A piece of the band for conveying either the chucks, or the large grain from the granulating machine, to the shed on the east side of the corning house.
q, A piece of the band which conveys the fine grain and dust from the granulating machine, to the shed on the east side of the corning house.
r, A barrel or tub for conveying the powder to the receiving magazine and dusting house.

In the process of granulating at this corning house, the mill cake is reduced to dust before it is pressed, and this operation takes place in the breaking machine house. The mill cake is put into the hopper marked C, on the drawing numbered 16, and the band which passes through the hopper conveys it up the trough marked D, and drops it between the upper pair of rollers marked A, which break or nip it in small pieces; these fall down a board divided into grooves, drop between the lower rollers, and by them are reduced to a powder, which falls down the trough underneath into barrels, and is taken to the press house. There the press boxes are removed from the presses by turning the pinion upon the revolving spindle in the washup house, and are turned upon their sides; two of the racks d, are placed opposite one another in each box, and as many of the copper or gunmetal plates marked e, as the grooves in the racks are intended for are put into each box, and the spaces between them are filled in with the broken mill cake; the racks are then taken out of the press boxes, and the latter are returned to their places in the presses by turning the pinion upon the revolving spindle marked L. When the broken mill cake is being filled in the spaces between the copper plates in the press boxes, the copper plates stand up edgeways, the boxes then laying upon their sides, but when the powder is being pressed, they lay flat, because the boxes have been turned from their sides to their bottoms. The men who have been employed in loading the press boxes now go into the washup house, and continue pumping at the two pumps until the powder between the copper plates in the press boxes of each press, has received a pressure of 210 tons, being about 47 tons upon each superficial foot. The press boxes are then turned out of their places as before, and the powder between the copper plates having become press cake of about ¼ of an inch thick, is taken out of the press boxes, and separated from the copper plates by the wooden mallet f, or the chisel g, or the knife k, is put into the tub I, and taken to the building on the west side of the corning house. The hopper in this building is occasionally supplied with the press cake, and the two bands marked m, in the drawing numbered 17, convey it to the granulating machines; here the press cake drops from the bands, and falls between the upper pair of gunmetal rollers marked H, in the section of the granulating machine on the drawing numbered 18, and is broken, some of it into chucks, and the remainder into grain and dust; the whole of it then falls upon the two small sieves underneath marked n, the grain and dust run through the wire cloth of these sieves, and fall in the nest of sieves marked o, whilst the chucks by the joggling motion run to the lower ends of the small screens, and drop between the lower pair of rollers marked I, are also reduced to grain and fall upon the nest of screens underneath, which separate the different sized grains from each other, and from the chucks and dust; the upper screen retains the chucks or pieces too large for grain if there be any, and lets through the grains and dust; the second screen retains the large grain and lets through the fine grain and dust; the third screen retains the fine grain and lets through the dust, which is caught upon the board underneath. The chucks, large and fine grain, and dust, fall off the lower end of the screens, upon the band appropriate for each, and are carried upon them into the shed on the east side of the corning house, and dropped into separate barrels; the dust is taken to the press house and is repressed, the fine grain is taken to the dusting house; and the large grain is taken to the reel room, and glazed in the same manner as that made at the shaking frames; it is afterwards taken to the receiving magazine.

Each pressing contains 500 lbs of powder, and produces as under,

Of large grain	320 lbs, or	64 per cent,
Fine grain	60 lbs, or	12 per cent,
Dust	120 lbs, or	24 per cent,
Total	500 lbs, or	100.

The number of men employed in these buildings when they are in full work, are

	No.
Foremen superintending the work	1
Attending the breaking machine	1
Pressing the broken mill cake	4
Attending the granulating machine	3
Separating the chucks from the grain	1
Attending the reels	1
Boatmen conveying the powder to, and from the building	2
Total	13 men.

Who press and granulate 4 pressings containing 2000 lbs of mill cake in one day, and from it produce about 1520 lbs of grain.

The expense of erecting these buildings was as follows,

	£
Building containing the breaking machine	500
Washup house	500
Three Traverses	4500
Press House	1000
Corning house	2500
Total	£9000

These buildings are capable of manufacturing 4000 barrels of gunpowder into grain annually at an expense of £1818 detailed as under

		Per bbl of gunpowder
	£	£ .. s .. d
Interest upon £9000 the first cost of the buildings at £4 per cent per annum	360, or	-.. 1.. 9½ - ‘4
One Foreman superintending the work	78, or	-.. - .. 4½ - ’72
The daily pay of 12 men	580, or	-.. 2..10¾ - ‘2
Water power equal to 5 horses	200, or	-.. 1.. -
Reworking the dust	100, or	-.. -.. 6
Repairs to the buildings and utensils	500, or	-.. 2.. 6
Total	£1818, or	-.. 9.. 1x - ’32

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Receiving Magazines

A receiving magazine is a brick built arched building about 20 feet long, and 12 feet wide, similar to the drawing marked 19, the inside is lined with wood, and the floor is covered with tanned hides. Every corning house has a receiving magazine for receiving the large grain in transit from it to the stores. The expense of erecting a receiving magazine is about £200.

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Process of Dusting the Fine Grain.

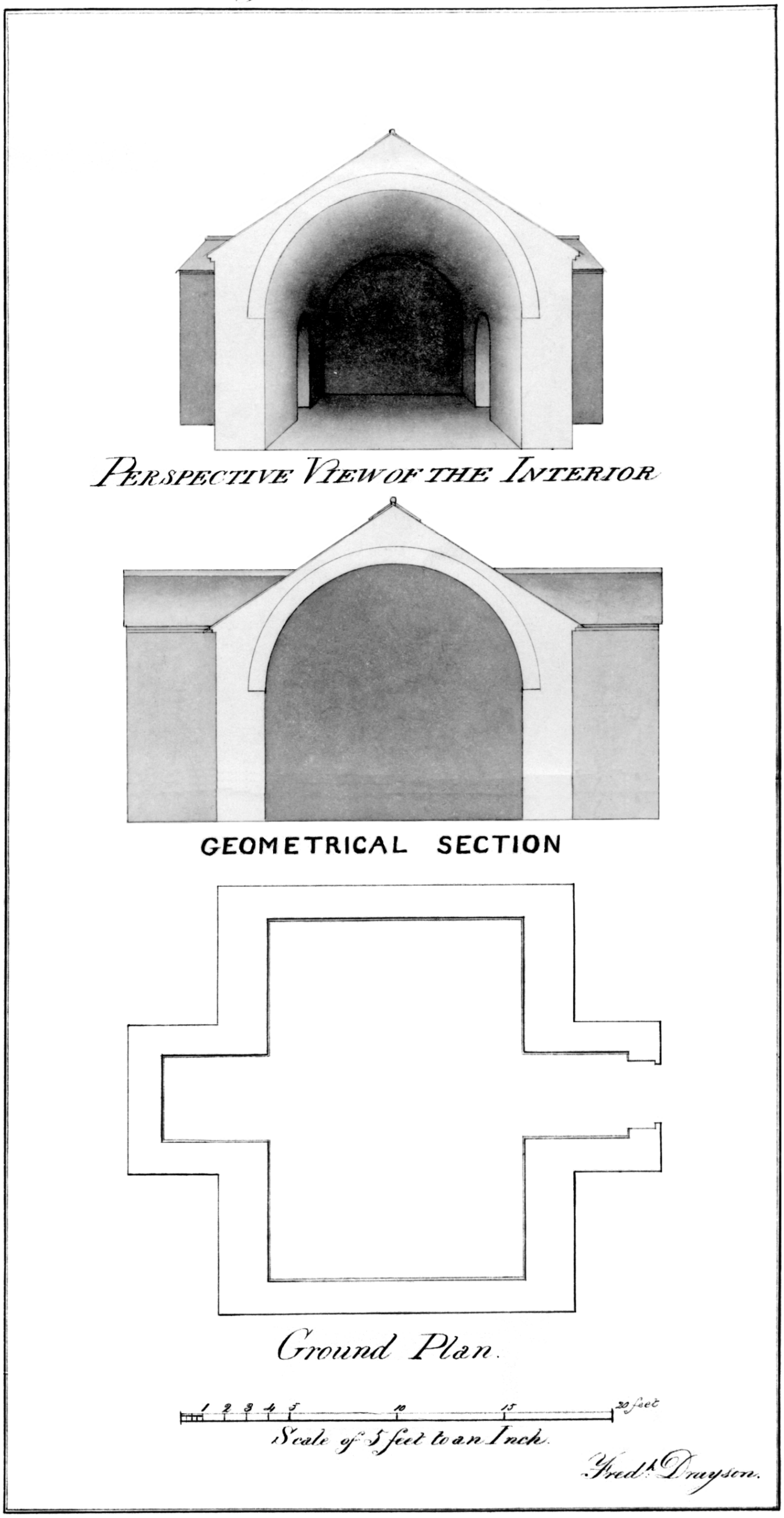
The building in which this operation is carried on is called the Dusting house, it is partly built of brick and partly of wood, similar to the drawing numbered 20, is 103 feet long, and 20 feet wide; the floor is covered with tanned hides. It contains 12 reels for separating the dust from the fine grain, when it is brought from the corning house, and after it has been glazed at the glazing mill. Eight of the reels are clothed with cyphrus silk of 48 meshes to the inch, and the other four with cyphrus silk of 60 meshes to the inch; they are placed with one end about 6 inches lower than the other, and the powder runs into them through hoppers at the upper end they are each enclosed in a wooden case, and are divided into sets, each set consisting of two coarse and one fine reel. They make 24 revolutions per minute and require power to work them equal to 2 horses.

The only utensils used in this building are tubs or barrels, wooden scuppits, and hair brushes and brooms.

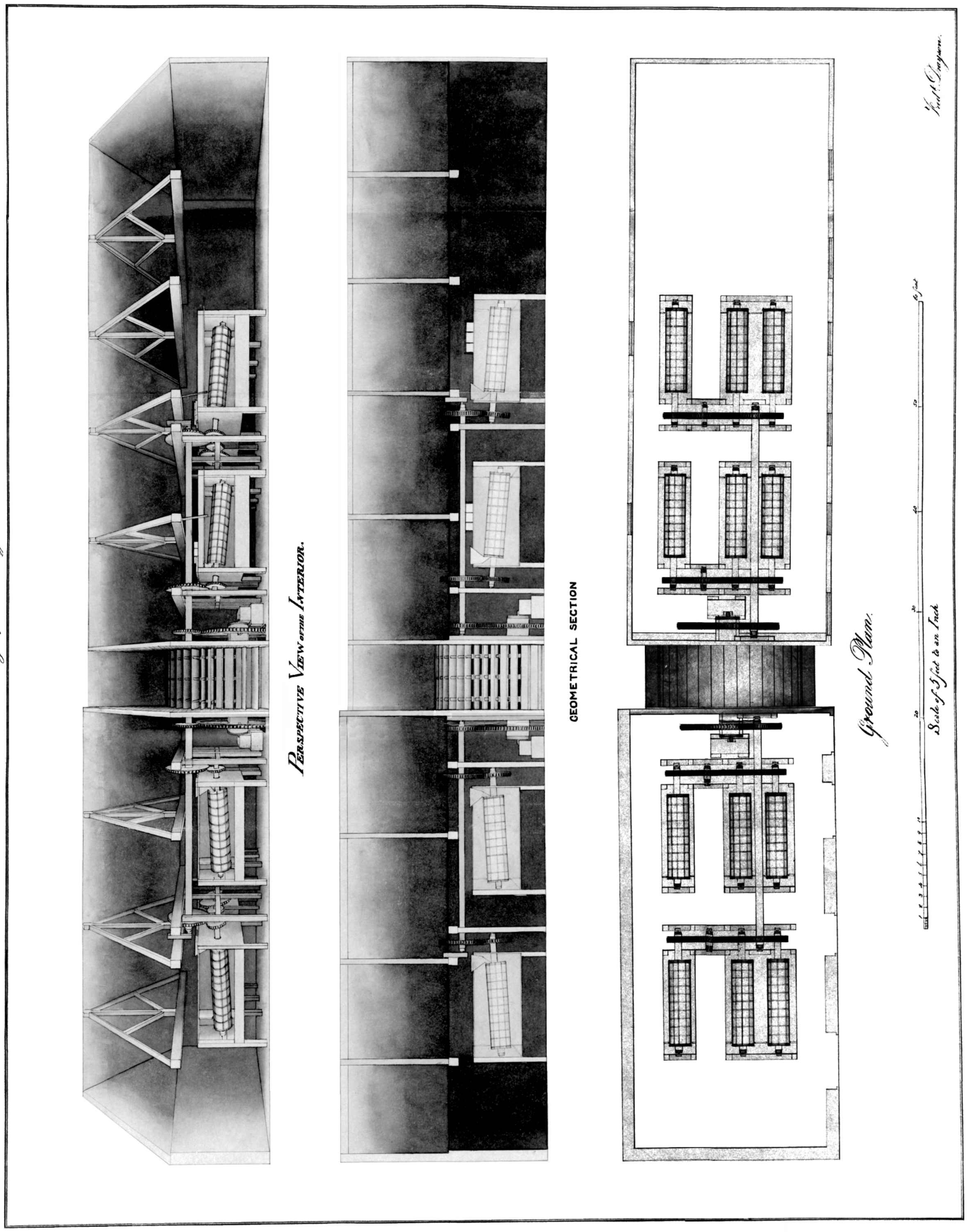
When the fine grain is brought from the corning house it generally contains about 20 per cent of dust, to clear it of which it is run through the reels in this building. The reels are first put into motion to revolve upon their own axis about 24 times in a minute; about 20 lbs of the powder at one time, are put into each of the hoppers of the coarse reels, and the mouth of each hopper, not being more than about one inch in diameter, only admits a small quantity into the reel at a time, and as the reels are placed slantingly, the grain runs to the lower ends, and falls into tubs, whilst the dust falls through the silk with which the reels are covered, into the reel cases, both ends of the reels are open. The grain which escapes at the lower end of each reel is again put into the hoppers of the coarse reels, and run through them a second time; it is afterwards taken to the glazing mill.

No. 19.

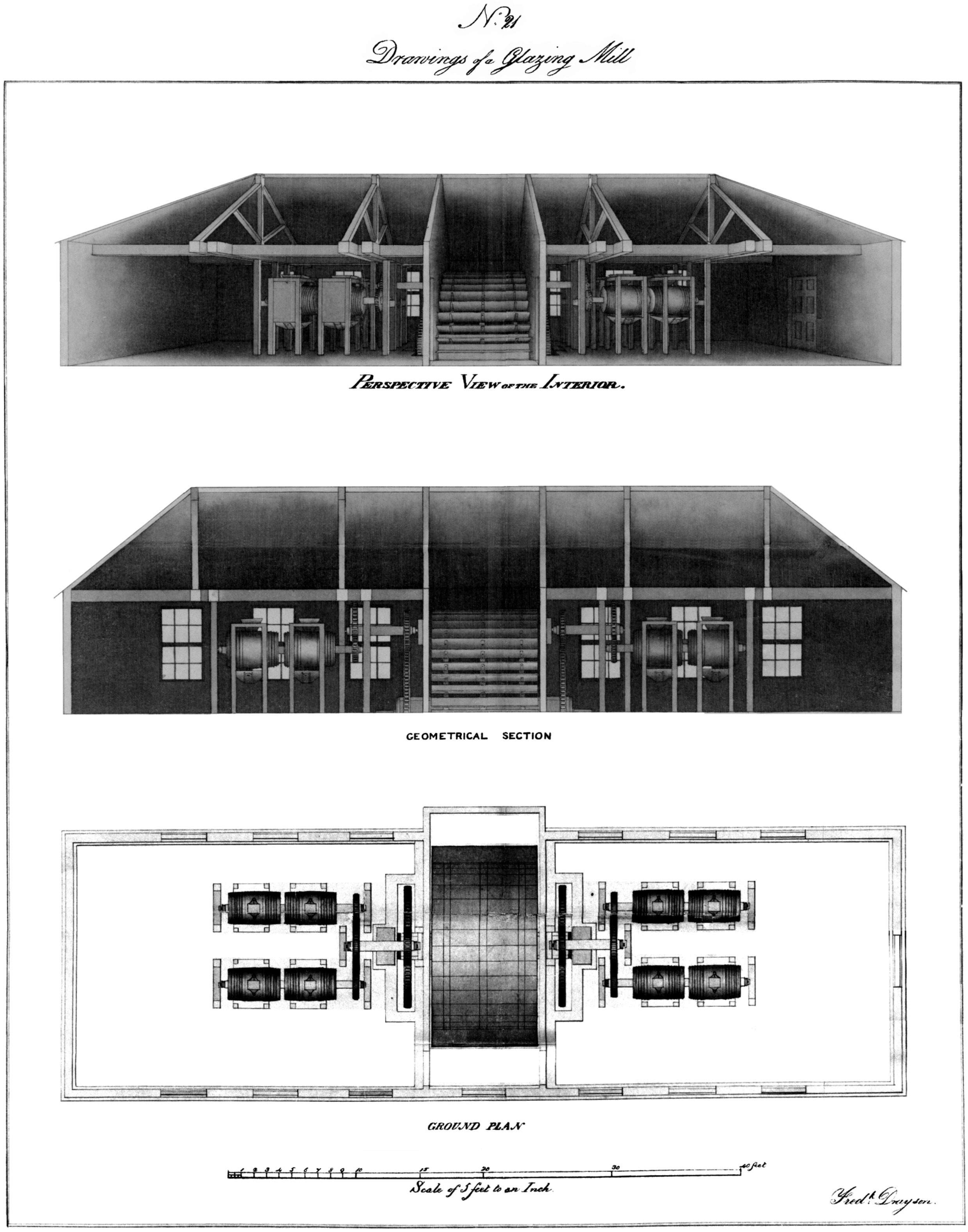
Drawings of a Receiving Magazine



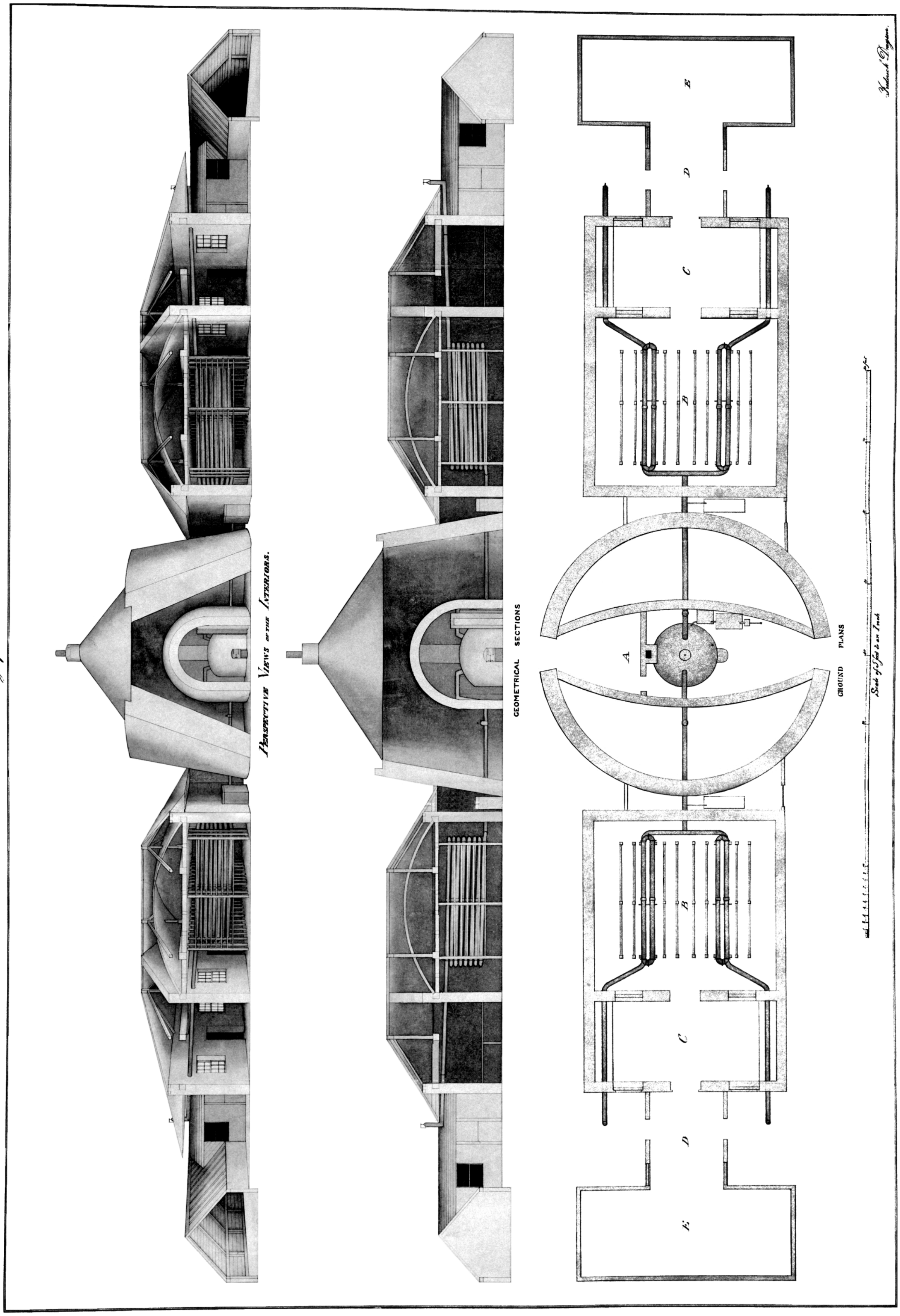
Drawing 19



Drawing 20


No. 21
Drawings of a Glazing Mill
Perspective View of the Interior.
GEOMETRICAL SECTION
GROUND PLAN
Scale of 5 feet to an Inch
Fredk. Drayson.

Drawing 21


PERSPECTIVE VIEWS OF THE INTERIORS
GEOMETRICAL SECTIONS
GROUND PLANS
A
B
C
D
E

Drawing 22

After undergoing the process of glazing, the fine grain is brought back to the dusting house, and run once through the fine reels in the same manner as it was run through the coarse reels; it is afterwards taken to a receiving magazine. The dust is occasionally collected in the reel cases, weighed into quantities of 42 lbs, and taken to the gunpowder mills to be reworked.

The expense of erecting a dusting house similar to the foregoing would be £3000, the present building is capable of dusting 14000 barrels of fine grain per annum at an expense of £610 detailed as under.

		Per bbl of gunpowder.
Interest upon £3000 the first cost of }	£	£ .. s ..d
the building at £4 per cent per annum}	120, or	-.. -.. 2x – ‘2285714+
The daily pay of 4 men	160, or	-.. -.. 2½ - ‘9714285+
Water power equal to 2 horses	80, or	-.. -.. 1¼ - ‘4857142+
Repairs to the building and machinery	250, or	-.. -.. 4¼ - ‘1428571+
Total	£610, or	-.. -..10¼ - ‘8285712+

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Process of Glazing the Fine grain

The building in which this operation is performed is called the glazing mill, it is 66 feet long, and 21 feet wide, is built of wood, the roof is slated, and the floor is covered with tanned hides. It contains eight large barrels for glazing the fine grain, which are each 4 feet long, 2 feet 3 inches in diameter at each end, and 2 feet 6 inches at the centres; they are turned by water power, revolve about their own axis and make 35 revolutions per minute. The machinery of the building requires a power to work it, equal to that of 5 horses.

The only utensils used in this building are hair brushes and brooms, and tubs.

In the process about 300 lbs of fine grain are put into each barrel at a time, and they are kept revolving at the rate of 35 revolutions per minute for 3 hours; the grains continue falling upon each other, the soft and angular parts are thus rubbed off, and to the powder is imparted a dark shining appearance. At the end of 3 hours, the barrels are made to go much slower, their mouths or doors are opened, and the grain falls into the cases which enclose them, and from thence into the barrels underneath. The powder is then taken back to the dusting house.

The expense of erecting this building was £3000, it is capable of glazing 14000 barrels of fine grain annually, at the expense of £500 detailed as under.

		Per bbl of gunpowder.
Interest upon £3000 the first cost of }	£	£ s d
the building at £4 per cent per annum}	120, or	-.. -.. 2 - ‘2285714+
The daily pay of 2 men	80, or	-.. -.. 1¼ - ‘4857142+
Water power equal to 5 horses	200, or	-.. -.. 3¼ - ‘7142857+
Repairs to the building & machinery	100, or	-.. -.. 1½ - ‘8571428+
Total	£500, or	-.. -.. -8½ - ‘2857141+

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Process of Drying the Powder.

There are two kinds of building for drying the powder, one being heated by steam, and the other by cast iron pots. The building heated by steam is called the

Steam Stove.

and the buildings connected therewith are

A Traverse,
Five drying rooms,
Two weighing rooms,
Two small cooperages, and
Two boat houses.

The traverse marked A on the drawing numbered 22, is a circular brick built arched room 35 feet 6 inches in diameter, with a slated roof. It contains a boiler for generating steam, with a pump and cistern for supplying the boiler with water.

The Drying Rooms marked B are brick arched rooms 23 feet 6 inches long, and 25 feet 6 inches wide; the ceilings and walls are lined with sheets of copper, and the floor with sheet lead. These rooms are heated by steam from the boiler in the traverse. which passes through each room in a copper pipe about 6 inches in diameter; each of these pipes is fixed into the top of the boiler and enters one of the drying rooms about 2 feet 6 inches from the floor; it then divides into two branches which pass backwards and forwards from end to end of the room, until they nearly reach the ceilings; each branch then passes through the walls, on the opposite side to where it entered the room, through the weighing room, and also through its wall to the outside of the building, and is then terminated by a kind of valve, which may be shut or open as required; there is a cistern between each drying room and the traverse for receiving condensed steam from the copper pipe. Each pipe has a cock in it near to the boiler so that the steam may be turned into only one room at a time; and on either side of each range of pipes there are wooden racks, upon which the powder is laid in stove cases to be dried. Each room is capable of drying 40 barrels of gunpowder at one time, and a brick arch is turned over each drying room between the ceiling and the roof.

The Weighing Rooms marked C, are under the same roofs as the drying rooms, they are built of brick are each 11 feet 6 inches long, 25 feet 6 inches wide, and the floors are covered with tanned hides. Each room contains screens, enclosed in a wooden case, for screening, and a pair of scales for weighing the powder after it is dried.

The Cooperages marked D, are each 13 feet 6 inches long, and 10 feet wide; they are built of wood, and the floors are covered with tanned hides. The Boathouses marked E, are built of wood over the canal, so that the powder boats may come underneath; they are each 30 feet long, and 12 feet wide.

Utensils used in these buildings and shewn on the drawing numbered 23.

A, A copper for generating steam, it is capable of holding 300 gallons of water, is 6 feet in diameter, and weighs about 16 cwt.
a, A stove case used in drying the gunpowder, the frame is made of wood, and one side is covered with fine Raffia duck.
b, A tub used in loading the stove cases with powder.
c, A copper bowl for loading the stove cases with powder.
d, A small copper barrel used in unloading the stove cases.
e, A screen for screening the powder after it is dried.
f, A barrel in which the powder is sent to the magazine.

In the process of drying, the gunpowder is taken into the weighing room, and 2 or 3 barrels at a time are thrown into the tub b, for the convenience of the workmen, and about 14 lbs are spread upon each of the stove cases with the bowl c; the cases are carried into the drying room, and put upon the racks on either side of each range of pipes. When the racks are loaded, the doors and windows of the drying room are shut, and a thermometer is placed in a small glass case in the door, so that the stove man may occasionally ascertain the heat of the room. The water in the boiler is then made hot, and in about 1½ hour the steam may be forced through each branch of pipes, and in about 3 hours, the room may be brought to a heat of about 130° of Fahr. and is kept so for 2 or 4 hours; at the end of which time the doors and windows are opened, and the room is allowed to cool before the powder is removed. The stove cases are then taken off the racks, and the powder is thrown into a small hopper in the weighing room, from which it runs into the small copper barrels d, which are handed up to a man at the screens, and the powder is run down them, to cool and to prevent its caking together when it is in the barrels. The powder is then weighed into barrels of 90 lbs and sent to the magazine.

The expense of erecting these buildings was £6000 and they are capable of drying 14560 lbs of gunpowder annually, at an expense of £710 detailed as under.

		Per bbl of gunpowder	
	£	£ .. s ..d	
Interest upon £6000 the first cost of the building at £4 per cent per annum	240, or	-.. -.. 3¾ -	‘8241758+
The daily pay of 5 men, attending the fire, loading and unloading the drying rooms	200, or	-.. -.. 3¼ -	‘1868131+
60 chaldrons of coals	120, or	-.. -.. 1¾ -	‘9120879+
Repairs to the buildings	150, or	-.. -.. 2¼ -	‘8901098+
Total	£710, or	-.. -..11½ -	‘8131866+

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The buildings heated by cast iron pots are called

Gloom Stoves.

There are two gloom stoves for drying gunpowder at Waltham Abbey, one is large, and the other is small.

The small gloomstove is a brick building containing
A Drying Room,
A weighing Room, and
A stoke hole.

There is also a covered passage called the cooperage where the coopers head up the barrels.

The Drying Room is 19 feet long, and 16 feet wide, the walls and ceiling are plastered, the floor is paved with foot tiles, and there are 3 vents in the ceiling for the escape of steam from the powder whilst drying. This room is heated by a cast iron pot, which is set up edgeways, and fixed in the wall, so that the bottom only projects about 1 foot 6 inches into the room; and whilst the men are loading and unloading the racks, it is first covered with a copper cover, and upon that is laid a large cloth. The pot is 4 feet deep, 4 feet 9 inches in diameter at the mouth; where it is 3inches thick, and 7 inches thick at the bottom, weighing 3 ½ tons. Three sides of the room are occupied by racks, which are capable of holding 40 barrels of gunpowder in stove cases at one time.

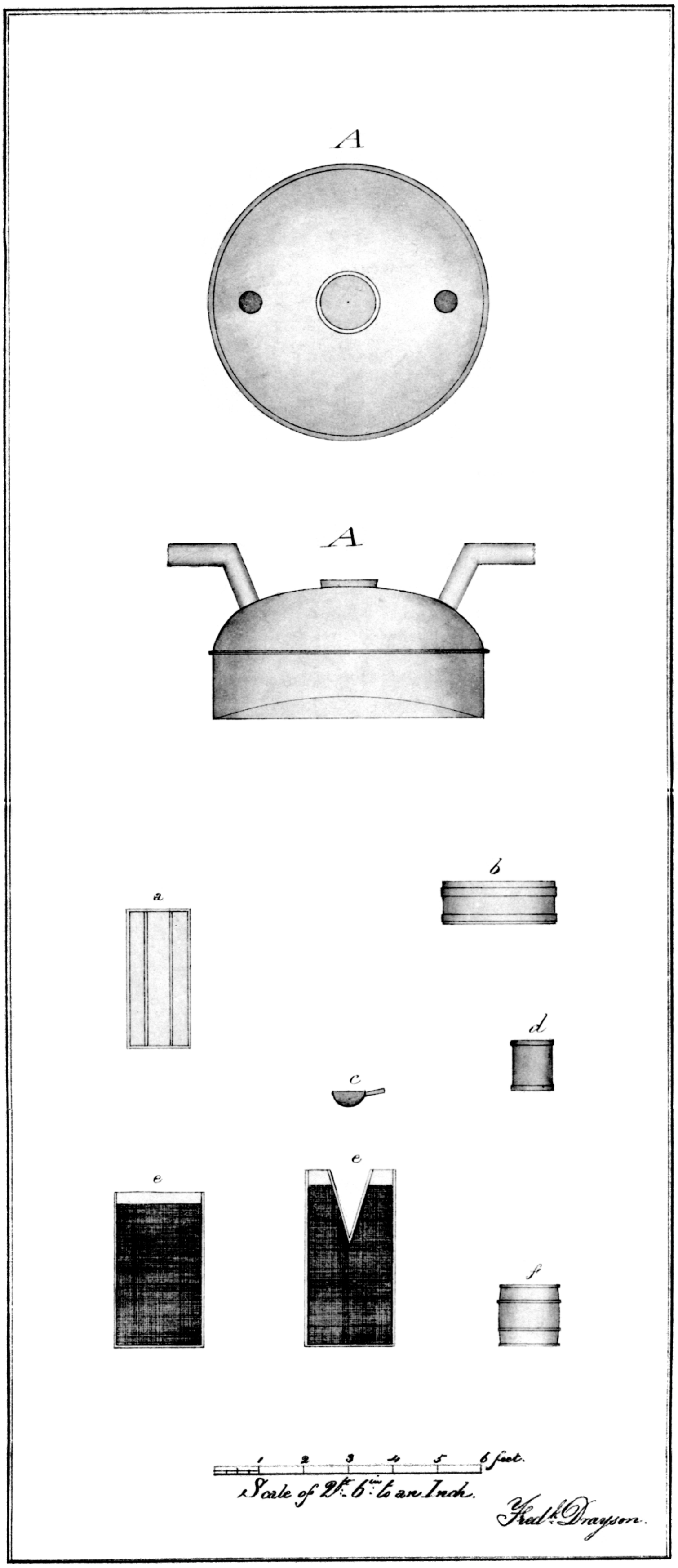
The Weighing Room is 18 feet long, and 17 feet wide, the floor is covered with tanned hides. It contains screens for screening, and a pair of scales for weighing the powder.

The passage called the Cooperage is 47 feet long, and 8 feet wide; the floor is covered with tanned hides.

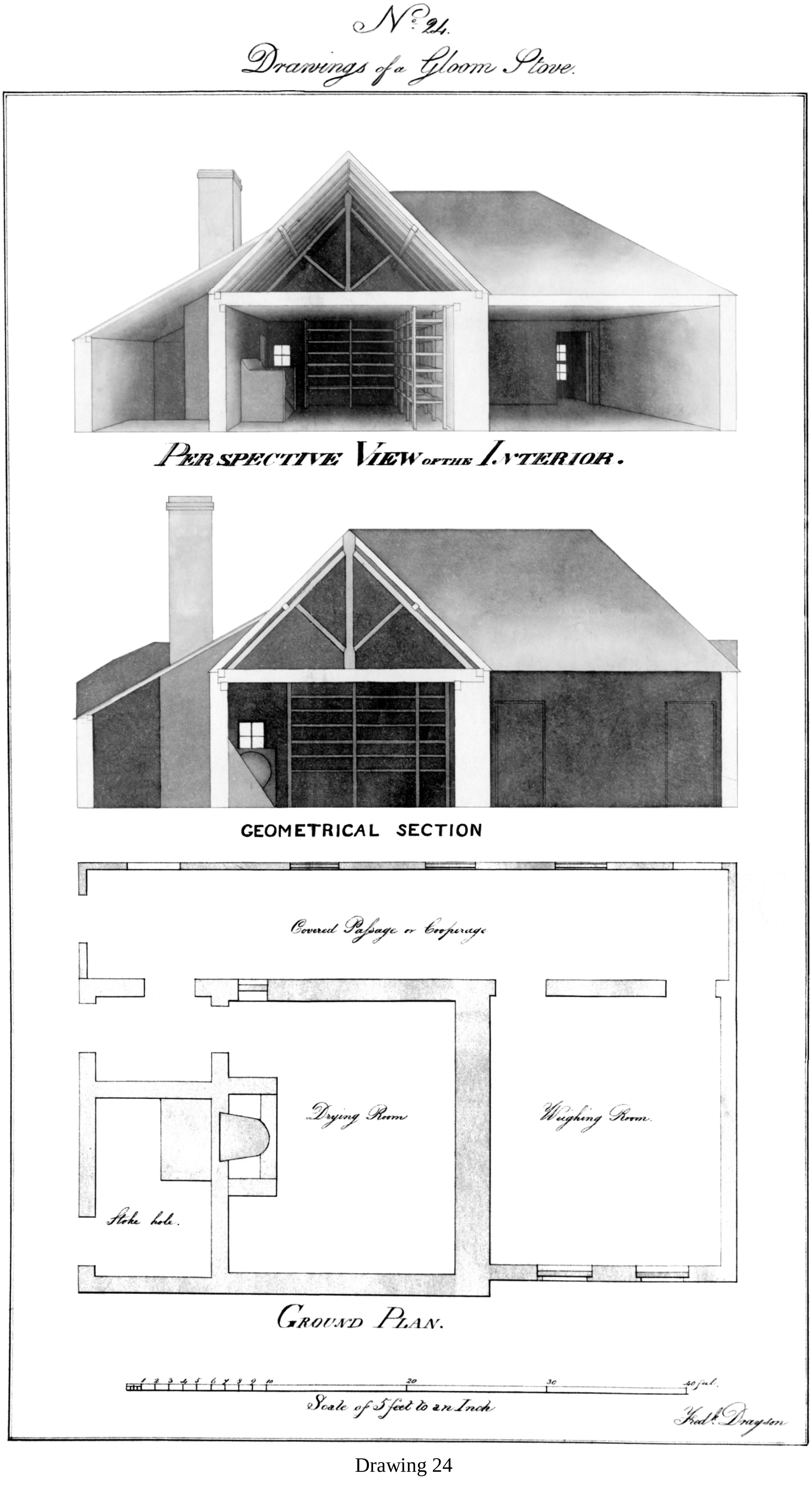
The utensils used in this building are similar to those used in the steam stove.

No. 23

Drawing of the Utensils used in the Steam Stove.



Drawing 23


No. 24.
Drawings of a Gloom Stove.
PERSPECTIVE VIEW OF THE INTERIOR.
GEOMETRICAL SECTION
Covered Passage or Cooperage
Drying Room
Weighing Room.
Stoke hole.
GROUND PLAN.
1 2 3 4 5 6 7 8 9 10
20
30
40 feet.
Scale of 5 feet to an Inch
Fredk. Drayson

Drawing 24

The powder is spread upon the stoves cases, and laid upon the racks in the same manner as at the steam stove; and the door of the drying room is shut. The fire which heats the drying room, is made in the interior of the cast iron pot, the mouth of which for security opens into the stoke hole. After the room has been kept at a heat of 180° of Fahr. for 24 hours the fire in the gloom or cast iron pot is put out and the room is allowed to cool, when the powder is taken to the weighing room, screened, barrelled up in the same manner as it is at the steam stove, and sent to the magazine.

The expense of erecting a building similar to the foregoing would be £1500, the present stove is capable of drying 4520 barrels of gunpowder per annum, at an expense of £250 detailed as under.

		Per bbl of gunpowder.
	£	£.. s.. d
Interest upon £1500 the first cost of } the building at £4 per cent per annum}	60, or	-.. -.. 3x - ‘7433628+
Labour in loading and unloading the} racks, attending the fires, &c }	100, or	-.. -.. 5¼ - ‘2389380+
25 chaldrons of coals	50, or	-.. -.. 2½ - ‘6194690+
Repairs to the building &c	40, or	-.. -.. 2x - ‘4955752+
Total	£250, or	-.. 1.. 1¼ - ‘0973450+

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Magazine

The magazine is a wooden building 60 feet long, and 21 feet wide, the roof is slated, and the floor is covered with tanned hides. It is divided into bays by means of standards for more conveniently packing the barrels; and is surrounded by a brick wall at the distance of about 15 feet, as shewn on the drawing numbered 25. The manufactured gunpowder is brought to this building in powder barrels; and here copper hoops are put on to them in addition to the hazel hoops which were fastened at the stoves. This building is capable of containing 2000 barrels of gunpowder, and was erected at an expense of £1500.

The expense in magazines for each barrel of gunpowder is about 6d.

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Gunpowder Barrels.

The barrels for containing the gunpowder in its finished state, are made of timber and with hazel and copper hoops; and all the staves are exactly the same size so that should one fail another may be instituted in its place without otherwise altering the barrel; the expense of each barrel is about 3s 6d.

Store houses.

The expense in store house for the saltpetre, charcoal, and sulphur is about 6d per barrel.

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The expense in superintending the different processes, keeping the accounts and official documents may be calculated at 2s 6d per barrel.

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The following is an abstract of the expense of manufacturing one barrel of gunpowder according to the foregoing processes; the expense in superintending and the first cost of ingredients, calculating that the barrel weighs 90 lbs.

	£ .. s.. d	
Refining saltpetre	-.. 2.. 4x – ‘3995533+	
Charring wood	-.. 1.. 4½ - ‘048	
Refining sulphur by fusion	-.. -.. 3½ - ‘6493504+	
Grinding the ingredients	-.. 1.. 1½ -	
Mixing the ingredients	-.. -.. 1¾ - ‘552	
Amalgamating the ingredients	-.. 7.. 1½ - ‘8571425+	
Pressing and granulating the gunpowder by screw presses and shaking frames	-.. 7.. 6½ - ’88	
Dusting the fine grain	-.. -..10¼ - ‘8285712+	
Glazing the fine grain	-..-.. 8½ - ‘2857141+	
Drying the powder by steam	-.. -..11½ - ‘8131866+	
For magazines	-.. -.. 6	
Cost of the barrel	-.. 3.. 6	
For storehouses	-.. -.. 6	

Total expense of manufacturing		£1.. 7.. 0¾ - ‘3135187+
Expense in superintendence		-.. 2.. 6
The following is the cost of the ingredients		
Saltpetre at £40 per ton for 15lbs would be	1..13.. 5	
Charcoal	-.. 1.. 1½	
Sulphur	-.. -.. 5	

Total cost of the Ingredients		1..14..11½
Total cost of one barrel of gunpowder		£3.. 4.. 6¼ - ‘3135181+

It must be understood that the foregoing calculations of the expense of manufacturing one barrel of gunpowder are made upon the supposition that each building is in full work.

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Process of Reworking, or as it is commonly called Regenerating Damaged Gunpowder.

In this process the damaged gunpowder merely undergoes some of the operations followed in manufacturing new gunpowder. It is first weighed into quantities of 42 lbs at the mixing house, and afterwards undergoes the process of amalgamating, pressing, granulating, dusting, glazing, and drying, in precisely the same manner as has been already described, with one exception, viz. that it is only worked from one to two, instead of three hours at the gunpowder mills.

The following is the expense of regenerating one barrel of damaged gunpowder.

	£ ..s .. d
Amalgamating at the gunpowder mills	-.. 3.. 6¾ - ‘4285712+
Pressing and granulating	-.. 7.. 6½ - ’88
Dusting the fine grain	-.. -..10¼ - ‘8285712+
Glazing the fine grain	-.. -.. 8½ - ‘2857141+
Drying by steam	-.. -..11½ - ‘8131866+
Magazines	-.. -.. 6 .
	£-..14.. 2¼ - ‘2360431+
Expense of superintendence	£-.. 2.. - .
Total expense	£-..16.. 2¼ - ‘2360431+

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Process of Extracting Saltpetre from unserviceable Gunpowder.

The building in which this process is carried on, is situated at Faversham, and is called the Extracting kitchen; it is similar to a saltpetre boiling house, and contains 8 cast iron large boilers and 2 smaller ones, and 2 large and 2 small copper boilers, with 4 moveable presses; is 69 feet long, and 29 feet wide. It is divided into two parts, one of which is shewn in drawing numbered 26; the roof is tiled, and has a louver vent at the top.

The utensils used in this building are exactly similar to those used in the saltpetre refinery; and each of the moveable presses is 8 feet 8 inches long and 4 feet 10 inches broad, and stands upon a frame which runs upon four wooden wheels. Two iron screws pass through nuts in two bars on each side of the press, and the ends of the screws are fixed to a slab of wood called the chuck; when the gunpowder has been boiled with water, it is put into a cloth or bag, placed between the two chucks of the press, and the iron screws are turned so as to bring the two chucks closer together, by which means the saltpetre which has been melted, is squeezed out of the black mass, and only the charcoal and sulphur remain.

In this process 1170 lbs of the unserviceable gunpowder are put together with 400 gallons of water into one of the pots marked A, and the solution is made hot, care being taken that it does not boil over the top of the pot. When the saltpetre contained in the gunpowder is melted, the solution is jetted out of the boiler, into the bag of one of the presses, and the charcoal and sulphur, which have not melted in the boiler, are pressed very hard so as to drive out as much of the saltpetre as possible contained in them. The liquor produced by this operation is reduced in one of the pots marked B, in the same manner as the liquor poured from the crystals in refining saltpetre, and is run through filtering bags; it is then allowed to stand 36 hours to crystallise, after which the liquor is poured from the crystals formed, and they are put together with clean water into one of the pots C, in the proportion of one cwt of the crystals, to 10 gallons of water, and the same process is followed as in boiling the crystals in the process of refining saltpetre; one boiling is deemed sufficient.

The liquor poured from the crystals is returned into the pot B, to be again reduced.

The black mass left in the bags after the liquor is poured from it, is chopped up fine, and again put together with 200 gallons of water into the pot A, but the water is made to boil before the black mass is put into it. The whole is then stirred until there are no lumps remaining, when it is again put into the bag of the press, and pressed a second time; the liquor now produced is put into the first pot A, with more water and fresh gunpowder.

The black mass left in the bag of the press after the second pressing consisting of charcoal and sulphur, is thrown away as useless.

The expense of erecting this building was £4000 it is capable of extracting the saltpetre from 16000 barrels of gunpowder annually. at an expense of 3s 6d per barrel.

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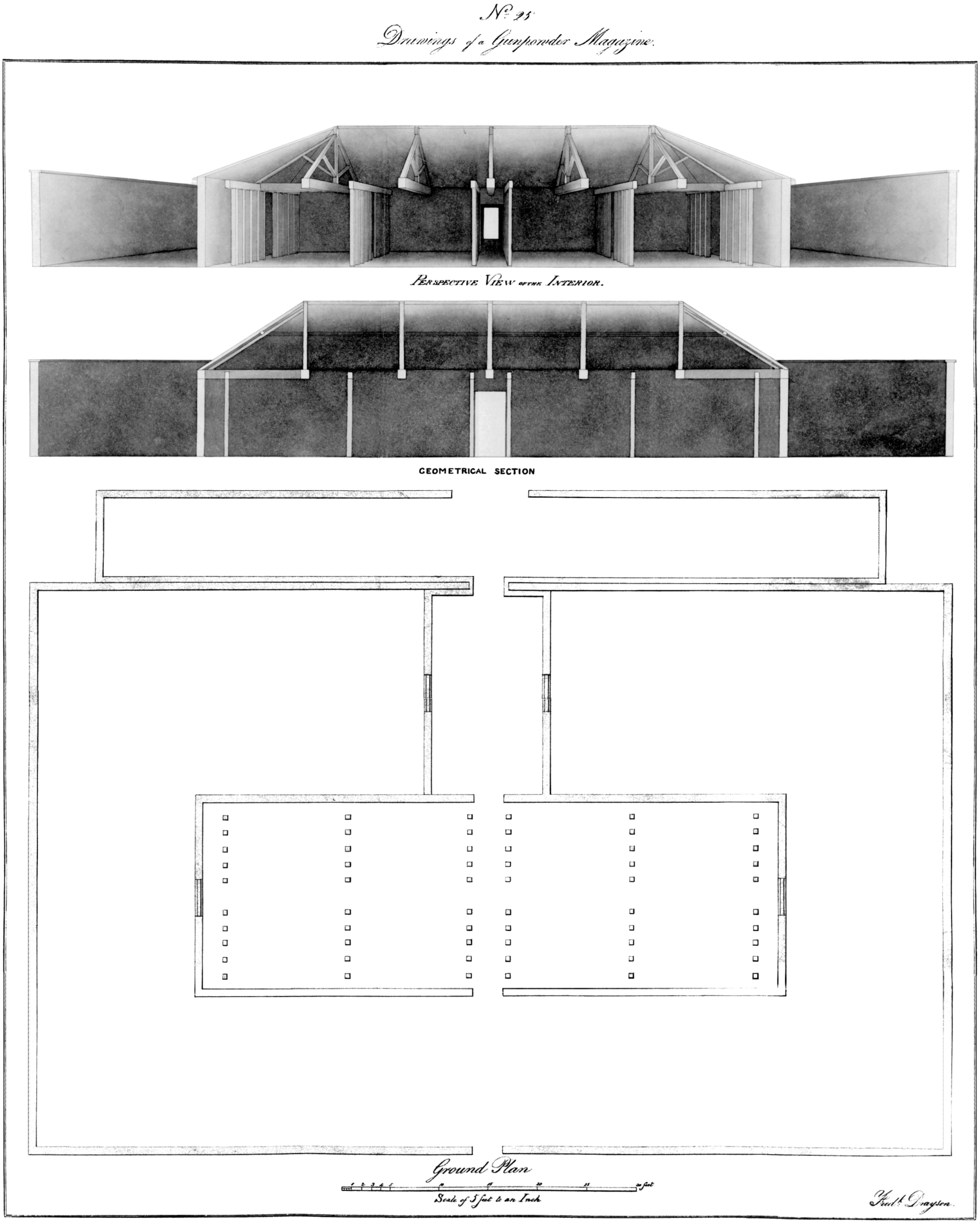
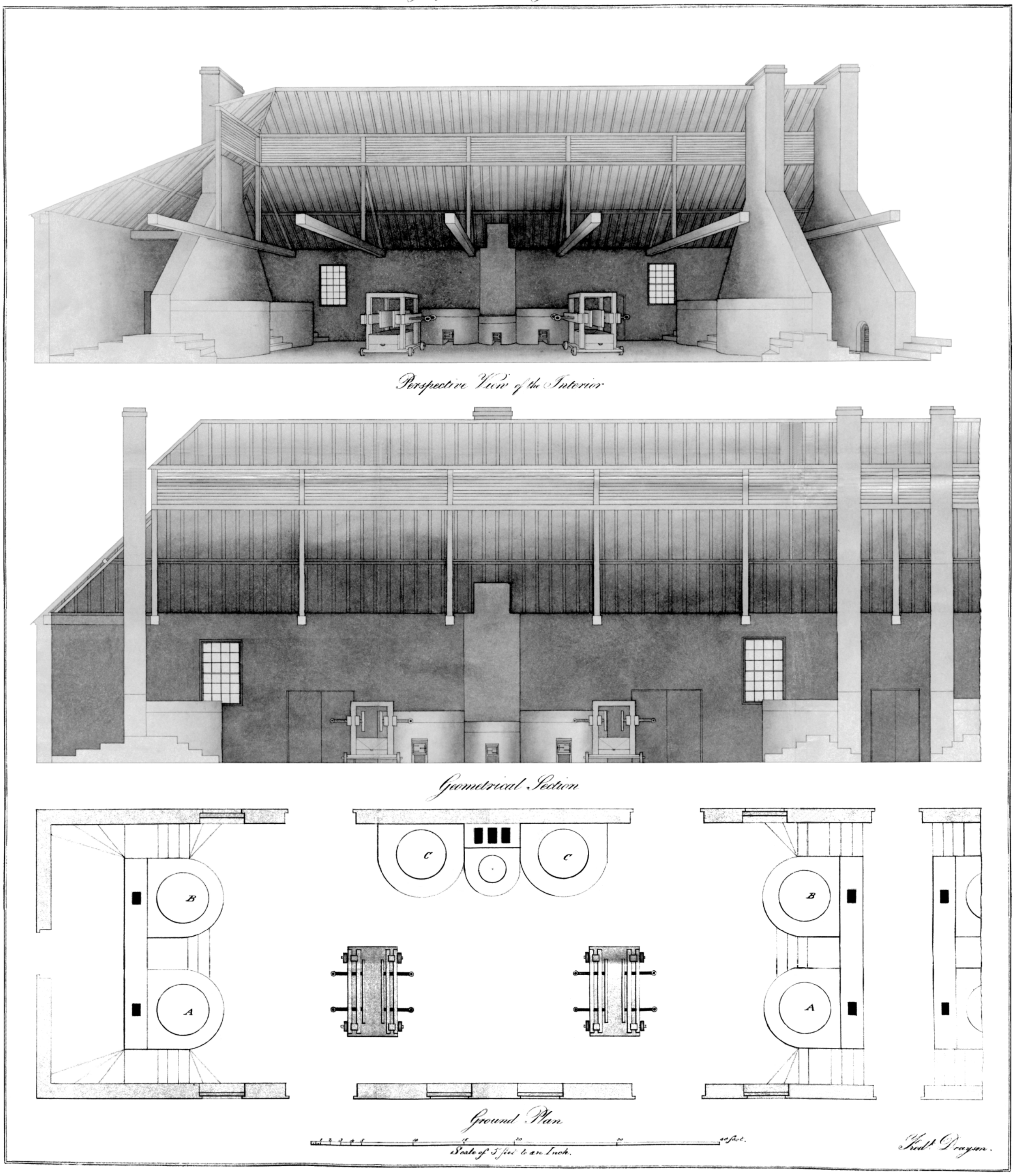

No. 25
Drawings of a Gunpowder Magazine.
Perspective View of the Interior.
GEOMETRICAL SECTION
Ground Plan
Scale of 5 feet to an Inch
Fredk. Drayson.

Drawing 25

No. 26
Drawings of the Extracting Kitchen



Drawing 26

Proving the Gunpowder.

In order to have a proper check over the workmen who carry on the different processes, the powder is proved after it has been incorporated at the gunpowder mills, and after it has been dried at the stoves; these proofs are made in the vertical eprouvette, shewn in the drawing numbered 27; the light blue part marked a, is of iron, which together with the slide b, to which it is affixed weighs 25 lbs, and the smaller blue part underneath the part marked a, is the chamber in which the powder is fired. Two drams at a time are put into this chamber, and the weight is lowered upon it, a match is then placed in the small hole in the weight a, and set on fire, which communicating with the powder in the chamber, causes it to explode, when it raises the weight a, from 2 to 7 inches according to its strength. The powder which has been dried at the stoves is also proved by flashing; in this proof 4 drams of powder are laid in a small neat heap on a clean polished copper plate, and fired by a red hot iron, when the powder is good, the explosion is sudden and sharp, no sparks fly off nor do any globules of alkaline residium remain on the plate which is left clean; but if the ingredients have not been properly prepared and well incorporated, the contrary is the case, and lights i.e. sparks may be seen.

The powder which has been manufactured and sent to the magazine during every three months of the year, is further proved at the end of each quarter in a ______ mortar, and in the pendulum or gun eprouvette shewn on the drawing numbered 27. The mortar has an elevation of 45 degrees, carries a ball of 68 ½ lbs and is charged with 2 ounces of powder, which projects the ball from 240 to 300 feet. The gun eprouvette is a small pendant brass cannon, and is also charged with 2 ounces of powder, the strength of which is determined by the number of degrees the cannon recoils when the charge is fired.

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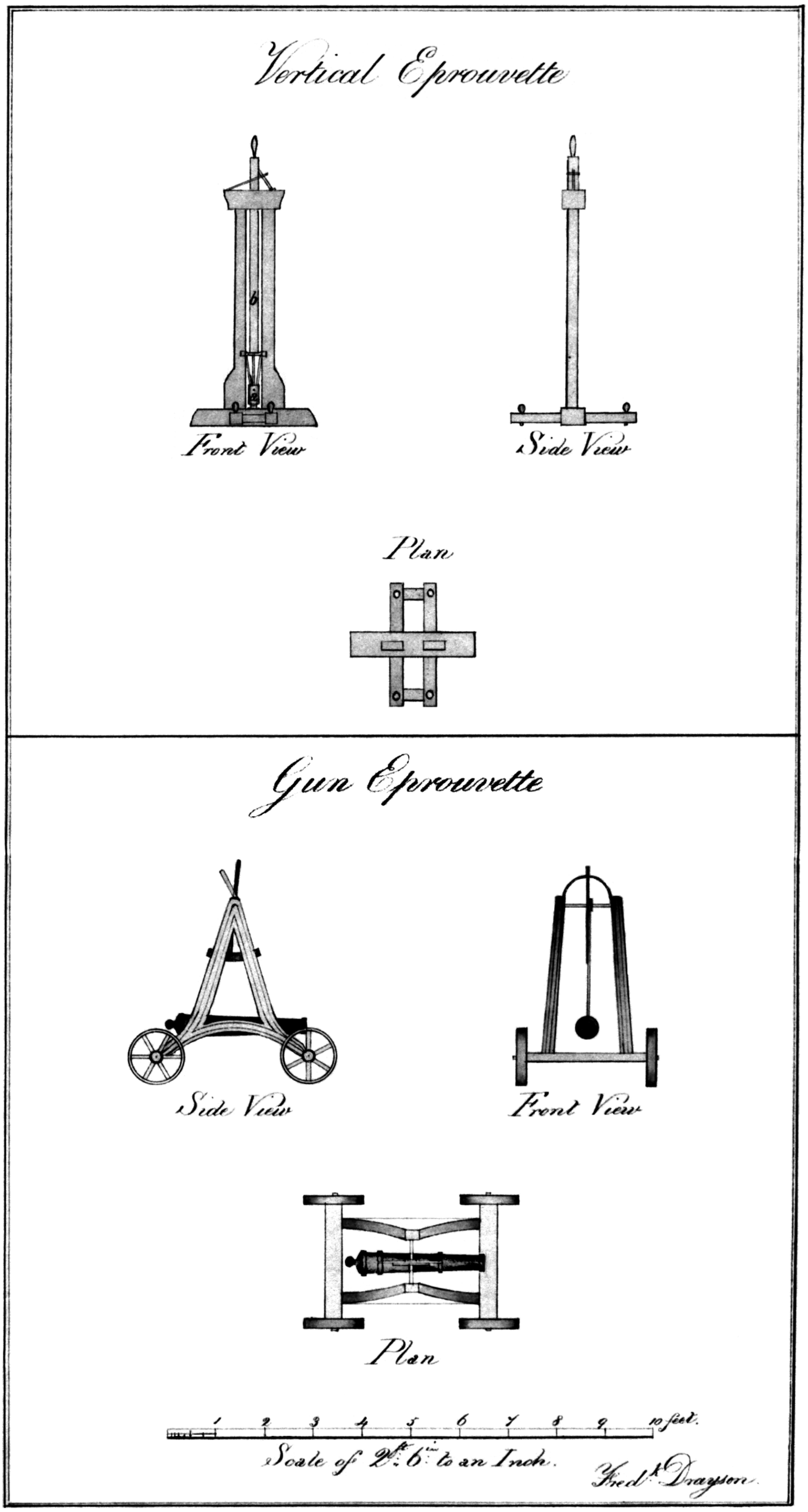
No. 27.

Drawings of the Machines for Proving Gun Powder



Drawing 27

Part the Second

Having given a description of the process carried on in each building connected with the manufacture of gunpowder, I have now to make my observations thereon, in doing which I shall endeavour to confine myself to what has taken place under mine own inspection, and to what I have proved by experiment. My object will be to point out such alterations both in the buildings and processes, as will I conceive improve the strength and keeping qualities of the gunpowder, and at the same time diminish the danger and expense of manufacturing.

On Saltpetre or Nitre

Saltpetre or Nitre being the principle ingredient in gunpowder claims our first attention, it is a production of nature, but as before stated is never found pure, being always contaminated with other salts and earthy matter, and is totally unfit for gunpowder until it has been refined. Saltpetre is more abundant in India than in other parts of the world, the greater portion that is used in England is brought from thence, but it first undergoes the operation of washing, and therefore is not received here in its natural state, and at this manufactory is termed [1]"Single refined Saltpetre", containing upon average 20 per cent of impurities. It has often been attempted to produce saltpetre by artificial means in this country but all attempts have failed.

In the process of refining nitre, the question arises, whether it is not deprived of a portion of its combustibility if it is boiled often, particularly when it is considered that it is afterwards melted and exposed to a heat of upwards of 700° of Fahr. That frequent boiling does not improve its qualities for gunpowder has been clearly proved within the last few years.

For previous to the year 1826 the gunpowder was manufactured with nitre only twice boiled with water, and afterwards melted by itself, but since that period it has been manufactured with saltpetre thrice boiled with water, and afterwards melted by itself, and it is neither improved in strength, or in its keeping qualities.

Many opinions are also entertained, as to whether the saltpetre ought to crystallise in large or small crystals, it being considered that the purity of the nitre depends much upon their size, it is however, of no importance because this wholly depends upon whether the liquor cools fast or slow; if it cools fast, the crystals are small, if slow, they are large, and there is always the same weight of crystals produced from the liquor, whether they be large or small.

The use of bullocks blood and eggs, has been recommended, but they have nothing to do with the salts, and cleanliness and practical knowledge are to be held in much higher estimation; it is true that lime will free the saltpetre of the foul salts and earthy matter in one boiling as well as it is now done by three boilings without it, but the nitre becomes so impregnated with the lime as to render it unfit for manufacturing gunpowder.

It has been observed by some writers that there is no danger of injuring nitre by simple fusion, and they contend that this may be proved by fusing a small quantity in a glass retort over a spirit lamp and endeavouring to obtain oxygen gas by means of the pneumatic trough.

It is very true that a small quantity of nitre may all soon melt in a glass retort and receive no injury; but this is no proof that no injury will be received when so large a portion as 3 or 4 cwt is melted together; for that which is at the bottom of the pot is first exposed to the action of the fire, and remains under its influence five or six times longer than necessary to reduce it to liquid, before the upper part of the contents of the pot is rendered in a state of fusion, consequently it is reasonable to suppose that the saltpetre continuing so long in this melted state, the temperature of which is necessarily on the increase, must suffer partial decomposition.

It has been further remarked however, that since fires are of necessity used in fusing nitre, and therefore it requires caution that the iron melting pots do not become over heated, for

[1] sample 1

should they attain a red heat, the nitre would of course be subject to partial decomposition, but if the process be understood and conducted in the common case, this need never occur.

It seldom happens that the nitre is brought to so great a heat as to appear red at the surface in day light, but if it were possible to see the nitre near the bottom of the pot, it would be found to be nearly as hot as the pot itself, and that the bottom of the melting pots have sometimes been red hot, although perhaps the nitre may never have appeared so at the surface is clear from the condition of the bottom of one of them having been found to be nearly melted away when the pots in the melting house at Waltham Abbey were reset in the beginning of the year 1829. I therefore deprecate this mode of melting the crystals when there is a probability of their suffering in their properties, and no necessity to resort to this measure, as they may be used soon after they are produced; better indeed for their purer and better keeping.

Saltpetre is not so liable to contract impurities in a solid cake as it is in the crystallised state, and therefore when it is to be kept for any length of time, or conveyed to any distance, it is perhaps better to be melted, but when it is refined only just before it is manufactured into gunpowder as at Waltham Abbey, the operation of fusing it not only creates an unnecessary expenditure, but as I have above shewn there is also the probability of injuring it by exposure to an intense heat. If the crystals require drying before they are used in the manufacture of gunpowder, I am of opinion that a much less degree of heat such as stove drying would be found sufficient.

But in order to determine this point by the test of experiment I would recommend that some gunpowder should be made with

[1]Saltpetre twice refined and not melted
Twice refined and melted
[2]Thrice refined and not melted

and as the gunpowder is made at present with [3]saltpetre thrice boiled and melted it ought to form the data for judging the quality and strength of the two kinds; if upon proving them, one should be found to be superior to the other, then it is plain that the nitre should in future be refined in the same manner as that with which such gunpowder was made; but if the gunpowders are all equally good, the nitre which is refined in the cheapest manner ought to be used in future, which would be that which is only twice boiled and not melted.

The chemical name of saltpetre is nitrate of potassa, and when melted it is called sal prunella.

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On Charcoal

Charcoal is generally considered the ingredient second in importance in gunpowder, it is a substance changed from its original nature of vegetable into a combustible matter by the process of charring; but it must not be considered that tar and acid exist in the wood in a perfect state previous to the operation, but the elements of which they are composed being driven from the wood during the process then combine and form tar, pyroligneous acid, &c.

Good charcoal ought to be light, firm, equally burnt, to break clean and smooth, to have a deep unpolished black color, and free from a glazed crust.

To produce such charcoal the elements driven from the wood must have a free escape from the vessel in which the operation of charring takes place, otherwise a portion remains therein, and those elements forming pyroligneous acid being of a thin nature are reabsorbed by the wood, whilst those forming tar offer themselves to the exterior and by the action of the fire are turned to a hard glazed crust. The want of proper vents is the principal objection to the gasometers and apparatus shewn on the drawing numbered 4, for as there is only one vent in

[1] sample 3
[2] sample 4
[3] sample 5

each retort for the escape of the elements named above and that in the upper part, the elements driven from the wood in the lower part cannot escape, but a portion remains, injuring it in the manner just described.

That apparatus was adopted under the impression that a great saving could be effected in the expenditure of fuel by turning the gas, driven from the wood during the operation of charring, into the furnaces and burning it instead of letting it escape as it had done previously. Experience however, has proved that this object is not obtained, for during the first five hours of the operation only those elements which compose pyroligneous acid escape from the wood in a steam which will not burn, and during the last three hours are those elements which compose tar escape in the shape of an inflammable smoke or gas, only a small quantity of fuel is required, because the cylinders and the brickwork around them are red hot, and almost afford sufficient heat of themselves for finishing the charring of the wood.

From various experiments which I have made upon the process of charring wood, I have found that to produce pure charcoal, the area of the vent for the escape of the elements comprising pyroligneous acid and tar, must be in proportion to the cubical contents of the retort; for instance if the cubical contents of the cylinder be 16 feet, the area of the vent must be 30 superficial inches.

In the apparatus shewn in the drawing numbered 4, the vent for the escape of these elements is only 9 inches, whilst the cubical contents of the cylinder are 16 feet; thus it may be seen, without the proof of daily witness, that pure charcoal cannot be produced from that apparatus; but unless the escape of the elements is properly regulated, it is impossible even with so large a vent as 50 superficial inches, to produce such charcoal as might be used in manufacturing gunpowder for Government.

To shew the great difference in the quality of the charcoal produced in the apparatus shewn in the drawing numbered 4, and in that produced in a cylinder the area of whose vent in the proportion to its cubical contents as 50 inches to 16 feet, it need only be stated, that 6 ounces of the [1]charcoal produced by the first named apparatus was analised and found to contain the following amount
of impurities viz.

Of carb lime	1 9/10	grains
Of sulphur and carb of potash with magnesia	9 1/10	“
Of oxide of iron	15	“
Of silex?	4	“
Of alumina	2	“
making a total of	32	grains

and 6 ounces of the [2]charcoal which I have produced in the last named apparatus have been analised, and not one grain of impurity was found therein.

Against pot burned charcoal there exists the same objection as against charcoal burnt in cylinders having only one vent, and gasometers attached; in fact there is no vent in pots for the escape of the tar and acid, and only a slight evaporation can take place through the earth and peat with which the wood is covered.

I would therefore recommend that the charcoal should be prepared in cylinders the area of whose vents should be in proportion to their cubical contents of 50 superficial inches to 16 feet; that the building should be similar to that shewn in the drawing numbered 28; and instead of having sand filled in between the stoppers and the outer door, I would recommend that the stoppers should be screwed onto the cylinders in the manner they are done in gas manufactories.

[1] sample 8
[2] sample 9

With regard to burning wood in iron cases within the cylinders I have only to say that no private manufacturer will adapt them, for ______ they have only been found to create additional trouble and expense.

The best woods for making charcoal are [1]willow, alder, and [2]black dog wood, the latter however is preferred, but being scarce it is only used by Government in making rifle powder. The wood ought not to be of more than 10 years, nor less than ________ months, it also ought to be cut 2 years before it is charred, and the bark to be stripped off as soon as it is cut.

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On Sulphur

The third and last ingredient comprising gunpowder is sulphur. It is a mineral chiefly abounding in volcanic countries, but is seldom found in a pure state, being impregnated with foreign matter such as sulphate of lime, oxide of iron, &c. The processes followed at Waltham Abbey for refining sulphur are as already stated "Fusion" and "Sublimation", the sulphur used in manufacturing gunpowder however, is refined by the process of fusion, and only a small quantity is occasionally refined by the process of sublimation for the Royal Laboratory at Woolwich.

On the Process of Fusion.

Sulphur is chiefly used in gunpowder to produce that intimacy of mixture which is imparted to the ingredients at the gunpowder mills, and upon which depends its strength, for although gunpowder may be made with only nitre and charcoal without sulphur, it will not keep, for the nitre and charcoal soon disunite and return to their primitive state of composition; therefore sulphur must be used in manufacturing gunpowder which is likely to be kept for any length of time, and the finer it is, the better will be the keeping qualities of the gunpowder.

The substance normally called [3]"grough" sulphur, upon average consists of 92 per cent of sulphur, and 8 per cent of impurities. The operation of refining this substance by the process of fusion as has already been shewn, is simply melting it, and whilst it is in that state those impurities which are lighter than the sulphur rise to the surface and are skimmed off, but those that are heavier sink, and remain at the bottom of the melting pots, therefore in lading out the sulphur into the cooling tubs care is taken not to stir them up, and they are put into a separate tub, and when cold this substance is called the bottom cake. Those impurities however which are of the same weight as the sulphur cannot be removed by this means.

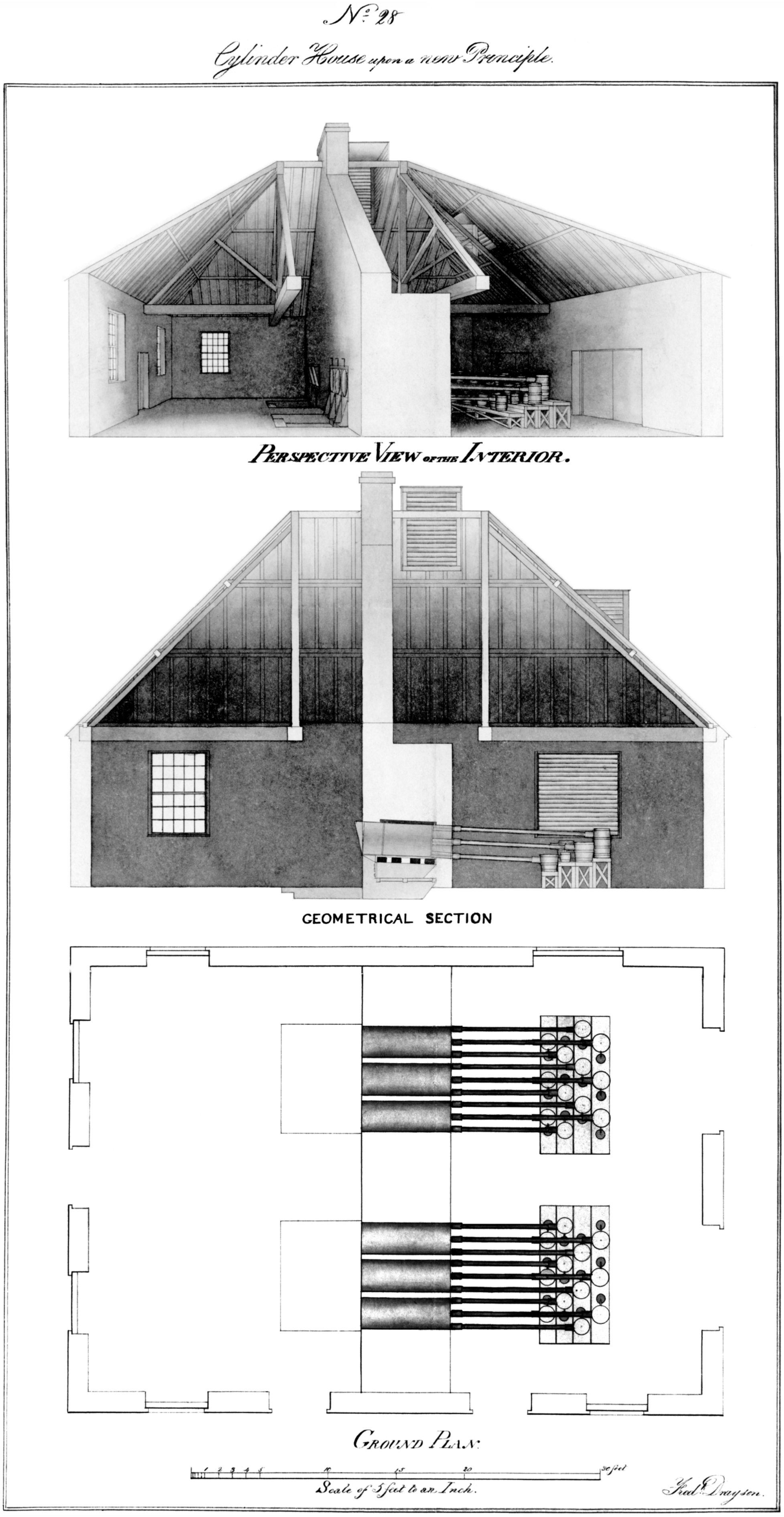
By the process of fusion one ton of grough sulphur yields

	Cwt..qu..lb	Pcent	
	14.. 1 .. 0, or	71¼,	of what is called [4]refined sulphur
	3.. 1 .. 0, or	16¼,	of cuttings
	1.. 0 ..14, or	5¾,	of skimmings, and
	1.. 1 ..12, or	6¾,	of bottoms, called sulphur vivium?
Cwt	19.. 3 ..26, or	100,	so that about 2 lbs are lost in the operation.

According to some of the most eminent chemists the three last kinds are composed as under.

The cuttings are considered equal to grough sulphur and consist of 92 per cent of sulphur, and 8 per cent of impurities.

[1] sample 6
[2] sample 7
[3] sample 11
[4] sample 13


No. 28
Cylinder House upon a new Principle.
Perspective View of the Interior.
GEOMETRICAL SECTION
Ground Plan.
1 2 3 4 5 10 15 20 30 feet
Scale of 5 feet to an Inch.
Fred.k Drayson.

Drawing 28

The skimmings consist of 84 per cent of sulphur, and 16 per cent of impurities. And the bottoms or sulphur vivium? consist of 77 per cent of sulphur and 23 per cent of impurities.

From this, the total quantity of impurities removed from the sulphur by the process of fusion may be ascertained as follows.

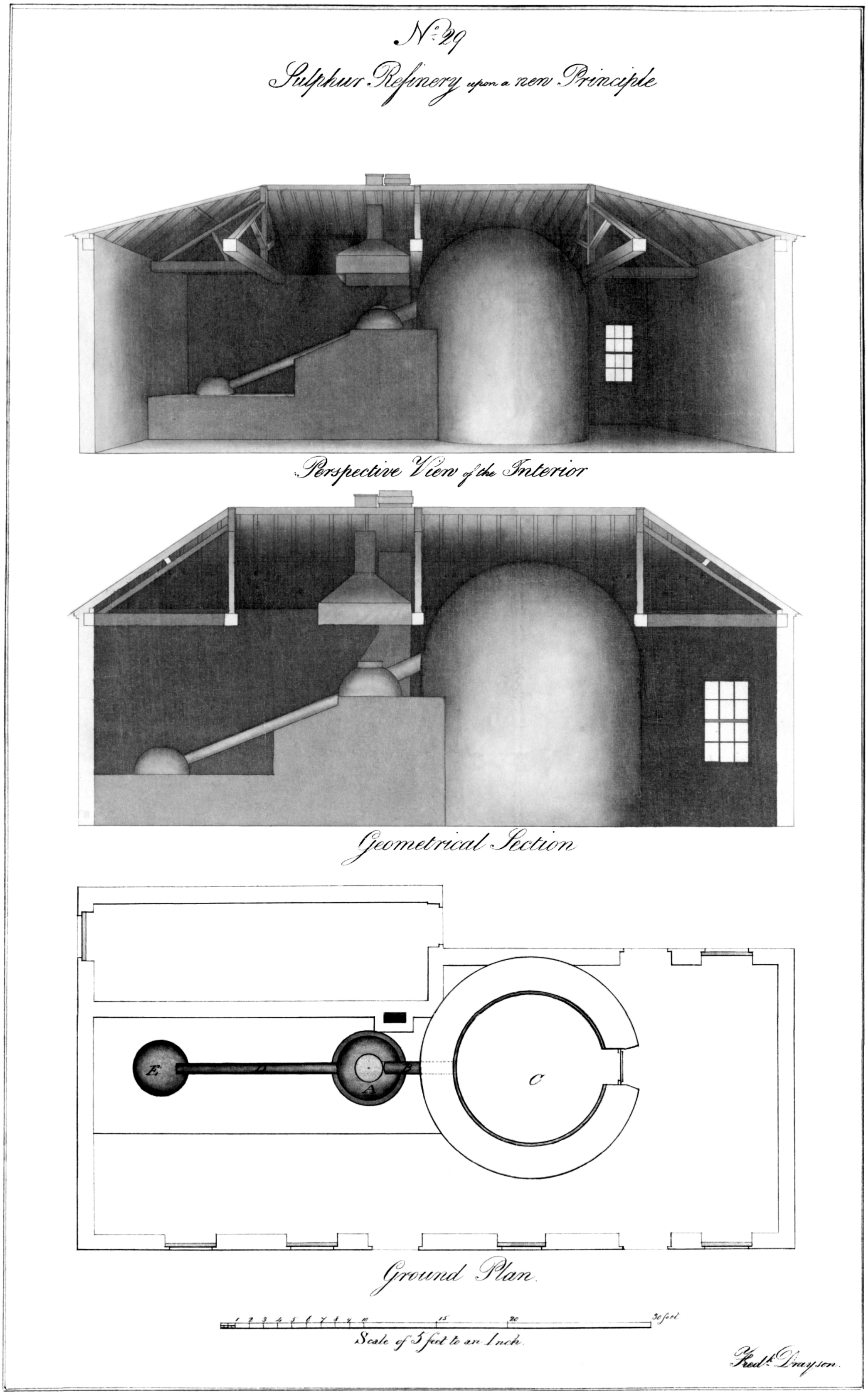
	Impurities per cent	Sulphur per cent	Total per cent
Grough sulphur consists of	8	92	100
About 16 ¼ per cent is cut from the sides of the cakes and is called cuttings; and as cuttings contain about the same quantity of impurities as grough sulphur this 16 ¼ per cent consists of	1 ½	14 ¾	16 ¼
About 5 ¾ per cent is skimmed off the surface of the sulphur, and is called skimmings, and so skimmings are composed of 84 per cent of sulphur and 16 per cent of impurities, this 5 ¾ per cent must consist of	1	4 ¾	5 ¾
About 6 ¾ per cent is cut from the bottoms of the cakes of sulphur, and is called bottoms; and as bottoms are composed of 77 per cent of sulphur, and 23 per cent of impurities, this 6 ¾ per cent must consist of	1 ½	5 ¼	6 ¾
Total quantity of impurities &c removed from the grough sulphur by the process of fusion	4	24 ¾	28 ¾
Leaving 71 ¼ per cent which is considered pure sulphur, but which must consist according to the foregoing table of	4	67 ¼	71 ¼
Total as above	8	92	100

Therefore only one half of the impurities are removed from the sulphur by the process of fusion, and even in clearing it of this small portion, upwards of 24 per cent of sulphur are taken off with them, 10 per cent of which, being amongst the skimmings and bottoms, is totally lost; the remaining 14 per cent however, being amongst the cuttings may be partly recovered by undergoing the process a second time.

Many trials have taken place for ascertaining whether sulphur refined by fusion is as pure as sulphur refined by sublimation; some took place as follows;

The different samples were first ground and exposed to ignition in a sand bath heated to a temperature of 235° of Fahr, and the residue once again subjected to the flame of a spirit lamp in a capsule of platinum; the result was that although the [1]sulphur refined by the process of sublimation was more pleasing to the eyes, yet the [2]sulphur refined by fusion did not leave a greater quantity of residuum. This trial however was ill calculated to ascertain which kind of sulphur was purest, because the flame of a spirit lamp is sufficiently hot to burn the greater portion of the impurities contained even in grough sulphur and if some of it had been tried in the same manner, it would not have left a greater quantity of residuum than the sulphur which had been refined by sublimation.

[1] sample 16
[2] sample 13


No. 29
Sulphur Refinery upon a new Principle
Perspective View of the Interior
Geometrical Section
E
D
A
B
C
Ground Plan
Scale of 5 feet to an Inch.
Fredk. Drayson.

Drawing 29

The most correct test for ascertaining the purity of sulphur, is to put it into a white earthen, or platina vessel, and set it on fire, but not to expose it to any other external heat; if the sulphur be pure, having nothing to impede its deflagration, it will burn clean out, leave no residuum, and only a light stain; if on the other hand the sulphur leaves a residuum, it is impregnated with some substance requiring a greater heat to cause its destruction than the flame emitted from burning sulphur. It must not be considered however, that the residuum from sulphur burnt in this manner always consists wholly of impurities, because it sometimes amounts to as much as 50 per cent, whilst the average quantity of impurities in grough sulphur is only 8 per cent, but it indicates the presence of some matter so intermixed with the sulphur as to impede its deflagration.

Another excellent but simple test for ascertaining the purity of sulphur is merely to melt any quantity in an iron pot or any other vessel, if it is clear and transparent, the sulphur is pure; but if it is full of little dark particles, it is impure; because as it melts at a heat of 218° of Fahr, these little particles cannot be sulphur, otherwise they also melt being exposed to the same degree of heat.

The purity of sulphur may also be known by its color, for when found perfectly pure, it is of a bright yellow; and further all the impurities which are taken from it in the process of refining are of a dark color; if therefore the sulphur is tinged with dark spots or streaks, it is impure, and the nearer it approaches to a bright yellow color, the less quantity of impurities does it contain.

On the Process of Sublimation

There are many kinds of apparatus for carrying on the process of subliming or distilling sulphur some being of very recent invention. In the process of sublimation described at pages 10 and 11, the sulphur turns to a vapour and passes through the pipe into the dome, where it falls to the floor in a powder[1]; when a greater degree of heat is employed, the sulphur remains in a liquid state upon the floor until the fire is put out, it then cools and forms [2]rock sulphur; but the impurities in the sulphur will not turn to a vapour, and instead of passing with it into the dome, they remain at the bottom of the melting pots, and are taken out after the sulphur has been sublimed, but even this process is defective.

The building for refining sulphur by sublimation shewn on the drawing numbered 8, is very inferior when compared with other buildings erected more recently by private individuals; and there has been no person at Waltham Abbey who was completely master of the process until within the last few years when a man was appointed to the situation of Master Refiner, whose father had worked Mssrs Brandrams refinery, and who was of course perfectly acquainted with the apparatus and process used by that person. The process followed by that individual is the cheapest that has ever been discovered, but the secret is confined to a few.

I would therefore recommend that the sulphur should be refined according to the process followed by Mssrs Brandram, to do which the building shewn on the drawing numbered 8, must be altered and made according to the drawing numbered 29, the flowers of sulphur would then escape through the upper pipe marked B, into the dome marked C, and the liquid sulphur would pass down the lower pipe marked D, into the pot marked E; there would be more lost, because only the 8 per cent of impurities would be removed therefrom.

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On the process of Grinding the Composition

[1] sample 14
[2] sample 15

This process is very simple, as it is merely the operation of reducing the three ingredients to a fine powder. The composition mill shewn on the drawing numbered 9, in which this process is carried on, is ill adapted for its purpose, and is too confined. Each division ought to be at least 10 feet longer, and 5 feet wider, and the reels 2 feet longer than they are at present. It is almost unnecessary to add that the finer the powder to which the ingredients are reduced, the better will they amalgamate, and the stronger will be the gunpowder.

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On the Process of Mixing the Ingredients and the Proportions.

This process is also very simple, although the proportions in which the ingredients are mixed is of great importance, and differ in almost every country. These might be just sufficient sulphur to set fire to the charcoal without one particle thereof igniting another, and to preserve longest that intimacy of mixture of the ingredients which is effected at the gunpowder mills; and in like manner sufficient charcoal to set fire to the nitre without one particle thereof igniting another, otherwise the explosion of the whole cannot be instantaneous.

According to the chemical analysis in data furnished by the most eminent chemists, the proportions of nitre, charcoal, and sulphur, ought to be as under viz.

Nitre	Charcoal	Sulphur	
75	13.24	11.76	in every 100 parts.

The composition of the following countries may be thus represented, shewing which comes nearest to this theoretical standard. The marks + and – referring thereto.

	Nitre	Charcoal	Sulphur
Great Britain	75	+ 15	- 10
	Nitre	Charcoal	Sulphur
France, Russia, and United States of America	75	- 12.5	+ 12.5
Authorities, Bottie and Riffault for France, Alaporth and Wolf for Russia, Hutbush for United States,			
Austria, according to Muller	76	- 11.5	+ 12.5
Piedmont, according to Antoni	- 71 3/7	+ 14 2/7	+14 2/7
Russia, according to Muller	- 73.78	+ 13.39	+ 12.63
China, according to Braddock	+ 75.7	+ 14.4	- 9.9

According to these authorities Great Britain uses a greater portion of charcoal, and less sulphur than any of the nations mentioned except China.

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On the Process of Amalgamating the Composition

This process is in fact that of manufacturing the gunpowder, as all the other operations which the ingredients undergo previous to being brought to the gunpowder mills, are for the purpose of preparing them for the process of amalgamation; and all those which the powder undergoes afterwards are for the purpose of bringing it to that state in which it is best capable of retaining the power imparted to it at the gunpowder mills, and in which it is best adapted to the purpose for which it is manufactured.

It is a well known fact that if gunpowder is reduced to grain just after it has been amalgamated, and is not pressed and glazed, it is nearly double in strength to that which has undergone these operations, but it is an equally well known fact that if it does not undergo them, it will not keep, but in a short time loses a great portion of its explosive properties.

It is in this process that the greatest practical knowledge is required, and unless the man who attends the gunpowder mill has a perfect knowledge of how much water to put to the charge previous to amalgamation, and at what period it is in a fit state to be taken off the bedstone, it is utterly impossible that the powder ever can be of a superior kind. The nominal time for working each charge of 42 lbs is 3 hours, but it sometimes happens that it is not fit to be taken off for 10 minutes or a quarter of an hour after that time, and vice versa.

The quantity of water put to a charge depends upon the state of the atmosphere more being required in dry than in wet weather; it is however a fact that the powder manufactured at the King's works has not been sufficiently liquored for the last 6 or 7 years, so that the amalgamation of the ingredients has not only been incomplete, but the expense of forming the grain has been greater, because more dust was produced than if the charges were worked damper. Another great evil attendant in the present system of amalgamating the composition at the Government works arises from the mill charges being liquored with water which has become condensed in the copper pipes at the steam stove, and sometimes lays many days in them, becoming impregnated with copper, has a highly injurious effect upon the gunpowder. The great liability of explosions in gunpowder mills is in consequence of the stone runners being separated from the stone beds only by the mill charges, which when spread upon the bed is not more than half an inch thick, and should it by any means be removed from any part thereof, the runners would come in contact therewith, and in all probability would produce a spark, and cause the gunpowder to explode; great care therefore is necessary in selecting for the beds and runners that kind of stone which has the least quantity of pyrites or flints, as it is from these pyrites that the production of fire is most to be apprehended. Many have been procured from Numur? in Flanders, others from Ireland, and a few from Wales; those procured from the latter place however, are far preferable to the others, because they have a less quantity of pyrites and work better than any other kind of stone, and amongst masons it is called black marble.

When a gunpowder mill works day and night, the beds and runners generally require rubbing and polishing once in two years, for during that time the softer parts on the face of the stone gradually wear away, leaving the harder parts such as pyrites in the form of sharp angles, not however protruding more perhaps than the thickness of a wafer beyond the face of the stone, but that is sufficient to render it extremely dangerous to continue working the mill. Great attention is also necessary to the state of the ploughs, which are intended to keep the composition in the track of the stone runners, thereby preventing their coming in contact with the stone beds.

It has been stated the two pairs of stones in a gunpowder mill do not require a greater power than that of 4 horses to send them round the bed stones 7½ times in a minute; this however is erroneous for upon a 6 feet fall of water the stone runners cannot be made to revolve at that rate by less than 16 cubic feet of water per second, which reduced to horses power by the common rule amongst mechanics gives rather more than 8 horses power; and further, when the horse gunpowder mills were at work, each pair of stones required two horses to make them revolve 3 times in a minute; therefore in making 7½ revolutions per minute it is not too much to calculate that 2 pairs of stones would require the power of 8 horses.

In all gunpowder mills that are erected in future, I would recommend that one uniform system should be introduced so that the machinery of one mill might be applicable to any of the others; that the shafts, arms, and rings of the water wheels should be of cast iron; that the water courses leading from the river in front of the mills to the water wheels should be made with the upstream side in a direction to meet the stream, so as to do away with the sharp angle which impedes the free course of the current; that the mill charges should be worked damper than they are at present; and that the water for damping or as it is commonly called liquoring the mill charges should be distilled in a small still.

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Charge Magazines.

The charge magazines for greater security, ought to have their doors facing the tail streams, and each magazine ought to be situated between the two mills to which it is appropriated.

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On the Process of Granulating Gunpowder by Shaking Frames

At the Government manufactories it is usual when speaking in general terms to apply the appellation of Corning house to a set of buildings including a washup house, press house, traverse, and corning house; and although not under the same roof, yet the processes carried on in the press and corning houses are connected, and the workmen assist each other in both buildings.

It has been already stated that the powder granulated by shaking frames is pressed in screw presses; upon reference to the description of this process page 17 it will be seen that the press man standing on the end of a lever sways the powder up and down until it is loosened from the sides of the press; this is sometimes soon accomplished, but at others not without running great risk of explosion from the immense friction attending it; to remedy this evil I would recommend that the chambers of the presses should be made about 2 inches narrower in the back part than they are at present, bevelling off to the front; if by this alteration the powder were not more easily forced out of the press, I would recommend that a screw and spindle should be introduced similar to that in the press house working Bramah's hydraulic press and shewn on the drawing numbered 17; but this latter alteration would be the most expensive, and the powder must be pressed in a kind of box, having a back, bottom, and two sides, the door of the press acting as the front, the follower and blocks to be laid upon the upper charge the same as at present.

Upon reference to the description of the same process it will be seen that in breaking up the press cake upon the breaking bin 24½ per cent are reduced to grain, and 12½ per cent to dust, the remaining 63 per cent to chucks pieces too large for grain; notwithstanding this fact the whole mess of chucks, grain and dust are collected together and put into the sieves upon the shaking frames. It is well known that the shaking frames are the principle point of danger in corning houses, from the cranks becoming heated by friction, from the powder being hammered and shook about in the sieves, and from the quantity of dust escaping out of them, floating about the building, and settling upon the iron bearings and other parts of the machinery, the 12½ per cent of dust amongst the chucks, arising in thick clouds whenever the sieves are replenished with broken press cake. Now if the grain and dust made upon the breaking bin in breaking up the press cake into chucks, were separated from the latter before they are thrown into the sieves upon the shaking frames, those clouds of dust would not be created, and the 24½ per cent of grain would not run the risk of being partially reduced to dust before it is forced through the holes in the parchment sieves, neither would the shaking frames be so long employed. Another great cost attendant on shaking frames arises from the dust by floating about the building, becoming too dry to repress without being reworked at the gunpowder mills at an additional expense.

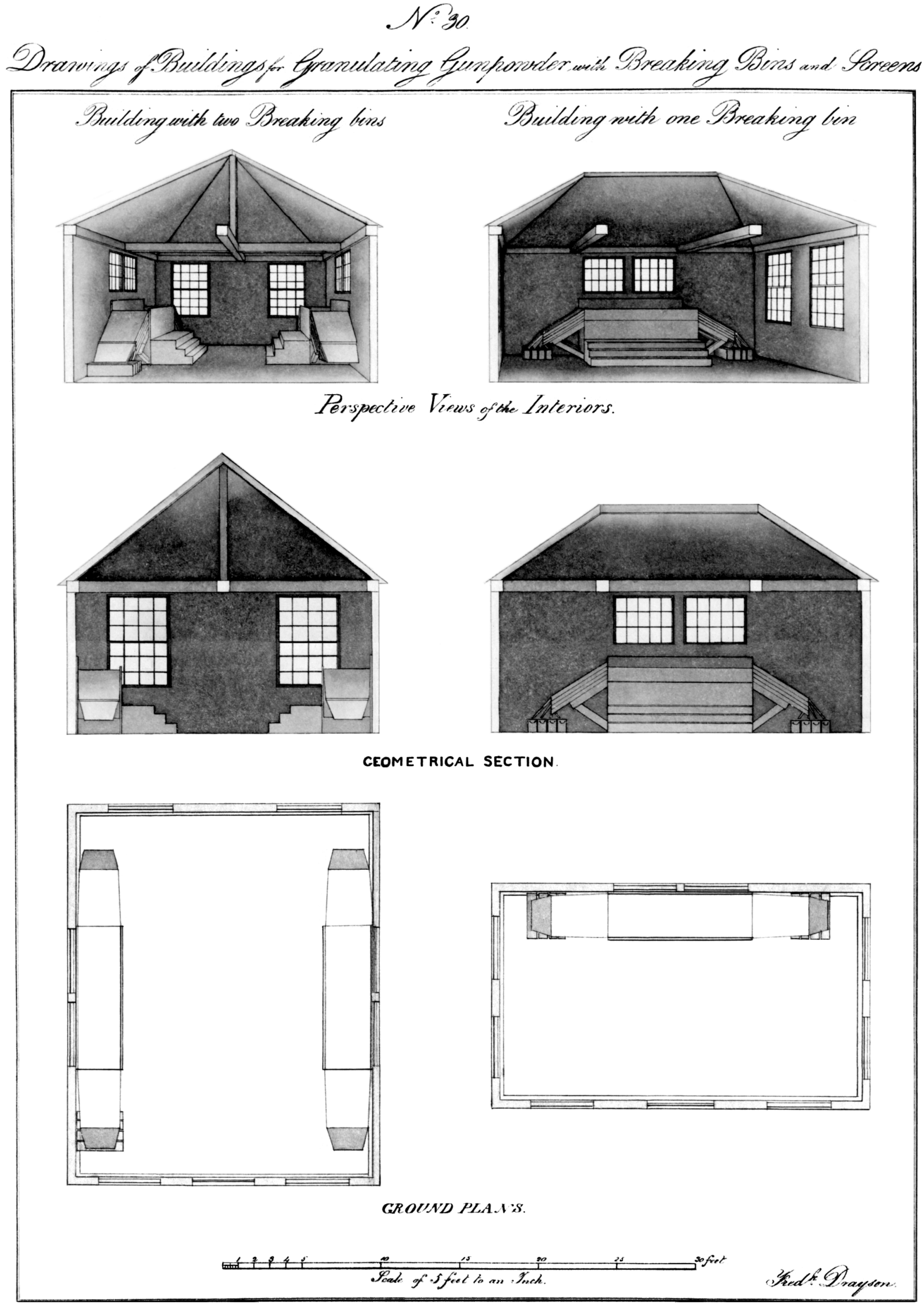
I have already proposed a remedy for these dangers by simply granulating the gunpowder upon breaking bins, and separating the different sized grains from each other and from the dust by sending them down a nest of sieves attached to each end thereof, instead of granulating it by shaking frames; as a mitigation of these dangers by separating the 24½ per cent of grain and the 12½ per cent of dust, made in breaking up the press cake upon the breaking bins in the ordinary way, from the chucks by sending them down the nest of screens which I proposed to attach to each end of the breaking bin, and only putting the chucks into the sieves upon the shaking frames.

A trial has already taken place to ascertain the expense of granulating by either of these methods, and the result has been transmitted to the Board of Ordnance; I shall therefore only here state, first, that when the powder was granulated wholly upon the breaking bin it was proved, that a less quantity of dust was produced than in the ordinary way of granulating with the shaking frames; that 84 per cent of that dust was separated from the grain by the screens, and did not float about the building, and therefore could be repressed without the expense of reworking at the gunpowder mills; that the expense of erecting the buildings and breaking bins and keeping them in repair would be three fourths less than the expense of erecting corning houses and shaking frames and keeping them in repair; that the breaking bins and screens would not require the aid of water power; that the process might be carried on in small buildings which would not cost more than £100; that only about 5 barrels of powder need be in each of these buildings at one time, instead of from 25 to 40 barrels, and consequently that if an accident did take place only those 5 barrels of powder would explode, destroying one building worth £100, instead of from 25 to 40 barrels destroying buildings worth £4700, and only two men would be killed instead of __; and finally that the expense of granulating the gunpowder would be 40 per cent less than the expense of granulating by shaking frames described at page 17 and next that when the screens were only used to separate the chucks from the grain and dust produced in breaking up the press cake upon the breaking bins in the ordinary way, and sending the chucks to be granulated in the sieves upon the shaking frames, it was proved that the 12½ per cent of dust already spoken of amounting however to 44 per cent of the total quantity of dust produced in the process of granulating gunpowder by shaking frames, could be repressed without being reworked, and only 56 per cent of the dust would require to be reworked at the gunpowder mills; that the quantity of dust floating about the building would be 44 per cent less; and finally that the total expense of granulating gunpowder would be 26 per cent less than if the shaking frames only were used.

This being the case it requires but little consideration to determine that screens ought to be attached to the breaking bins; but as there are 2 corning houses at Waltham Abbey working shaking frames, and each erected at an expense of £3000, it would perhaps be inadvisable to incur the expense of taking them down and erecting other buildings for breaking bins and screens, particularly as the water by which their machinery is now worked would run to waste; but I would recommend that the breaking bins at each press house should have screens added thereto, so that the broken press cake might be sent down them and cleared of the grain and dust unavoidably produced even in the common way of breaking up the press cake before it is put into the sieves upon the shaking frames. The expense of adding screens to each breaking bin would be about £15.

Again, these two corning houses are quite equal to granulate the powder required during a time of peace, and consequently, any corning buildings erected in addition thereto, could only be required because of a war, and therefore would only be employed whilst the war lasted; under these circumstances, it would be most economical to erect such buildings as would cost least, because it is probable they would be pulled down at the re-establishment of peace, as two corning houses were at the end of the last war; and as buildings with breaking bins and screens may be erected at one quarter the expense of corning houses and shaking frames, and yet do the same quantity of work, I would recommend that the additional quantity of gunpowder required whenever the country may be engaged in war, should be granulated in buildings with breaking bins and screens similar to those shewn in the drawing numbered 30.

It has been suggested to have one of the corning houses fitted up with four shaking frames and the other with 6 reels, instead of the buildings remaining as they are at present; and also to have the tumbling shafts and machinery that work the shaking frames placed under the floor of the building. These proposed alterations in the machinery of the corning houses


No. 30
Drawings of Buildings for Granulating Gunpowder with Breaking Bins and Screens
Building with two Breaking bins
Building with one Breaking bin
Perspective Views of the Interiors.
GEOMETRICAL SECTION.
GROUND PLANS.
1 2 3 4 5 10 15 20 25 30 feet
Scale of 5 feet to an Inch.
Fredk. Drayson.

Drawing 30

however, would have rather an injurious than a beneficial effect; for the buildings would not be enabled to do any more work in consequence of them, and a greater expenditure in labor would be required in conveying the grain from the building proposed to contain the shaking frames to the one proposed to contain the reels; and further, if the tumbling shafts and machinery that work the shaking frames were placed under the floor of the building, they would be as liable to heat from friction as they are now, placed as they are above the floor, but the workmen would not be able to ascertain when such an occurrence took place so soon as they now do, because the machinery would be out of their sight, and the offensive effluvia arising from the oil, by which the overheating is now discovered would not be as easily smelt.

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On the Process of Granulating Gunpowder by the machine
invented by the late Sir Wm. Congreve.

Before entering into any remarks upon this machine it may be proper to observe that it was intended more as a model than a machine for constant work.

It has been shewn (see page 26) that the powder granulated by this machine is first reduced to a powder and then pressed in thin cakes between copper plates. In practice however, these copper plates are found to bend unequally from the difficulty of always filling the spaces between them equally with the broken mill cake, so that whilst some parts of the powder are pressed very hard, other parts will almost crumble into dust upon being squeezed between the fingers; and the operation of separating the hard pieces of press cake from the copper plates is attended with great danger from the copper knife and chisel frequently coming in contact with them.

The rollers which reduce the press cake to grain are constantly out of order, in consequence of the teeth becoming blunt, and the spaces between them choked up with powder; when the teeth are sharp the press cake is nipped into grain, and little dust is made, but when the teeth have become blunt the press cake is only crushed to pieces, and at such times a large quantity of dust is produced.

The rollers and numerous bearings on this machine render it one of a most dangerous description, and it has not been adopted by any private gunpowder manufacturer; indeed it is surprising that it has stood so long without destruction, and it can only be accounted for from the men having taken great care, and from its never having been urged to do any great quantity of work in a given time.

I would therefore recommend that the use of this machine, the hydraulic presses, and the breaking machine should be discontinued.

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On the Process of Dusting the Fine Grain

This process is merely the separation of the fine grain from the dust produced in forming the grains at the corning house, and which is not separated from them at that building; it is therefore taken to the dusting house and undergoes the operation described at page 28.

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On the Process of Glazing the Fine Grain.

This process is intended to produce the same effect as the operation of glazing the large grains, viz. the removal of the soft parts and sharp angles from the grains, and imparting to them a polish, by which they are better enabled to withstand the effects of the atmosphere and of time. This operation causes the [1]large grain to assume a greyish color, whilst the [2]fine grain becomes of a deep black.

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On the Process of Drying Gunpowder by Steam.

The Steam Stove is far preferable to the gloom stove for drying gunpowder, but the pipes in the drying rooms of the building shewn in the drawing numbered 22, are inconveniently placed so far as regards the equal distribution of the heat, being too high from the floors, and too near to the ceilings. I would however recommend that the drying room should be heated by warm water instead of steam as they are at present, because it is a more simple and less expensive made.

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On the Process of drying Gunpowder by Cast Iron Pots.

This operation is more expensive than the operation of drying powder by steam; the workmen must take great care in removing the powder from the racks after it has been dried, and properly cover the iron pot, to prevent any of the grain from falling thereon.

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General Remarks on the Manufacture of Gunpowder.

To make gunpowder of superior quality the ingredients must be perfectly pure. Impure ingredients produce injury in two ways, first, because they interpose extraneous matter between the atoms of the combustible substances and thereby impede rapidity of explosion; and secondly because they are deliquescent, they therefore imbibe moisture, which induces an incipient crystallisation of the nitre, and thus gunpowder of impure elementary parts includes within itself the germ of its own destruction.

In the operation of charring the wood, two points should be attended to, first not to char too much, and second to produce charcoal light and free from a glazed crust.

Minute commination facilitates incorporation, indeed the ingredients may be prepared & mixed in such a manner[3], as either greatly to increase the strength of gunpowder, or diminish the time required for its incorporation. The greatest attention ought to be paid to the process of amalgamation, though of course it ought not to monopolise all, and pure water should be used in liquoring the charges. On cutting a piece of mill cake it ought to be without any white specks and exhibit an ashey grey color if made with willow charcoal; if made with alder charcoal it ought to be of a brown cast, and if made with black dog wood charcoal the color ought to be a decided brown.

The operations of pressing and glazing should not be carried to excess they are necessary because of the susceptibility which even the best gunpowder possesses of absorbing moisture from the hygrometic property of the charcoal, it is necessary that gunpowder should not only posses great propellant force when newly made, but also retain its power to remote periods. These operations preserve the powder and make it competent to withstand the shaking and

[1] sample 31
[2] sample 32
[3] sample 21

friction of carriage. Another advantage resulting from the operation of pressing is equality of projectile effects; for when the [1]gunpowder is taken from the gunpowder mill some is hard, some in pieces that easily crumble, and some in dust; of course the density is not equal, and as density has a very influential operation in practical results, it is desirable that equal density as far as attainable should be possessed by every grain; and to secure this, the same weights of powder is always placed in the press at one time, and the thickness to which it is reduced is always invariably the same. Thus equal density must follow as far as practice can effect it, and regularity of projectile force, when the powder is used in actual service.

The benefits of pressing and glazing therefore are absolute, although they interrupt the rapidity of combustion, and thereby reduce the propellant force of gunpowder nearly one half, for if it be granulated without being pressed and glazed it will raise the eprouvette about 6 inches, but if it be first pressed, then granulated, and afterwards glazed it will seldom raise the eprouvette more than 3 inches; this refers to the powder only when newly made, for if kept any length of time the mill cake looses its force, but the pressed and glazed powder remains at the same strength as when first manufactured.

The best gunpowder being as aforesaid, exceedingly susceptible of deterioration, it is of great importance that the wood of which the gunpowder barrels are made, should be perfectly dry and well seasoned, and the best wood for this is Quebec oak.

It may be now seen that cannon and musket powder are produced by the same operations, and that the only difference existing between them is this, in that the [2]cannon powder is in grains that will go through a sieve of 8 meshes to the inch, and not through one of 24 meshes to the inch; whilst the [3]musket powder is in grains sufficiently small to go through a wire of 24 meshes to the inch, and yet large enough not to go through one of 48 meshes to the inch; it is true the latter possesses more propellant force than the former powder, because being in smaller grains a greater surface is exposed to the action of the flame; and therefore its explosion, although the difference may not be perceptible, as more instantaneous. It might also be known that in manufacturing these two powders, of the dust that is sent to be reworked [4]43 per cent is in grains that will pass through a sieve of 48 meshes to the inch, and also large enough not to pass through one of 60 meshes to the inch, corresponding in size with rifle powder which has been manufactured by Government, and with the best sporting powder[5] sold by the gunpowder merchants; any grains remaining that will pass through a sieve of 60 meshes to the inch are so small as scarcely to be distinguished from dust. It is not imperative to have the grains of cannon and musket powder of the same size as they are at present, and the wire, reel cloth and cyphrus silk through which they are run and by which their size is regulated have been frequently changed, it therefore becomes a question whether they should not be reduced to finer grains, for it need scarcely be added that the smaller the grains to which it is reduced the stronger is the powder. It is true a greater expense would be incurred in reducing the powder to smaller grains, but it is to be considered whether this increased expense would not be more than counterbalanced by the saving that would be effected in the expenditure of the powder from smaller charges becoming necessary, and also whether an increased effect would not be produced in actual service, in consequence of the more instantaneous explosion of the charges of the
cannon.

In producing rifle powder (of which I believe none has been manufactured since 1815) some deviation from the mode of making cannon and musket powder has taken place, the charcoal having been made of black dog wood instead of willow or alder, and it was submitted to the process of amalgamation from one to two hours longer, was granulated in sieves having their

[1] sample 22
[2] sample 33
[3] sample 34
[4] sample 29
[5] sample 35

bottoms made of brass wire cloth of about 53 meshes to the inch, and was all reduced to grains sufficiently small to go through the wires of those sieves, it not being as in manufacturing cannon and musket powder, some reduced to grains that will and some that will not pass through a wire of 24 meshes to the inch. This alteration in the mode of making rifle powder is in consequence of greater nicety being required than in the two other kinds, from smaller charges being used, and from the difference in the bores of rifles, it being desirable that they should be fouled as little as possible after each discharge, and rifle powder produces this objectionable effect in a less degree than cannon or musket powder. It appears to me however, that the process which has been hitherto carried on to effect this object has created a greater expense than necessary, was highly detrimental to the quality of the powder, for when it is all broken up small enough to go through a wire of 53 meshes to the inch, nearly one half of it is reduced to dust, which requires reworking very often, and thus looses much of its propellant force from the lighter and more inflammable parts of the charcoal escaping, and that other means of granulating it of a less dangerous character may be introduced, for be it remembered that three corning houses exploded at Faversham whilst producing this powder, killing 24 men, and destroying £15000 worth of property, besides injuring many thousand pounds worth more. The expense of granulating a barrel of rifle powder hitherto has been 6s.. 1¾d more, than the expense of granulating a barrel of cannon or musket powder; the former being 13s.. 8¼d, and the latter 7s.. 6½d per barrel; whilst the additional cost of dog wood over willow or alder for a barrel of powder is only 1s.. 4½d, the former being 2s.. 6d, and the latter 1s.. 1½d per barrel. I would therefore suggest that whenever any rifle powder is required, sufficient dog wood should be purchased to make enough mill cake to produce the number of barrels required by breaking up and granulating the powder as it is done at present, thus producing cannon, musket, and rifle powder at the same time, and out of the same materials, the latter to consist of the 43 per cent of grain amongst the dust that will pass through a wire of 48 and be retained by one of 60 meshes to the inch, and thus a saving of 4s 9½d per barrel would be made in the process of granulating alone. The total saving in manufacturing each barrel however would be 13s, for if made as it has been hitherto it will cost £2.. 0.. 0¾, but if in the manner I have just proposed it will only cost £1 7 0¾ per barrel, besides giving at the same time improved quality of cannon and musket powder. And I would recommend that the 43 per cent of grain amongst the dust, produced in manufacturing cannon and musket powder should be separated from it, for I cannot perceive the advantage of incurring an expense of 11s.. 1¼d per barrel in reamalgamating, repressing, and regranulating that which is already in grains that will pass through a wire of 48 meshes and be retained by one of 60 meshes to the inch and actually fit for service, merely for the sake of having it so large as not to pass through the first wire.

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On the Process of Regenerating damaged Gunpowder.

The process of regenerating damaged gunpowder is of recent introduction, its effect was first tried by the late Sir Wm. Congreve; it has been in operation at Waltham Abbey since the year 1822, and about 18000 barrels of damaged gunpowder have been operated upon.

After gunpowder has been manufactured about 20 or 25 years particularly if it has been exposed to the deteriorating effects of a sea voyage, it looses its form of grain, crumbles into dust, and is deprived of its propellant force; the purity of the ingredients however is seldom affected unless the powder is allowed to remain in its deteriorated state for any length of time. If it therefore undergoes the process of regeneration described at page 34, the incorporation of the ingredients is again rendered as perfect as in new gunpowder; and for the sum of 16s.. 2¼d, the value of a barrel of damaged gunpowder is increased from £1..7s to £4..10 or £5.

The process of regenerating gunpowder therefore must be considered of great advantage, where the quality of the ingredients is not affected, and particularly where a large stock is kept in store.

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On the Process of Extracting Saltpetre from unserviceable Gunpowder

This process is very simple and differs little from the process of refining the saltpetre before it is manufactured into gunpowder. When the gunpowder has lost its propellant force, and the ingredients have become contaminated with foreign matter, it is not only impossible to restore to them their former explosive properties but exceedingly dangerous to attempt it; still however the nitre may be extracted from the charcoal and sulphur by the process described at page 34, and be again used in the manufacturing of new gunpowder.

It would be advisable that the persons appointed to select the powder to be extracted, should be well aquainted with its nature, and be careful they do not condemn that which may only require to be regenerated; for there has been much powder sent to Faversham to be extracted which was but little deteriorated, and these samples were recently tried at Waltham Abbey in the mortar with 2 ounces of powder, the usual charge, the ball of which was propelled the following distances, viz.

1st Proof 280 feet
2nd " 236 "
3rd " 230 "

whilst the average distance it was propelled on the same day by the newly manufactured powder was not more than 300 feet; thus clearly shewing either that a proper examination was not made, or that the persons who condemned the powder were not sufficiently aquainted with it; for by the process of regeneration it might have been rendered as good as any that had undergone that operation, and for every barrel of powder that is thus unnecessarily extracted, a loss of £1..4..8 is entailed upon the country.

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On the Proof of Gunpowder.

Gunpowder is invested with difficulties from the earliest stage of its manufacture down to its proof; the methods described at page 36, constitute a sufficient check upon its manufacture.

In proving gunpowder, extraordinary discrepancies take place, indeed the results are often so capricious as to make it impossible to account for them; and the mere proof of gunpowder affords no further criterion for the guidance of actual service, than as it gives the range of the particular charge in the particular piece of ordnance in which the proof is made. Equal range has often been mistaken for equal quality, this however is a great error if applied universally, for it will frequently happen that bad gunpowder when fired in large charges will project a ball as far as good gunpowder, but if fired in small quantities it will not range one quarter the distance of the powder to which it was before equal; but where different gunpowders range equally in artillery of all sizes and denominations with all the diversified multiplicity of charges used in actual service, they may be regarded as equally good.

The only principle upon which gunpowder should be tried as to its strength is that in which all the charge explodes before the projectile is sensibly acted upon, and this, it is almost certain takes place in the mortar when small charges are used.

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On the Strength of Gunpowder

No satisfactory explanation has ever been given of the cause of the power of gunpowder, by some it is attributed to the gases it generates on ignition, by others it is attributed to other causes, none of which tend to place it without clear position, in which it is possible to determine its power by any certain rule or data.

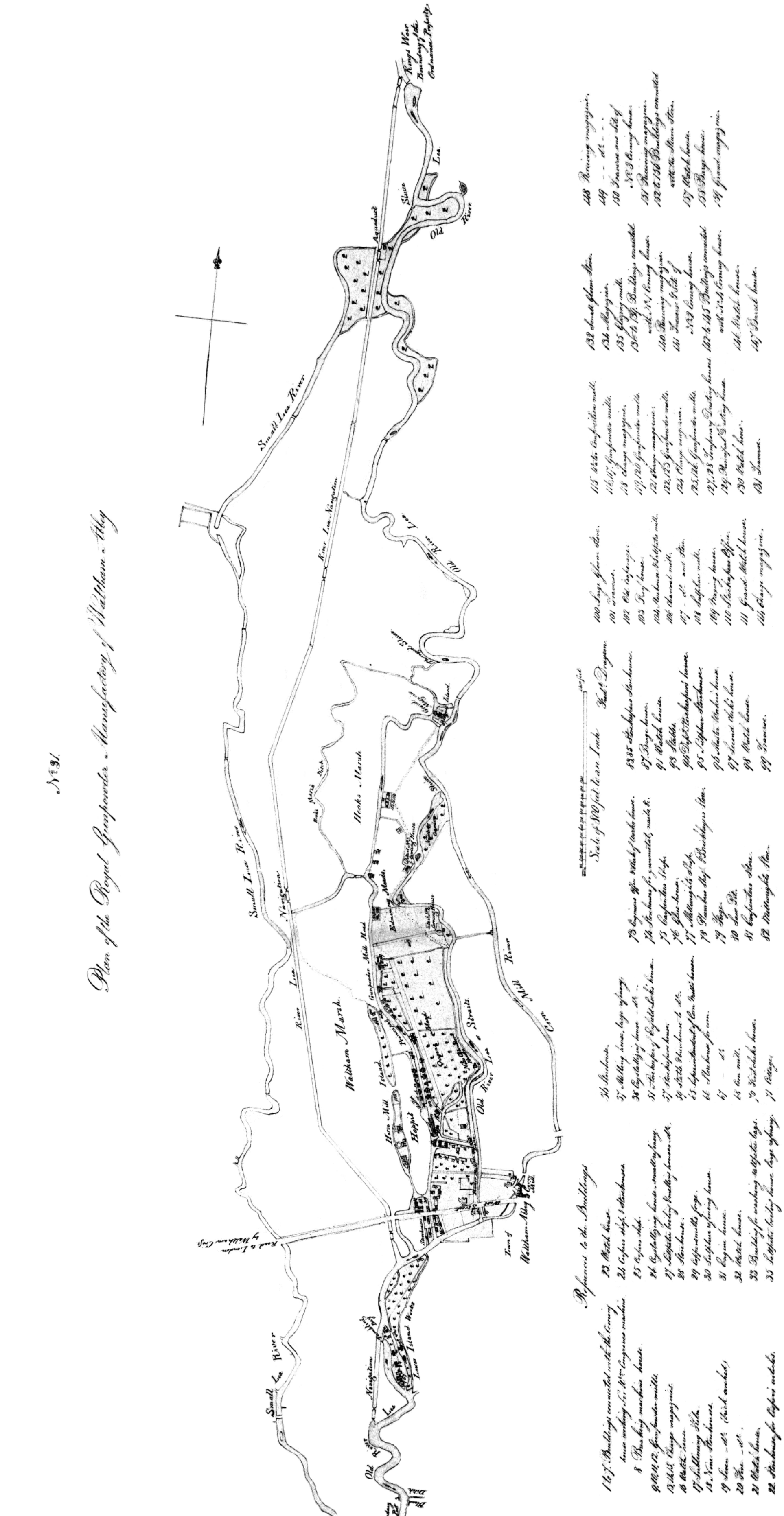
The strength of gunpowder it appears to me, depends upon the size of the flame it produces, and the size of that flame depends upon the quality of the ingredients, the perfectness of their amalgamation, and the instantaneousness of their explosion. The flame produced by gunpowder must be considered to be a body brought suddenly into existence, and to confine it is impossible, for it will destroy or displace every thing opposed to it. This flame denominated by chemists a permanently elastic fluid, is calculated by some writers to be 244 times the bulk of the gunpowder, by others 4000 times and upwards; but to ascertain this point with accuracy is very difficult, and at best it can only be matter of speculation, it however by any experiments approaches nearer to the latter than the former amount.

The size of the flame produced by gunpowder is liable to great variation, and although two powders may be exactly equal in strength it is doubtful if they will project a ball equal distances in actual service; this variation is caused by the difference in loading the cannon, firing the charge, and many other circumstances, which although they may appear of little importance, have a very influential effect upon the size of the flame produced; and therefore, even if there were any means of ascertaining with accuracy what are the dimensions of the flame created by exploding gunpowder, it would not form any certain data for actual service for the reasons just stated.

A charge of gunpowder confined in a piece of ordnance may be considered as a short bulky train, in a 42 pounder it is nearly two feet in length, and unless the whole explodes before the ball is sensibly acted upon, it cannot receive the full effect thereof. It sometimes happens that a great portion of the charge is driven out of the cannon without igniting; this has been proved by laying a piece of linen in front of the cannon, and it was covered with grains of powder after the piece had been fired. In actual service, only that portion of the powder can be effective which explodes before the ball has left the cannon; and from this cause may be partly traced the variations in the ranges of powders possessing equally good qualities, and the reason of bad powder ranging as far as good powder when used in large quantities. It appears an established fact that there is a certain charge for any piece of ordnance beyond which it is useless to go, but the following trials made in a 24 pounder at the several degrees of elevation specified, may put the question in a clearer point of view, the range is taken to the first graze of the shot.

		yards		yards
Pointblank	6 lbs of powder	480,	10 lbs of powder	480
2° Elevation	“	1100	“	1100
2 ½°	“	1210	“	1216
4°	“	1552	“	1552
4 ½°	“	1646	“	1646
5°	“	1746	“	1740

Hence we may conclude that in each case 4 lbs of the larger charge was blown out of the cannon unconsumed, or exploded uselessly, and therefore, that a large proportion of high charges explodes to no useful purpose.


No 31
Plan of the Royal Gunpowder Manufactory of Waltham Abbey
References to the Buildings
Waltham Marsh
Small Lea River
River Lea

Drawing 31

A Treatise on Gunpowder

Part the Third

Report upon the Royal Gunpowder Manufactory of Waltham Abbey
Situation and Extent

The Royal Gunpowder Manufactory at Waltham Abbey is situated in two falls of water in the river Lea, about 12 miles N. of London. It was formerly a moderate sized private manufactory, and was purchased by Government in the year 1787, and then consisted of a Saltpetre Refinery since pulled down,

A Composition mill worked by horses,
A Mixing house;
Seven gunpowder mills,
A Corning house, worked by horses, which was destroyed by an explosion in the year 1801, and has not been rebuilt,
A Dusting house, and
Two Gloom Stoves,

and might be considered capable of producing 6000 barrels of gunpowder annually. At that period the gunpowder manufactory drew only a portion of the stream of the river Lea, the remainder being divided between the Cheshunt and Waltham Abbey corn mills. By the purchase of these two mills, the stream which had worked them could be applied to the processes of the gunpowder manufactory; and by the erection of additional buildings upon the old mill head, and others upon a new mill head below the town of Waltham Abbey, this manufactory was enabled in the year 1813 to manufacture 25000 barrels of gunpowder.

At the establishment of peace in 1815, some of the oldest and most expensive buildings were pulled down and their materials sold, only the most efficient buildings have been kept in repair and worked, so that many of the remaining buildings and particularly some of the old mills have become much dilapidated giving the manufactory a desolate and ruinous appearance. Its capabilities however are little impaired, and more than equal to the work it now performs; and the whole might be restored to its former efficiency, at an expense which it would be undesirable to incur until a larger quantity of gunpowder is required than at present.

Previously however, to entering into any details upon the state of the buildings it may be necessary for the sake of clearness, to give an account of that agent upon which the capabilities of the manufactory mainly depend, viz.

The Water Power.

The water power possessed by the Ordnance at Waltham Abbey consists of 8750 yards, or almost 5 miles of the river Lea, commencing at the tail of the Kings weir about 4 miles above, and extending to Black Ditch, about one mile below the town of Waltham Abbey, where it joins the Enfield water, also the property of the Ordnance. In the course of this distance the river divides into four channels. The first channel called the small river Lea branches off from the main stream about a quarter of a mile below Kings weir, passes under the river Lea navigation cuts (from which this part of the Ordnance property derives the name of the Aqueduct) and after continuing a winding course for about 5 miles, joins the main stream at Enfield Lock;
this channel varies from about 15 to 50 feet in width, from 2 to 10 feet in depth, and assists in carrying off flood water from the main stream by means of a sluice at the Aqueduct. Only a portion of this channel belongs to the Ordnance. From the Aqueduct the main stream pursues a course of about 2½ miles, varying from 50 to 100 feet in width, and from 3 to 16 feet in depth, and arrives at a place called Thorogood sluice; here the second channel commences called the principal gunpowder mill head, which runs by the back of Paynes Island, and after pursuing a course of about 1½ mile, passes in two streams through the town of Waltham Abbey; this channel varies from 20 to 70 feet in width, and from 4 to 20 feet in depth; the water from the

main stream is admitted into it through two sluices at Paynes Island, the sluice at Thorogood was removed some years ago, and an overshot erected in its place, with the mill higher than the surface of the water in the main stream, so that the water only runs over during floods.

From Thorogood sluice the remainder of the river passes in front of Paynes Island, and flows to Newtons garden, where it divides into two streams; the first is called the old river Lea, or straits, and after pursuing a winding course of about 1¼ mile passes through the town of Waltham Abbey under a part of the Storekeepers house; this channel varies from 20 to 50 feet in width, and from 3 to 20 feet in depth, and the water is admitted into it through a sluice at Newtons garden. The second of these streams is called the corn mill river, and after pursuing a course of about one mile passes through the town of Waltham Abbey in two streams; this channel varies from 20 to 50 feet in width, and from 4 to 8 feet in depth.

The three last streams after passing through the town of Waltham Abbey unite into one which flows on to black ditch, varying in its course from 50 to 100 feet in width, and from 3 to 16 feet in depth.

From the tail of Kings weir to Black ditch there is a fall of 19 feet, and in the course of this distance the water is collected into 3 heads, thereby creating three falls. The first head consists of all the water contained in the main stream from the tail of Kings weir to Paynes Island, and also includes the water from hence to the Waltham Abbey corn mill; the fall into the principal gunpowder mill head at Paynes Island is 1 foot 6 inches; the sluices acting as outlets for surplus water during floods have different heights of fall, that at the Aqueduct being about 4 feet, and that at Newtons about 3 feet; and owing to the shallowing of different parts of the river, there is a further fall of 8 feet 6 inches between the tail of Kings weir and Paynes Island.

The second head consists of that part of the second branch which exists between Thorogood sluice and a tumbling bay commonly called the gullies near to the Storekeepers Office; this mill head has a fall of 6 feet.

And the third head consists of the water from the gullies to the tumbling bay at the Lower island; the mills &c are erected upon a small cut about a quarter of a mile in length, commencing a little above the tumbling bay; this head has a fall of 2 feet 10 inches.

The power of these falls of course depends upon the quantity of water passing through Kings weir, and varies according to the different seasons of the year, there being a greater quantity in the winter than in the summer months; and during the year 1830 the supply was as shewn in the following table.

Periods	Smallest quantity	Largest quantity	Average quantity	Remarks
	Cubic feet	Cubic feet	Cubic feet	These quantities are exclusive of floods. The greatest floods generally occur in the latter end of Jan. or the beginning of Feb. when the snow which has fallen during the winter melts, and causes the river to run from 4 to 6 feet above its ordinary level, overflowing the adjacent country in many parts upwards of 3 feet deep. During such floods the supply is sometimes as much as 4000 cubic feet per second.
From 1st January } To 21st April }	270	270	270	
From 22nd April } To 16th June }	180	270	200	
From 17th June } To 10th September}	120	180	140	
From 11th September} To 31st October }	180	270	200	
From 1st November} To 31st December }	270	270	270	

These quantities are the average of measurements taken two or three times a week during the whole year; the smallest quantity viz. 120 cubic feet per second was during the month of August, which is generally the driest portion of the year.

It has been stated by others, that the supply of water in the river Lea at Waltham Abbey during 6 months of the year is only 200 cubic feet per second, during another 3 months 120 cubic feet per second, and during the remaining 3 months of the year only 70 cubic feet per second; & that the annual average supply may be taken at 110 cubic feet per second, which upon the two falls employed in turning the machinery of the manufactory is calculated to be equal to the power of 84 horses. This account not only differs greatly from that I have given above, but is also greatly at variance with the report upon the water power made by Mr. Rennie in the year 1806, for that gentleman there states that the average of three measurements taken in the month of August of that year was 120 cubic feet per second, exclusive of the water required for the purposes of navigation, and that of the 120 cubic feet the gunpowder manufactory drew 76 cubic feet per second, the remainder being employed in working the Waltham Abbey corn mill, and further, that the 76 cubic feet per second drawn by the gunpowder manufactory was expended at the fall of 6 feet in working 7 Gunpowder mills, One corning house, and a dusting house.

During the year 1815, when the gunpowder manufactory drew the whole of the stream of the river Lea, exclusive of what was required for the purposes of navigation, there were upon the fall of 6 feet, eleven gunpowder mills, two corning houses, a dusting house, and a glazing mill, all worked by water, now if the supply of water had not been greater than 70 cubic feet per second, it is obvious that a portion of the buildings must have been unable to work, since in 1806 only seven gunpowder mills, one corning house, and a dusting house upon the same mill head required a supply of 76 cubic feet per second. The seven mills at work in 1806 were at work in 1815, and no alteration had been made in their machinery; and further, two gunpowder mills which were erected about the year 1810, and which are at work at present require more water than any two mills that were at work in 1806. In the usual explanations relating to water power, I shall refer to the measurements contained in the foregoing table, which are corroborated by Mr. Rennie, and other eminent Engineers.

The common rule amongst mechanics for reducing water power to horses power, is by multiplying the supply in cubic feet by 62½ lbs the weight of a cubic foot of water, then by the height of the falls, and by 60 minutes, and dividing the total by 44000 the number of pounds it is calculated that a horse can lift one foot high in a minute, and according to this rule the quantity of water given in the foregoing table as the supply on the river Lea at Waltham Abbey would be equal to the following number of horses power, during the periods stated.

Periods	Fall of 6 feet		Fall of 2 feet 10 in		Total number of horses power
	Supply in cubic feet	reduced to horses power	Supply in cubic feet	reduced to horses power	
From 1st Jan To 21st April, and} From 1st Nov To 31st December} a period of nearly 6 months }	270	138	270	65	203
From 22nd April To 16th June, and } From 17th Sept To 31st October } a period of rather more than 3 months}	200	102	200	48	150
From 17th June To 16th September} a period of 3 months }	140	71	140	34	105
Average quantity during the year	220	112	220	43	165

The foregoing calculations are exclusive of fractions; the amounts stated may be taken as the average of future years.

In order to have a correct idea of the power to be obtained from the stream, it must be considered that the machinery in the different buildings cannot with safety <operate> at a greater velocity than has been mentioned in the description of them, that the buildings must be at such a distance from each other, as to be reasonably secure in case of the accidental explosion of any one of them, that in severe winters the frosts will occasionally freeze up the water wheels of the mills and other manufacturing buildings, and finally that from the necessary cleaning, oiling, and repairing the machinery, &c, the full number of working days in the year for each building might not be calculated at more than 300 including Sundays.

Greatest Produce of the Manufactory

When the manufactory was at its highest degree of efficiency the stream did work buildings during a portion of the year, requiring the power of 103 horses upon the fall of 6 feet, and 36 horses on the fall of 2 feet 10 inches, making a total of 139 horses power, viz.

On the fall of 6 feet		horses power	On the fall of 2 ft 10 ins		horses power		Total horses power
11 Gunpowder mills	=	88	4 gunpowder mills	=	32	=	120
2 Corning houses	=	8	1 Corning house	=	4	=	12
1 Dusting house	=	2					2
1 Glazing mill	=	5					5
Total	=	103			36	=	139

The above mentioned machinery worked by water power was aided by 5 Composition mills,
9 Gunpowder mills, each having one pair of stone runners, for reworking dust, and
2 Corning houses.
worked by the animal labour of 50 horses; with those two powers and the gunpowder mills working day and night, the manufactory was enabled in the year 1813, to produce 25000 barrels of gunpowder.

At present however the manufactory only employs occasionally a portion of the stream equal to the power of 43 horses, viz.

1 Composition mill	=	4
4 Gunpowder mills	=	32
1 Corning house	=	4
¼ Dusting house	=	½
½ Glazing mill	=	2 ½
Total	=	43 horses power

Present State of the Buildings

The following is a list of the buildings comparing this manufactory in the year 1833 shewing upon which fall they are situated, and what quantity of work each class is capable of doing.

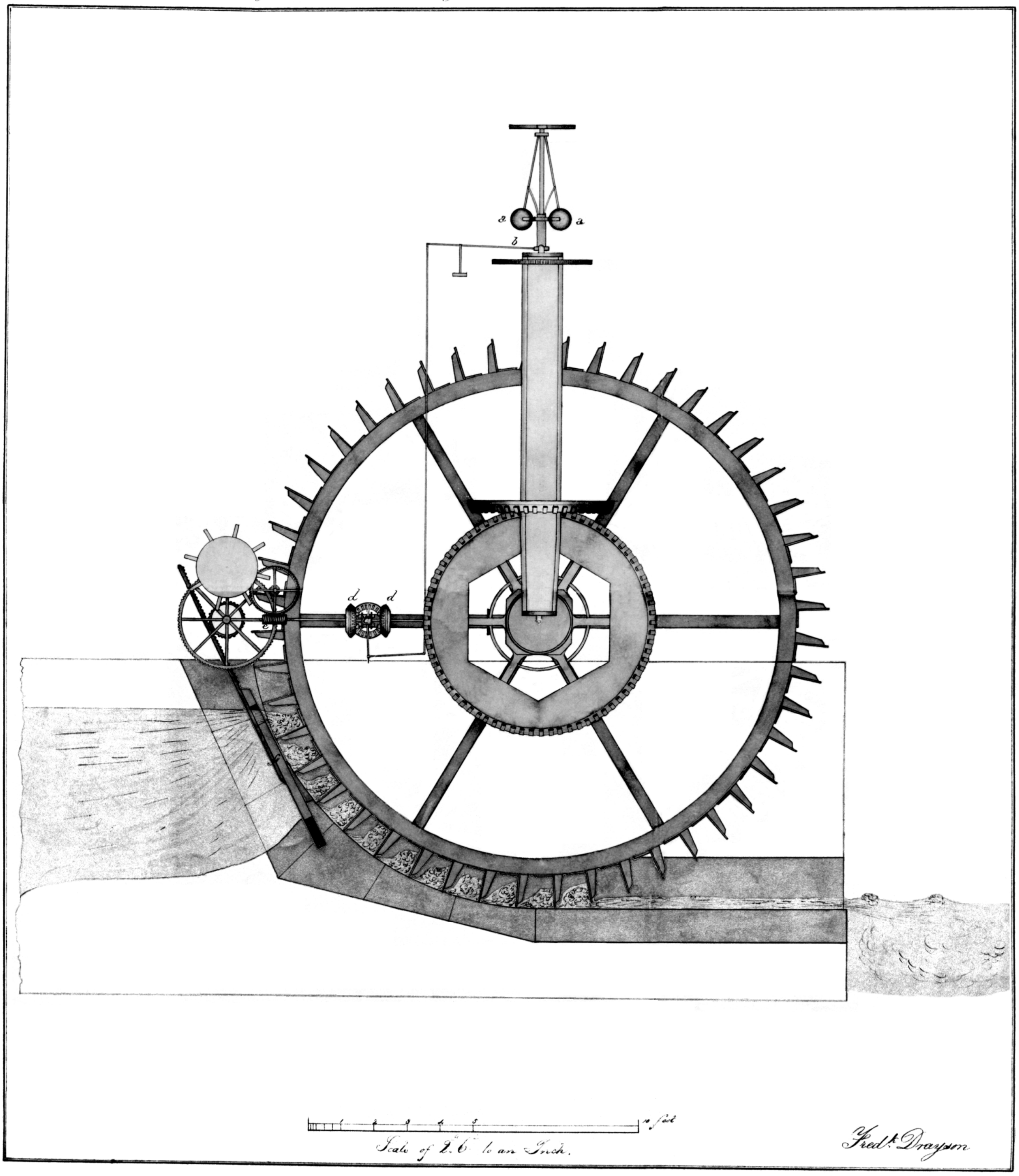
Description of building		On the fall of 6 feet				On the fall of 2 ft 10 ins				Buildings not connected with either fall	Total number	Number of barrels each class of buildings is equal to	Remarks
		Working at present	Not working but repairable	Not repairable	Total	Working at present	Not working but repairable	Not repairable	Total				
Buildings worked by horses power	Composition Mills	-	-	-	-	-	-	-	-	5	5	{25000 ↓ {33000 ↑	1
Buildings worked by water power	{Composition Mills	1	-	1	1	-	-	-	-	-	1	{8000	2
	{Gunpowder mills	4	1	3	8	-	4	-	4	-	12	13500	3
	{Corning houses	2	-	-	2	-	1	-	1	-	3	14000	
	{Dusting house	1	-	-	1	-	-	-	-	-	1	14000	
	{Glazing mill	1	-	-	1	-	-	-	-	-	1	14000	4
	Mixing house	-	-	-	-	-	-	-	-	1	1	30000	
	Charge magazine	2	2	-	4	-	3	-	3	-	7	25000	
	Press house	2	-	-	2	-	1	-	1	-	3	14000	
	Receiving Magazines	4	2	-	6	-	1	-	1	-	7	25000	
Stoves	{Gloom	-	2	-	2	-	-	-	-	-	2	10760	
	{Steam	½	½	-	1	-	-	-	-	-	1	14560	
	Barrel house	1	-	-	1	-	-	-	-	-	1	30000	
	Magazine	1	-	-	1	-	-	-	-	-	1	2000	
	Nitre Refineries	-	-	-	-	-	-	-	-	2	2	28672	
Sulphur Refineries	{Fusion	-	-	-	-	-	-	-	-	1	1	{35840	5
	{Sublimation	-	-	-	-	-	-	-	-	1	1	{	

Remarks

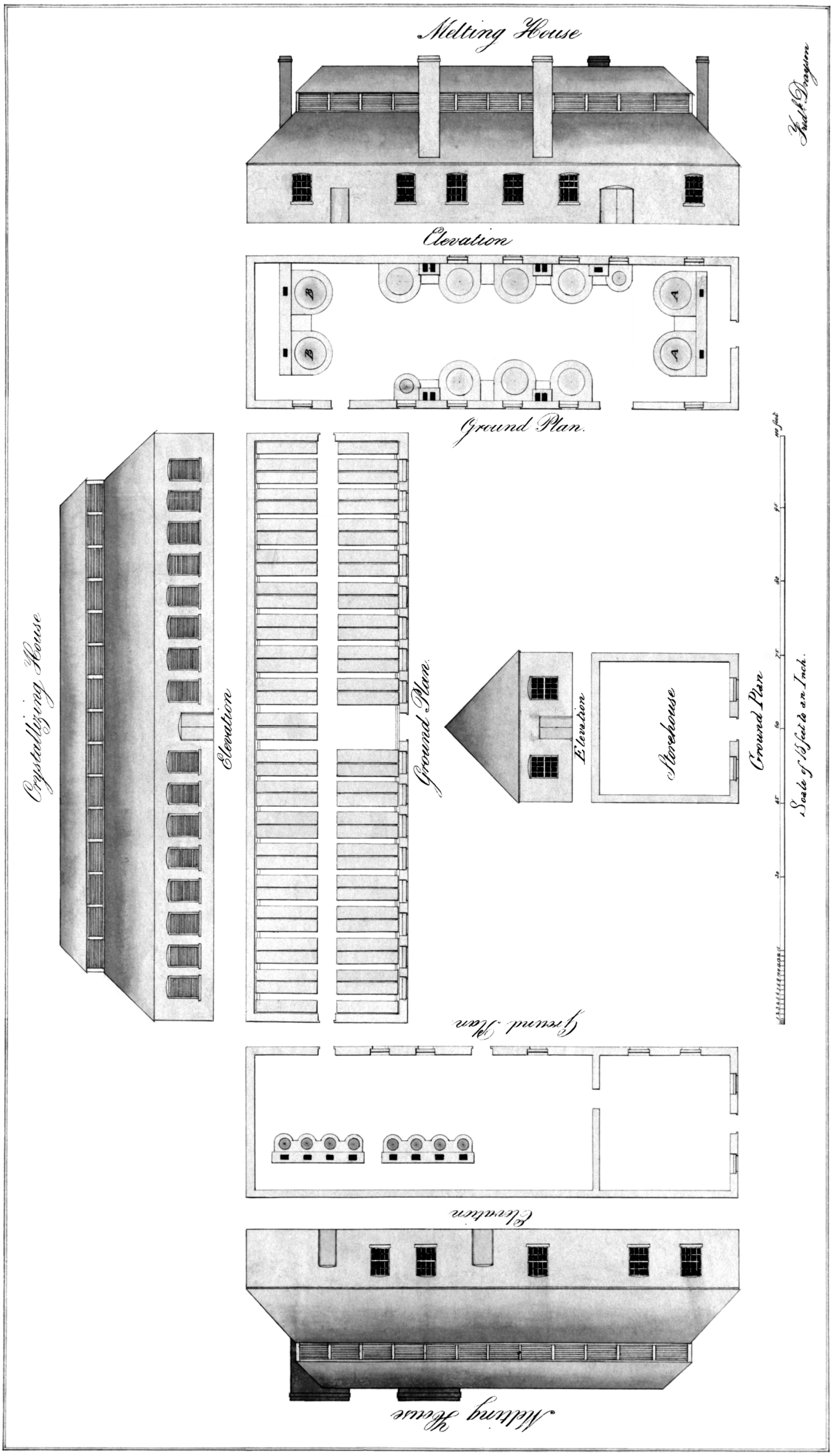
1. These horse composition mills have not been worked since 1815, they are old, but might be repaired so as to grind composition for 25000 barrels of gunpowder per annum, and are situated in the vicinity of the mixing house.
2. This water composition mill was formerly a gunpowder mill, it is a very old building and was at work when the manufactory was purchased in 1787.
3. Excepting two mills erected in 1814 similar to the drawing numbered 12, the whole are upon very defective principles, and the machinery is not alike in any two of them, the water is let on the water wheels by breast instead of sinking gates, so that its force is greatly diminished.
4. The two mills erected in 1814, the corning house on the fall of 2 feet 10 inches and the glazing mill, have each a regulator to regulate the speed of their machinery, those on the gunpowder mills are similar to that shewn on the drawing numbered 32. When the machinery moves with too great velocity, the balls marked a, expand, raise the lever b, and cause the clutch c, to catch one of the small wheels d, which tension the multiplier e, and which turning the other wheels so as to ease the water gate f, admit a less quantity of water on the water wheel, and when the machinery moves too slowly, the balls contract, and the motion of the wheels & c is vice versa.
5. These refineries are adjoining the main street of Waltham Abbey at considerable distances from the river banks.

No. 32

Drawing of the Machinery connected with a Regulator.



Drawing 32


No. 33
Drawings of the Large Saltpetre Refinery
Crystallizing House
Elevation
Ground Plan
Melting House
Elevation
Ground Plan
Elevation
Storehouse
Ground Plan
Scale of 15 feet to an Inch
Ground Plan
Elevation
Melting House

Drawing 33

Besides workshops, Storehouses, and a cooperage? equal to a manufactory producing 30000 barrels of gunpowder annually. The charcoal used at this manufactory had of late years been prepared at the cylinder house at Faversham, a cylinder house with one set of cylinders has just been erected at Waltham Abbey.

From this it may be seen that the only manufactory buildings working at present and in a fit state to work are

A water composition mill,
Four gunpowder mills,
Two corning houses,
A dusting house, and
A glazing mill,

which might if pressed to their utmost force, produce 6000 barrels of gunpowder annually.

It may be necessary to say that the horse composition mills are in a state to be readily repaired, that of the remaining gunpowder mills, four are in a state to be readily repaired, three are in a state of total decay, and one is so dangerously situated as to render its removal imperative, and that the corning houses, the dusting house, and the glazing mill, are in good order.

Drying Establishment.

The buildings composing the drying establishment are one steam and two gloom stoves are much out of repair, excepting one room of the steam stove, in which the powder now manufactured and regenerated is dried, and of course must undergo a thorough repair previous to their doing a large quantity of work. An improvement in the manner of heating the drying rooms of the steam stove has been recommended in the second part of this work, whenever it is intended to put that building in an efficient state.

Refining Establishment.

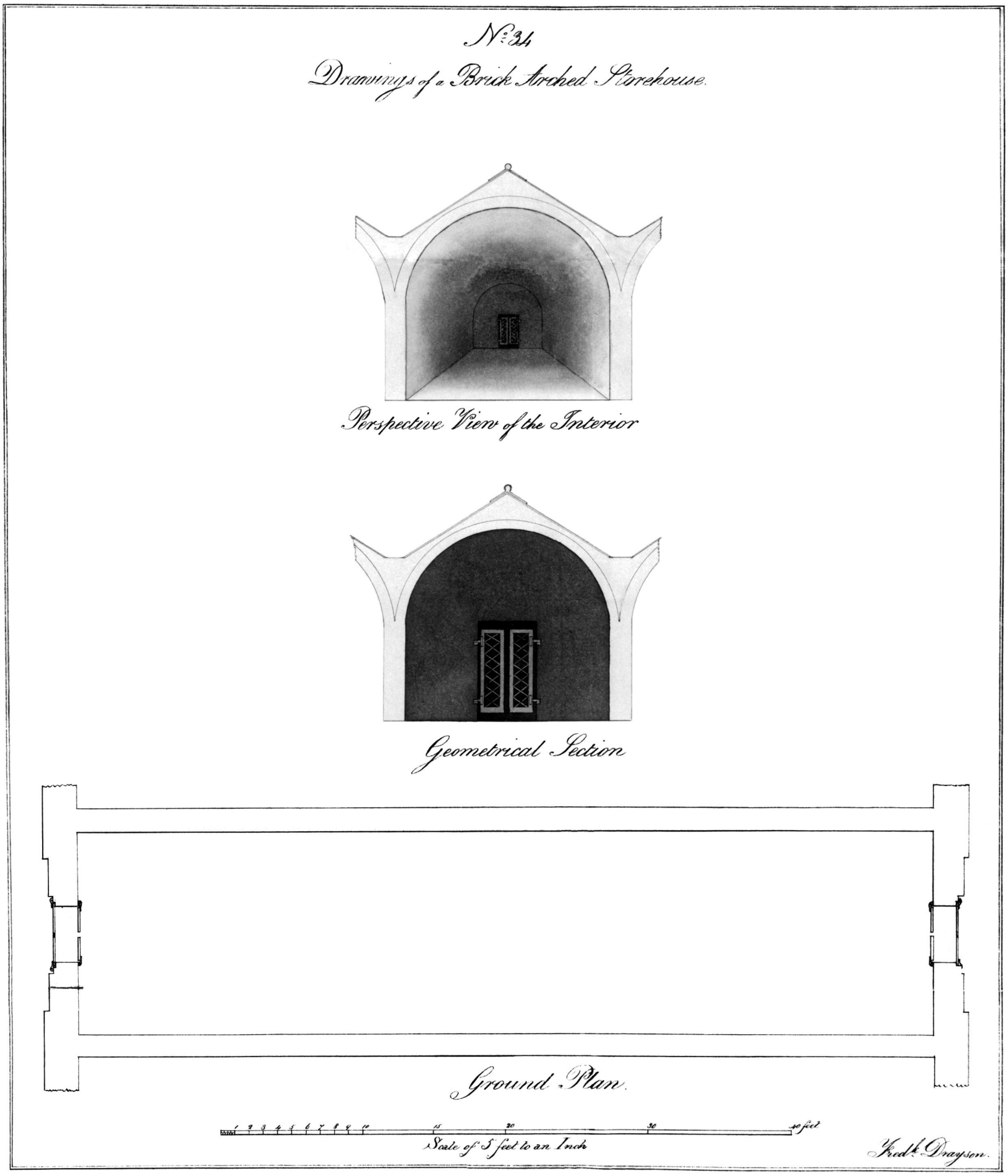
Nitre Refineries.

There are two nitre refineries at Waltham Abbey, one capable of producing 320 and the other 640 tons of refined nitre annually by the process described at page 1, making a total of 960 tons. They are inconveniently placed particularly the large refinery, causing a greater expenditure of labour than would be required were they situated differently; but as it would require the rebuilding of the crystallising houses to obviate this defect completely it is not a measure to be recommended.

In order to point out more clearly the situation of the buildings, I have annotated a drawing of the large refinery numbered 33, shewing the boiling, crystallising, and melting houses as they are actually situated; AA, and BB, are four copper boiling pans. The disadvantage resulting from the situation of the buildings might be greatly diminished by pouring the liquor boiled in the pans BB into the crystallising pans in that part of the crystallising house nearest to them; and the liquor boiled in the pans AA, might be conveyed into the farther part of the crystallising house in a wooden trough, from which it might run into pouring pans, and be poured into the crystallising pans.

Sulphur Refineries.

These buildings are in good order for carrying on the processes for which they were originally intended; an improvement in the system of refining sulphur has been recommended in the second part of this work.


No. 34
Drawings of a Brick Arched Storehouse.
Perspective View of the Interior
Geometrical Section
Ground Plan.
Scale of 5 feet to an Inch
Fredk. Drayson.

Drawing 34

Storehouses.

For Nitre.

The storehouses for containing grough nitre are brick arched buildings similar to the drawing numbered 34, they have cast iron doors, and are fire proof; they are capable of containing 25000 tons of grough nitre, and there are also other storehouses attached to the refineries capable of holding between 500 and 600 tons of refined nitre; they are all in good order.

For Sulphur.

There is at present at Waltham Abbey upwards of 2000 tons of grough sulphur, which is more than equal to 220 years of consumption at the present rate of manufacture; the storehouses are all in good order, except one on horse mill island, which has been much injured by being overloaded.

General Storehouses.

There is sufficient storehouse room for any quantity of stores that may be required to be kept for the purposes of the manufactory at its utmost extent; they are all in good order.

Cooperage.

The cooperage is in good order, and quite equal to supply all the demand of the manufactory, at its utmost extent.

Charring Establishment.

There has never existed any establishment for charring wood at Waltham Abbey, the charcoal was during the war prepared in Sussex, and since then at Faversham, where there is a cylinder house containing 4 sets of cylinders, comprised of three cylinders to a set, which is capable of producing a sufficient quantity of charcoal for 10000 barrels of gunpowder annually.

A cylinder house with one set of cylinders similar to the drawing numbered 35, has just been erected at this manufactory, upon a very expensive system.

Plantations of Willow &c.

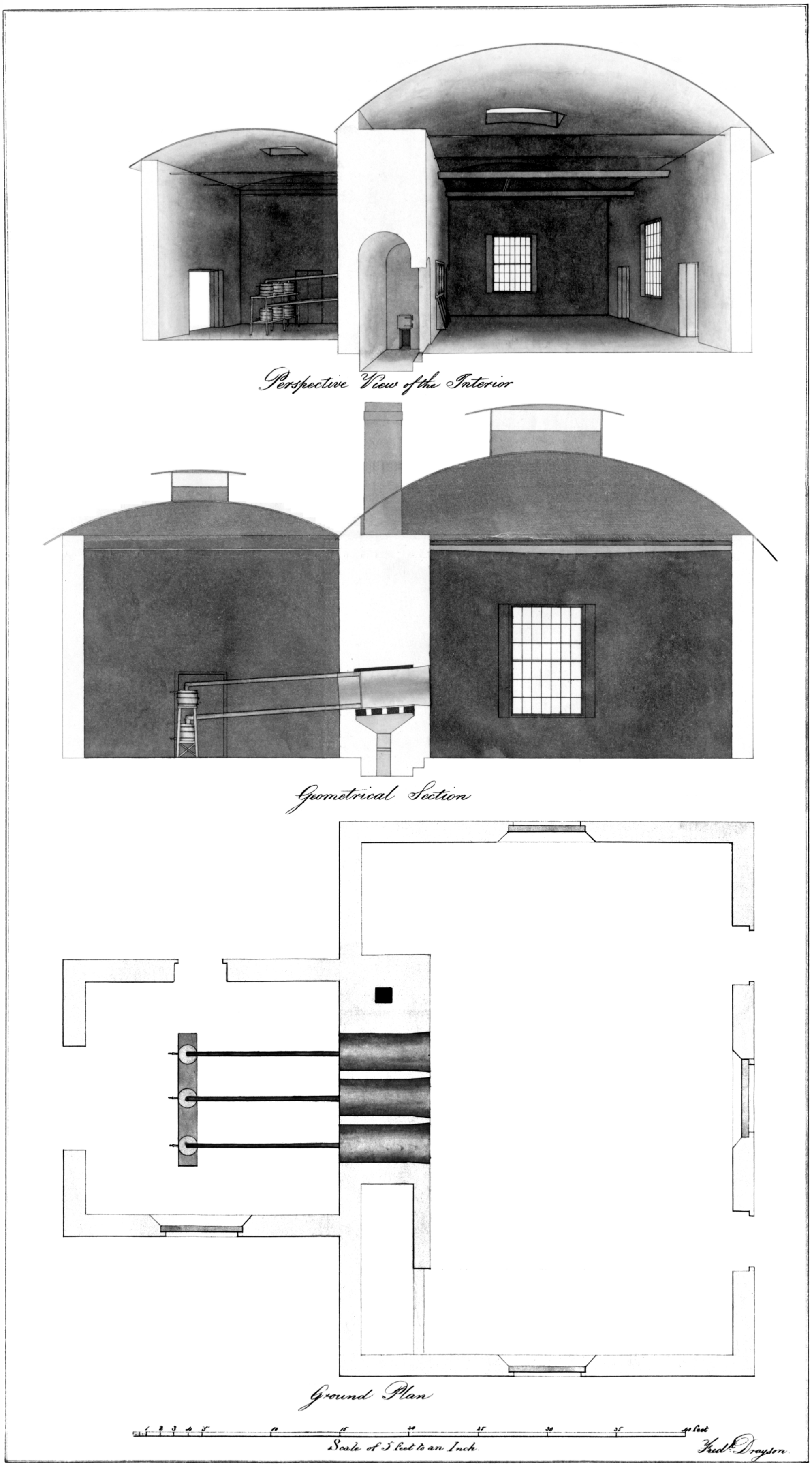
An acre of ground will grow one cord of wood weighing 17 cwt annually, which will produce about cwt 4..3..10 of charcoal, being sufficient for 36 barrels of gunpowder; and I would recommend that willow and alder should continue to be cultivated upon the ground which is at present growing them at Waltham Abbey, Enfield, and Faversham, but that all the remainder of the land belonging to the Ordnance at these stations at present unplanted with any kind of wood, should be planted with black dog wood, because it is much more scarce than willow and alder and a wood difficult to obtain.

Engineers Establishment.

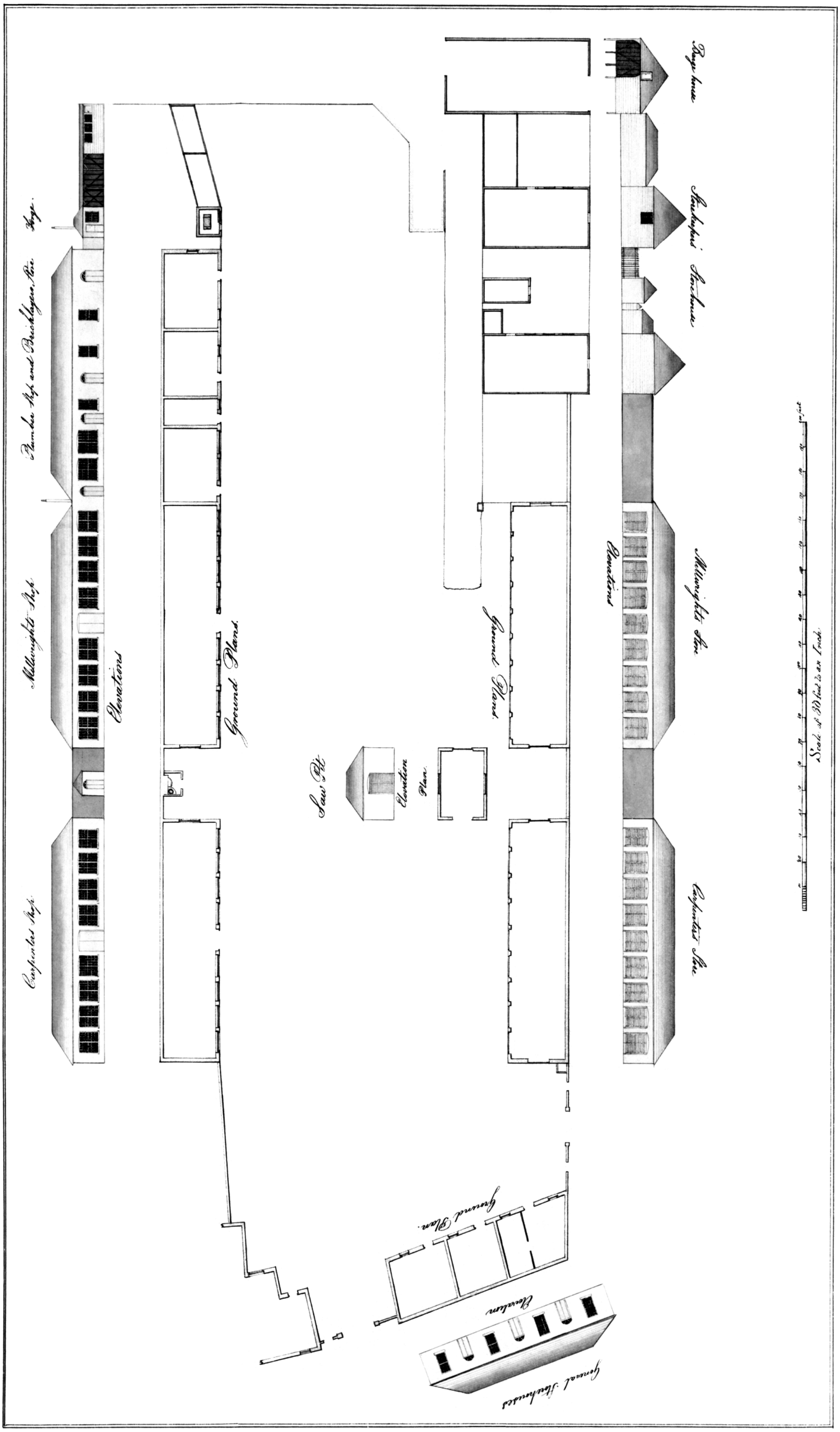
The Engineers department have workshops, and storehouses sufficiently spacious to be able to keep every part of the manufactory in good repair, when working to its utmost extent; the buildings are all in good order, except the millwrights store, which will soon require to be taken down and rebuilt, the foundations having given way; and are shewn on the drawing numbered 36.

No. 35

Drawings of the new Cylinder House



Drawing 35


No. 36
Buildings forming the Engineers Establishment
Elevations
Ground Plans
Saw Pit
Elevation
Plan

Drawing 36

Present state of the Water Courses and Sluices.

The whole of the water courses and tail streams have landed up very much of late years, in consequence of the small sum which has been expended on them since the war, and from the same cause the sluices have very much gone to decay so that a large quantity of water escapes through them. Upon the re-establishment of the manufactory it would be necessary to clear out the water courses and tail streams, and re-instate many of the sluices.

Capabilities of the Present Water Power.

The water power at Waltham Abbey which is now available for the purposes of the manufactory, cannot of itself work more machinery than would produce 18000 barrels of gunpowder annually, even upon the improved principles pointed out in the second part of this work; and with the view of manufacturing this quantity it would be better to re-establish the mills and the manufacturing buildings upon their present sites, than to erect them elsewhere, excepting one mill at the Lower Island which is so dangerously situated, as to render its removal as before stated imperative. The expense of re-establishing the manufactory to produce the above quantity of gunpowder would be £40590 detailed in Estimate No. 1

Increase to the Power of the Stream.

It has just been stated that the present water power could not of itself work more machinery than would produce 18000 barrels of gunpowder annually, but as that quantity may not be sufficient to meet the wants of Government, I have to submit plans for the extension of this manufactory as a means of increasing it.

The fall of 1 foot 6 inches at Paynes Island is not available for the purposes of the manufactory; but by puddling and raising the banks of the present mill head from Paynes Island to the gullies this 1 foot 6 inches might be added thereto, and could increase the fall at this mill head from 6 feet to 7 feet 6 inches, and would add,

36 horses power during 6 months of the year,

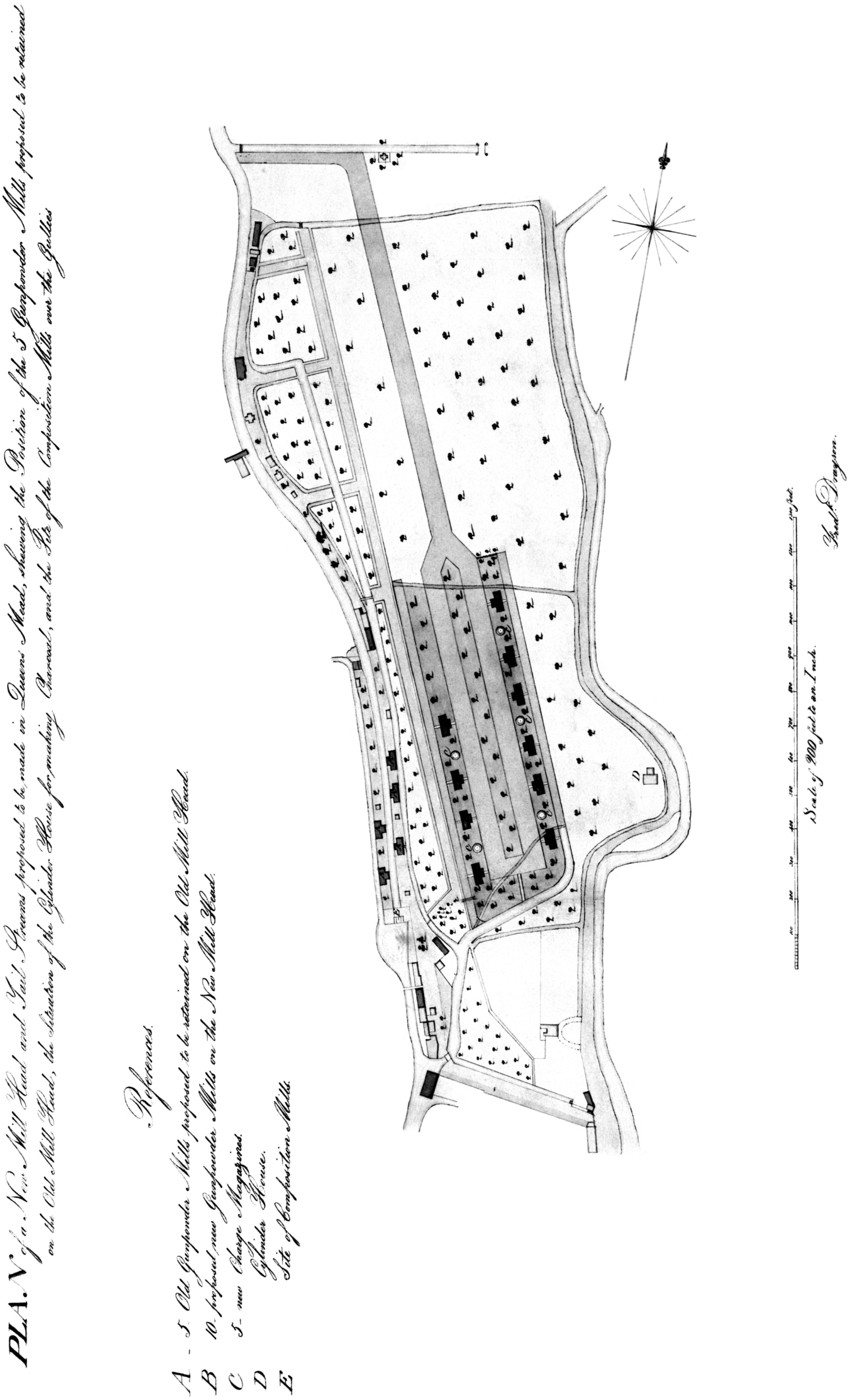
25 horses power during another 3 months, and

18 horses power during the remaining 3 months of the year, to the power of the stream at this fall.

Previously however, to making any increase in the height of this fall, it will be necessary to create additional space, wherein to erect additional mills, as any buildings placed higher up the stream than the existing ones would in danger and be in dangerous to the dusting house and gloom stoves.

In order to keep each class of buildings as near together as possible, the most ____ mode of creating additional space whereon to erect additional mills, would be to create a new mill head and tail streams in Queen’s mead according to the accompanying plan numbered 37, in which it will be seen that each line of mills is separated from the opposite line by an intervening embankment, so that the risk to which the present mills on one side of the mill head are liable of destroying those on the other would be altogether avoided.

Increased space being thus obtained whereon to erect additional mills; and the banks of the old mill head having been raised 1 foot 6 inches, the force of the stream belonging to the Ordnance at Waltham Abbey would be equal to the following number of horses power during the periods stated.


No. 37.
PLAN of a New Mill Head and Tail Streams proposed to be made in Queens Mead, shewing the Position of the 5 Gunpowder Mills proposed to be retained on the Old Mill Head, the Situation of the Cylinder House for making Charcoal, and the Site of the Composition Mills over the Gullies
References.
A - 5. Old Gunpowder Mills proposed to be retained on the Old Mill Head.
B 10. proposed new Gunpowder Mills on the New Mill Head.
C 5. new Charge Magazines.
D Cylinder House.
E Site of Composition Mills.
D
Scale of 400 feet to an Inch.
Fred.k Drayson.

Drawing 37

	Fall of 6 feet horses power	Fall of 2ft 10 horses power		Total number of horses power
During 6 months of the year	172	65	=	237
During another 3 months,	127	48	=	175
During the remaining 3 months of the year	89	34	=	123

If however the water for working the mills upon the fall of 2 feet 10 inches is taken from the river Lea navigation, which is liable to constant variation, it would not be possible to calculate upon having a greater number of buildings upon that fall than there is at present.

The above amount of water power upon the fall of 7 feet 6 inches if applied to work machinery upon the improved principles pointed out in the second part of this work would during 6 months of the year work

2 composition mills
15 gunpowder mills,
2 corning houses,
1 dusting house, and
1 glazing mill.

During another 3 months of the year,
2 composition mills,
10 gunpowder mills,
2 corning houses,
1 dusting house, and
1 glazing mill.

And during the remaining 3 months of the year,
1 composition mill,
1 gunpowder mill,
2 corning houses,
1 dusting house, and
1 glazing mill;

and with the view to combine the old with the new mill head in the most advantageous and economical manner I shall submit that the buildings should be arranged as follows.

Composition mills.

To be erected entirely new on the gullies of the old mill head	2

Gunpowder mills.

To be retained and re-installed upon the old mill head	3
To be erected entirely new on the new mill head	10
On the fall of 2 feet 10 inches at the Lower island, one to be removed and erected elsewhere, three to be retained and repaired	4
Total	19

Press houses.

To be retained as at present upon the old mill head	2
On the fall of 2 feet 10 inches at the Lower island, to be altered and the screw presses introduced instead of Bramah’s hydraulic presses	1
Total	3

Corning houses.

To be retained as at present upon the old mill head	2
On the fall of 2 feet 10 inches at the Lower island, to be altered and the} the shaking frames to be introduced instead of the present machine }	1
Total	3

Dusting house.

To be retained as at present upon the old mill head	1

Glazing mill.

To be retained as at present upon the old mill head	1

Granulating buildings

To be erected entirely new on the banks of the canals at Edmondsey mead } for granulating by breaking bins and screens, the additional quantity of } press cake over and above what the 3 corning houses are capable of doing }	3

The foregoing allotment of the several buildings and machinery, would add much to the security and efficiency of the manufactory, and would ensure an annual produce of 23500 barrels of gunpowder, with a much less number of hands, and at much less expense than heretofore. The expense of this proposed new mill head, and the re-establishment of the buildings upon the old mill head and at the Lower island would be £73040, detailed in estimate No.2.

The manufacture of Gunpowder may be greatly increased by the

Purchase of additional Water power.

The water belonging to the Ordnance commences at the tail of Kings weir, where there is a fall of 3 feet 6 inches, and from thence to Paynes island there is as before stated, a further fall of 8 feet 6 inches, making a total of 12 feet from the upperpart of Kings weir; therefore if the foregoing annual produce of 23500 barrels should not be deemed sufficient, the purchase of Kings weir would afford the means of more than doubling the water power now possessed by the Ordnance, and of raising the annual produce of the manufactory to upwards of 50000 barrels. The purchase of land however to form the requisite mill heads and tail streams, and erection of new mills &c would amount to upwards of £150000.

Manufacture of Gunpowder during Peace.

It appears by the Parliamentary returns printed by the order of the House of Parliament that in 1828 there were 279602 barrels of gunpowder in store in different Magazines and Forts at Home and in the Colonies; and that the average annual consumption of gunpowder for the eleven years preceding that period, had been 5888 barrels.

A portion of the foregoing large quantity of gunpowder is that which was left <unused> at the end of the last war, and the remainder is the produce of contracts entered into with private gunpowder merchants previous to the establishment of ___ but the greater portion of which was not supplied until the demand for it <had passed>.

Provided a war were to take place it would require 120000 barrels of gunpowder <annually to supply> the navy and army, of which the former would require 80000, and the latter 40000 barrels; the colonies would require 60000 barrels, and it would be <advisable> to have about 20000 barrels in store in addition, as a reserve in order of <10 per cent, giving> a total of 200000 barrels.

Although there is so large a quantity as 279602 barrels of gunpowder in store, from its age, and from the small quantity which has been regenerated it is doubtful whether a large portion of it is not unfit for service, and in treating upon the manufacture of gunpowder during peace, it is to be considered whether only 5888 barrels are to be manufactured or regenerated, to supply the peace demands or whether in addition thereto 200000 barrels of gunpowder are to be kept in a serviceable state to supply the navy, army, &c upon a war breaking out.

Supposing the former to be the case, the manufactory in its present state is quite capable of producing for the peace demand of gunpowder, because if pushed to its utmost force it can produce 6000 barrels of gunpowder annually, whereas the average expenditure is only 5888 barrels.

But if it is the intention of Government to keep in store in a reasonable state the before mentioned quantity of 200000 barrels of gunpowder, in addition to the manufacturing of 5888 barrels annually, some of the manufacturing buildings which have gone to decay must be re-instated to afford the means of so doing; for as gunpowder requires regenerating about once in 20 or 25 years there would be about 8000 barrels requiring to be regenerated annually, in addition to the 5888 barrels to be manufactured.

To manufacture and regenerate this quantity of gunpowder the following buildings would require to be kept in partial or constant work, viz.

The composition mill,
Seven gunpowder mills, working day and night,
Three press and corning houses,
Half of the dusting house,
Half of the glazing mill, and
The steam stove.

Previously however to re-establishing any of the buildings upon the fall of 6 feet, it is necessary to determine whether the fall of 1 foot 6 inches at Paynes island is now, or at any future period to be added thereto, as the machinery applicable to the fall of 6 feet, would be inapplicable to the increased fall of 7 feet 6 inches, and in order to add this fall to the powers of the manufactory it would require an outlay of £4000, exclusive of the expense of raising the floors and machinery of the support buildings existing on the banks.

I would therefore propose to provide for the peace demand of gunpowder and the keeping 200000 barrels of powder in a serviceable state, by re-establishing the mills at the Lower island, which are totally independent of the upper part of the stream, to work in addition to those working at present upon the fall of 6 feet.

Under this view of the case an outlay of £9900 detailed in estimate No.3 would render the manufactory efficient for many years.

Calculated Expense.

For the sake of clearness the expense will be considered according to amount beginning with the smallest sum, viz. The expense of rendering the manufactory efficient to supply the peace demand of gunpowder, and to keep 200000 barrels of gunpowder in a serviceable state. Upon referring to the magazine store of gunpowder during Peace, it will be seen that it is proposed to reestablish the mill on the fall of 2 feet 10 inches at the Lower island to work in combination with the mills working at present upon the fall of 6 feet; and the expense is calculated at £9900 detailed in estimate No. 3.

On the second supposition that the manufactory is to be made efficient to the extent of the present water power so as to produce 18000 barrels of gunpowder annually, it will be necessary to erect two new composition mills on the gullies at the mill head, and four gunpowder mills on their present sites, to pull down one at the Lower island and erect it farther from the corning house, and to reinstate the water courses and repair the machinery of six others; to repair the stoves; to enlarge the cylinder house for charring wood, to alter one of the corning houses; to clean out the mill heads and tail streams; and to repair the sluices. The expense of this plan would be £40590 detailed in estimate No.1.

And on the third supposition that the manufactory is to be rendered efficient to the utmost extent of the water power possessed by the Ordnance, so as to produce 23500 barrels of gunpowder annually, the banks of the old mill head from Paynes island to the gullies will require to be raised 1 foot 6 inches, and it will be necessary to puddle around some, and raise the floors of other buildings on the banks, to erect two new composition mills on the gullies, and three new gunpowder mills on their present sites; to create a new mill head and tail streams in Queen’s mead, and erect ten new gunpowder mills thereon; to repair the stoves, to enlarge the cylinder house; to remove one gunpowder mill and erect it farther from the corning house, re-instate the water courses and repair the machinery of three others, and to alter the corning house at the Lower island, to clean out the mill heads and tail streams, and to repair the sluices. The expense of this plan would be £78040, detailed on estimate No. 2.

In conclusion I have only to state that I have considered the foregoing explanations to point out how the different processes are carried on at this present, and to bring at once under review the several improvements I have proposed therein, viz.

at page 37, that the process of refining nitre may be rendered less expensive, and that the ingredient need not be melted, thus exposing it to the liability of receiving injury.
at page 39 that the charcoal may be produced of a far superior quality and at less cost than that now used.
at page 43 that the sulphur may be rendered perfectly pure by a process not so expensive as the one to which it is now submitted, and which only removes one half of the impurities from it.
at page 45 that the process of amalgamation may be much improved.
at page 47 that the danger and expense of granulating may be greatly reduced, and the operation rendered much less complex.
at page 50 that the mode of drying the powder may be improved.
at page 50 I have also mentioned that the ingredients may be prepared and mixed in such a manner[1] as either greatly to increase the strength of gunpowder, or to diminish the time required for its amalgamation, and exclusive of all these observations and proposed improvements, I have pointed out that there is 43 per cent of grain[2], superior to either the cannon or musket powder now produced, contained in the dust and is sent to be reworked, but which might be separated from it without again undergoing the processes of amalgamation, pressing, and granulating, which alone I trust is a suggestion entitled to a favorable consideration.

[1] see sample 21
[2] see sample 29

Estimate No. 1

Estimate of the expense of rendering the manufactory capable of producing 18000 barrels of gunpowder per annum.

On the fall of 6 feet.

	£
To rebuild the gullies at the mill head	2000
T erect two new composition mills thereon	4000
To re-build four gunpowder mills upon their present sites	10000
To re-instate the water courses and repair the machinery of three others	4500
To repair the Stoves and other buildings	2000
To re-instate the overshot above the mills on the west side of the mill head	400

On the fall of 2 feet 10 inches.

To re-instate the water courses and repair the machinery of three gunpowder mills	4500
To remove another and erect it at a greater distance from the corning house	2000
To alter the press and corning houses, and to introduce the screw presses and shaking frames, instead of the present hydraulic presses and granulating machine	1000
To clean out mill head and tail streams, and to erect a waste gate for flood waters	1500
To enlarge the cylinder house and to make it capable of charring wood for 18000 barrels of gunpowder annually	5000
	£36900
Add 1/10 for contingencies	£ 3690
Total	£ 40590

Estimate No.2.

Estimate of the expense of rendering the manufactory capable of producing 23500 barrels of gunpowder annually.

	£
On the old mill head	
To raise the banks of the old mill head from Paynes island to the gullies	2000
To raise the floors and machinery of the dusting house, one gloom stove, the glazing mill, and one corning house, and to puddle in front of and make drains at the back of one corning house and the steam stove	3000
To rebuild the gullies of the mill head	2000
To erect two composition mills thereon	4000
To rebuild three gunpowder mills upon their present sites	6500
To repair the stoves and other buildings, and to erect three buildings with breaking bins and screens for granulating gunpowder	2500
To reinstate the overshot above the mills on the west side of the mill head	400
Proposed new mill head in Queen's mead.	
To excavate a new mill head and tail streams	5000
To erect a waste gate for flood waters	1000
To erect ten new gunpowder mills	25000
On the fall of 2 feet 10 inches.	
To reinstate the water courses and repair the machinery of the gunpowder mills	4500
To remove one gunpowder mill and erect it at a greater distance from the corning house	2000
To alter the press and corning houses, and to introduce the screw presses and shaking frames, instead of the present hydraulic press and granulating machine	1000
To clean out the mill head and tail streams and to erect a waste gate for flood waters	1500
To enlarge the cylinder house and to make it capable of charring wood for 23500 barrels of gunpowder per annum	6000
	£ 66400
Add 1/10 for contingencies	£ 6640
Total of	£ 73040

Estimate No. 3.

Estimate for the expense of rendering the manufactory efficient to manufacture 5888 barrels of gunpowder annually, and to keep the store of 200000 barrels of gunpowder in a serviceable state.

On the fall of 2 feet 10 inches.

	£
To reinstate the water courses and repair the machinery of three gunpowder mills	4500
To remove one gunpowder mill and erect it at a greater distance from the corning houses	2000
To alter the press and corning houses, and to introduce the screw presses and shaking frames, instead of the hydraulic presses and present granulating machine	1000
To clean out the mill head and tail streams, and to erect a waste gate for flood waters	1500
	£ 9000
Add 1/10 for contingencies	£ 900
Total of	£ 9900