1877

# Illustration of the concentration and Flintshire furnace treatment of lead ores at the Desloge Mines, Missouri

A. H. Ohmann-Dumesnil

THESIS

LEAD ORES AT DESLOGE MINES

OHMANN-DUMESNIL

1877

# MISSOURI SCHOOL OF MINES AND METALLURGY.

# ILLUSTRATION OF THE CONCENTRATION & FLINTSHIRE FURNACE TREATMENT OF LEAD ORES



AT THE

# DESLOGE MINES MISSOURI

A Thesis for the Degree of M.E.
by
A.H. OHMANN-DUMESNIL.
Class '77.





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The Desloge Mines, the subject of the present thesis, are situated in Township 37 North and Range 4 East St. Francois Co. Mo. and are directly North of the St. Joe mines. They are 10 miles distant, in a South-Easterly direction, from Cadet, a station on the St. Louis, Iron Mountain and Southern Rail-Road, 57 miles from St. Louis. Though Cadet is insignificant in point of population; still as a shipping point, it ranks high among those in South East Missouri; since it is the depôt and entrepôt for the Desloge, St. Joe and Old Mines.

The country about here is of an undulating character and well covered with timber, chiefly of the varieties of white, post and scrub oak. Numerous streams intersecting each other, and chiefly arising from springs, form a network giving the country a reticulated appearance.

On Plate I is given a small portion of the surrounding country,

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On Plate I is given a small portion of the surrounding country,

(the topographical features being omitted) and is intended to convey a correct impression of the relative positions of the Mines and supply point.

Plate II. is a plat containing all the principal buildings and the shafts. The blocks have been laid out as represented and the limits on the North, East and West extend much farther but sufficient is given for the needs at present.

At present the means of transportation to and from Cadet are, very limited, consisting as they do of six-mule teams, which under the most favorable circumstances can make but two round trips per day and are often compelled, on account of the inclemency of the weather, bad roads or other causes, to make but one trip and return. They haul the products of the Mines i.e. lead; and, on their return trip, the supplies for the Company's store.

The subject of lead treatment at the Desloge Mines, will be taken up in three separate parts viz.:

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the Mining; Concentrating and Smelting of ores.

## Mining.

The ore occurs as an impregnated dolomitic limestone of the Third Magnesian Limestone series. The galeniferous lime-rock occurs in stratified beds varying in thickness, from a few centimetres to three metres as a maximum. There are found small seams of calcite and galena. The general dip is 2° East and beds of mineral are met with at varying depths. There are also found pockets of Chalcopyrite* called by the miners "sulphur" and regarded by them as an indication of "rich rock" to follow.

The following may be taken as the composition of the average ore taken out:—

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*Analysis of the nearly pure Chalcopyrite shows 0.612 % of Nickel and Cobalt.—

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*Analysis of the nearly pure Chalcopyrite shows 0.612% of Nickel and Cobalt.

Specific Gravity 4.011

| Empirical | | Rational | |
|---|---|---|---|
| Pb | 42.981 | Galenite | 49.625 |
| Cu | trace | Sphalerite | 1.921 |
| Fe | 0.966 | Chalcopyrite | trace |
| Zn | 1.287 | Millerite | 0.226 |
| Ni + Co | 0.146 | Pyrite | 2.070 |
| S | 8.462 | Gangue | 46.158 |
| Gangue | 46.158 | chiefly $MgO, CO_2$ & $CaO.CO_2$ | |
| | 100.000 | | 100.000 |

At present there are three shafts worked, viz.: the Clara, Middle and Sophie. Their relative positions may be ascertained from Plate II.

The Clara shaft has been sunk 37.195 metres (122'), but there is only one gallery 9.146 metres (30') from the surface, that is worked. It general height is about 2 metres (6.5'), this being the thickness of the bed. This is a dry shaft and the material is hoisted by a ten-horse-power engine, in buckets (Kibbles) whence it is transported to the skips (of which Figs. 1 & 2 Plate III are a rear and side elevation, in which it will be seen that they are dumped

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by opening a hinged door forming the end) which are drawn to the concentrating house by a mule, on a slightly inclined tramway .508 metres (20") wide. The return of the cars to the mouth of the shaft is automatic, this being effected by the grade.

The middle shaft has been sunk to a depth of 18.29 metres (60') and is not yet worked, there being no galleries opened as yet. It was full of water which had been due to its remaining uncovered and being filled by rains and snow.

The Sophie shaft is by far the most important, although only sunk to a depth of 50.48 metres (165'). There are two levels, the first being at 30.48 metres (100') below the surface and the second at 50.48 (165'). It is a wet shaft and consequently pumps are employed to raise the water which is utilized in the concentrating house.

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These pumps consist of a Cameron pump from the bottom to the first level and a Cornish plunger from the first level to the surface.

The hoisting engine, which is of twenty horse-power, operates these pumps besides its regular works of raising the ore. The same means of transportation to the concentrating house are here employed, as in the case of the Clara shaft; the tramway being about 91.47 metres (300') long.

The shifts in the shafts consist of eight hours each. The material is obtained by blasting, hand drilling being employed. The total amount broken per diem has not been estimated, although it far exceeds the amount smelted or concentrated —

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# Concentration.

This consists essentially in crushing the ore, sieving it and passing them to the jigs and classificator which completely separate the galena from the limestone The ore is hauled from the shafts and dumped on an elevated platform built by the side of the concentrating house and shown at P Plate IV. D is a track on which a dumping car runs and S is a screen to protect the work-men. From this platform the ore is shovelled into a Blake crusher c. (of which more anon) and it falls then between two sets of Cornish rolls R & r to be ground still finer. It finally falls in the pit Q whence it is elevated by means of the elevator h h' whose diametric length is 12.8 metres (42'). The scoops ss, s's' dump the crushed material into the hopper H, whence it is distri-buted to the sieves S'. These size the ore and drop it in a trough

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T Plate V., whence it is distri-
buted to the jigs $J^1$, $J^2$ &c
by side canals not shown in the
drawings. The classificator or
Rittinger table completes the
series of concentrating apparatus
which will now be taken up
in detail.

The concentrating house is a
building 12.19 by 30.48 metres
(40'×100'), exclusive of the
boiler shed which is about
9.146 by 12.19 metres (30'×40'). The
machinery is operated by an
engine of one hundred nominal
horse-power, having cylinders
1.066 by .406 metres (16"×42"). There
are two boilers .711 metres (28") in
diameter and 3.05 metres (10') long
with 9 flues .152 metres (6") in diameter,
and carrying on an average 34.59
kilogrammes (75 lbs) of steam.
The consumption of fuel is
about 35.985 cubic metres (10 cords)
per day of ten hours.

The Blake crusher is of
the size known as No. 5 of which
a section is given in Fig. 3 Plate III.

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a section is given in Fig. 3 Plate III.

of which the following gives the different parts:

D – section of fly-wheel shaft.
E – section of crank.
F – connecting rod.
G – lever.
H – fulcrum of lever.
I & J, J – toggle joint.
K – fixed jaw.
L – cheeks holding back the fixed jaw.
M – movable jaw.
N – pivot.
O – india rubber spring.
P – screw-nut to raise and lower wedge.
Q – wedge.
R – toggle-block.

The action of the machine is readily understood from the drawing. The space between the jaws is about .039 metres (1.5").

The next machines for crushing consist of two pairs of Cornish rolls, whose construction is easily understood, and which crush the ore still finer and make it ready to be screened.

The elevator needs no description.

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The elevator needs no description.

The screens are four in number and are placed as shown in Plates IV & V, making fifteen to twenty revolutions per minute. Taking them in the order of the size of the holes we find that the first sieve is of perforated iron having holes 15 millimetres in diameter. The second is also of iron and consists of three divisions $s^2$, $s^3$ & $s^4$ (Plate V.) $s^2$ & $s^3$ having holes 7 mm in diameter and $s^4$ holes 10 mm in diameter. The third sieve, of iron, has three divisions also $s^5$, $s^6$ & $s^7$, $s^5$ & $s^6$ having holes 3.25 mm and $s^7$ holes 5 mm in diameter. The fourth and last sieve is made of perforated copper plates and has three divisions $s^8$, $s^9$ & $s^{10}$, $s^8$ & $s^9$ having holds 1 mm and $s^{10}$ holes 2 mm in diameter.

By this means the ore is effectively screened, all the particles not passing through the first sieve being returned to the rolls. The stuff from the first two screens is also sent to the rolls after being washed; also the middlings from the jigs.

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particles not passing through
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to the rolls. The stuff from the first
two screens is also sent to the rolls after
being washed; also the middlings from the jigs.

The material that has been properly sized is then sent on to the jigs to be concentrated. The stuff is sent by a means already indicated. The jigs are of the self-discharging pattern and yield as products; washed ore, middlings, slimes, coarse and fine chats. The washed ore is taken off to be smelted, the middlings of nearly all the jigs and the coarse and fine chats are sent to the rolls, whilst the middlings of one set of jigs and all the slimes are sent to the classificator for treatment.

There are four sets of jigs, two in each set. The first three sets are plunger and the fourth set eccentric jigs. The jigs are 1.22 × 1.22 × 1.83 metres (4'×4'×6') and require no particular description here as they are well known; being Rittinger's self-discharging jigs.

The first set J' (Plate V) has two jigs which size to 15 mm, the first having a stroke of 5.08 centimetres (2") and the second

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and require no particular description
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discharging jigs.

The first set J[1] (Plate V)
has two jigs which size to 15 mm,
the first having a stroke of 5.08
cemtimetres (2”) and the second

one of 3.81 centimetres (1½"). The washed ores discharged have the following compositions respectively.

No. 1.

Sp. Gr. 6.149

| Empirical | | Rational | |
|---|---|---|---|
| Pb | 51.549 | Galenite | 59.517 |
| Cu | 0.383 | Sphalerite | 0.490 |
| Fe | 1.855 | Chalcopyrite | 1.108 |
| Zn | 0.328 | Millerite | 0.300 |
| Ni+Co | 0.194 | Pyrite | 3.143 |
| S | 10.249 | Gangue | 35.442 |
| Gangue | 35.442 | | 100.000 |
| | 100.000 | | |

No. 2.

Sp. Gr. 6.579

| | | | |
|---|---|---|---|
| Pb | 52.897 | Galenite | 61.074 |
| Cu | 0.942 | Sphalerite | 0.251 |
| Fe | 0.910 | Chalcopyrite | 2.725 |
| Zn | 0.168 | Millerite | 0.480 |
| Ni+Co | 1.316 | Pyrite | 0.178 |
| S | 9.475 | Gangue | 35.292 |
| Gangue | 35.292 | | 100.000 |
| | 100.000 | | |

The second set of jigs ($J^2$ Plate V) size respectively to 7 and 5 mm, the stroke being 3.81 cm (1½") for the first

one of 3.81 centimetres (1 ½"). The washed
ores discharged have the following
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No. 1.

| Empirical | | Rational | |
|---|---|---|---|
| Sp. Gr. 6.149 | | | |
| Pb | 51.549 | Galenite | 59.517 |
| Cu | 0.383 | Sphalerite | 0.490 |
| Fe | 1.855 | Chalcopyrite | 1.108 |
| Zn | 0.328 | Millerite | 0.300 |
| Ni+CO | 0.194 | Pyrite | 3.143 |
| S | 10.249 | Gangue | 35.442 |
| Gangue | 35.442 | | 100.000 |
| | 100.000 | | |

No. 2.

Sp. Gr. 6.579

| | | | |
|---|---|---|---|
| Pb | 52.897 | Galenite | 61.074 |
| Cu | 0.942 | Sphalerite | 0.251 |
| Fe | 0.910 | Chalcopyrite | 2.725 |
| Zn | 0.168 | Millerite | 0.480 |
| Ni+CO | 1.316 | Pyrite | 0.178 |
| S | 9.475 | Gangue | 35.292 |
| Gangue | 35.292 | | 100.000 |
| | 100.000 | | |

The second set of jigs ($J^2$ Plate V)
size respectively to 7 and 5 mm,
the stroke being 3.81 cm (1 ½") for the first

and 3.18 cm (1¼") for the second; the stuff being finer than that of the first set is consequently purer as may be seen from the annexed compositions of the washed ore from each jig.

No. 3.

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 6.760 | | |
| Pb | 53.851 | Galenite | 62.175 |
| Cu | 0.805 | Sphalerite | 0.301 |
| Fe | 0.896 | Chalcopyrite | 2.517 |
| Zn | 0.202 | Millerite | 0.484 |
| Ni+Co | 0.316 | Pyrite | 0.274 |
| S | 9.681 | Gangue | 34.249 |
| Gangue | 34.249 | | 100.000 |
| | 100.000 | | |

No. 4

Sp. Gr. 6.856

| | | | |
|---|---|---|---|
| Pb | 55.974 | Galenite | 64.627 |
| Cu | 0.077 | Sphalerite | 0.243 |
| Fe | 0.931 | Chalcopyrite | 0.224 |
| Zn | 0.163 | Millerite | 0.101 |
| Ni+Co | 0.065 | Pyrite | 0.918 |
| S | 8.903 | Gangue | 33.887 |
| Gangue | 33.887 | | 100.000 |
| | 100.000 | | |

The third set of jigs ($J^3$ Plate V.) sizes to 3.5 and 2 mm with strokes that are respectively 3.18 cm (1¼") and 1.91 cm (¾"), the


and 3.18 cm (1 ¼") for the second; the stuff being finer than that of the first set is consequently purer as may be seen from the annexed compositions of the washed ore from each jig.

No. 3.

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 6.760 | | |
| Pb | 53.851 | Galenite | 62.175 |
| Cu | 0.805 | Sphalerite | 0.301 |
| Fe | 0.896 | Chalcopyrite | 2.517 |
| Zn | 0.202 | Millerite | 0.484 |
| Ni+CO | 0.316 | Pyrite | 0.274 |
| S | 9.681 | Gangue | 34.249 |
| Gangue | 34.249 | | 100.000 |
| | 100.000 | | |

No. 4

Sp. Gr. 6.856

| | | | |
|---|---|---|---|
| Pb | 55.974 | Galenite | 64.627 |
| Cu | 0.077 | Sphalerite | 0.243 |
| Fe | 0.931 | Chalcopyrite | 0.224 |
| Zn | 0.163 | Millerite | 0.101 |
| Ni+CO | 0.065 | Pyrite | 0.918 |
| S | 8.903 | Gangue | 33.887 |
| Gangue | 33.887 | | 100.000 |
| | 100.000 | | |

The third set of jigs ($J^3$ Plate V.) sizes to 3.5 and 2 mm with strokes that are respectively 3.18 cm (1 ¼") and 1.91 cm (3/4"), the

washed ore being fine and having a good appearance as may be inferred from the annexed compositions:

No 5

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 7.116 | | |
| Pb | 63.568 | Galenite | 73.298 |
| Cu | 0.025 | Sphalerite | 0.106 |
| Fe | 0.217 | Chalcopyrite | 0.071 |
| Zn | 0.071 | Millerite | 0.019 |
| Ni+Co | 0.011 | Pyrite | 0.202 |
| S | 9.804 | Gangue | 26.304 |
| Gangue | 26.304 | | 100.000 |
| | 100.000 | | |

No 6.

Sp Gr. 7.536

| | | | |
|---|---|---|---|
| Pb | 60.001 | Galenite | 69.277 |
| Cu | 0.028 | Sphalerite | 0.144 |
| Fe | 0.616 | Chalcopyrite | 0.080 |
| Zn | 0.096 | Millerite | 0.018 |
| Ni+Co | 0.011 | Pyrite | 0.653 |
| S | 9.440 | Gangue | 29.808 |
| Gangue | 29.808 | | 100.000 |
| | 100.000 | | |

The fourth set ($J^4$ Plate V) consists of two eccentric jigs which wash the fine stuff and have respectively strokes of .42 c.m. (1/6") and .32 cm (1/8").

washed ore being fine and having a good appearance as may be inferred from the annexed compositions.

No. 5

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 7.116 | | |
| Pb | 63.568 | Galenite | 73.298 |
| Cu | 0.025 | Sphalerite | 0.106 |
| Fe | 0.217 | Chalcopyrite | 0.071 |
| Zn | 0.071 | Millerite | 0.019 |
| Ni+CO | 0.011 | Pyrite | 0.202 |
| S | 9.804 | Gangue | 26.304 |
| Gangue | 26.304 | | 100.000 |
| | 100.000 | | |

No. 6.

Sp. Gr. 7.536

| | | | |
|---|---|---|---|
| Pb | 60.001 | Galenite | 69.277 |
| Cu | 0.028 | Sphalerite | 0.144 |
| Fe | 0.616 | Chalcopyrite | 0.080 |
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| Ni+CO | 0.011 | Pyrite | 0.653 |
| S | 9.440 | Gangue | 29.808 |
| Gangue | 29.808 | | 100.000 |
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The following are the compositions of the washed ores from these.

No. 7.

Empirical | Rational

Sp. Gr. 6.974

| | | | |
|---|---|---|---|
| Pb | 55.334 | Galenite | 63.888 |
| Cu | 0.027 | Sphalerite | 0.203 |
| Fe | 0.175 | Chalcopyrite | 0.068 |
| Zn | 0.136 | Millerite | 0.025 |
| Ni+Co | 0.016 | Pyrite | 0.334 |
| S | 8.830 | Gangue | 35.482 |
| Gangue | 35.482 | | 100.000 |
| | 100.000 | | |

No. 8.

Sp. Gr. 6.979

| | | | |
|---|---|---|---|
| Pb | 54.805 | Galenite | 63.277 |
| Cu | 0.050 | Sphalerite | 0.181 |
| Fe | 0.854 | Chalcopyrite | 0.145 |
| Zn | 0.121 | Millerite | 0.024 |
| Ni+Co | 0.016 | Pyrite | 1.736 |
| S | 9.517 | Gangue | 34.637 |
| Gangue | 34.637 | | 100.000 |
| | 100.000 | | |

The fine and coarse "chats" (the average composition of each of which is given further on) when sufficiently fine are sent to the classificator and when too coarse to the rolls.

The following are the compositions
of the washed ores from these.

No. 7.

Empirical | Rational

Sp. Gr. 6.974

| | | | |
|---|---|---|---|
| Pb | 55.334 | Galenite | 63.888 |
| Cu | 0.027 | Sphalerite | 0.203 |
| Fe | 0.175 | Chalcopyrite | 0.068 |
| Zn | 0.136 | Millerite | 0.025 |
| Ni+CO | 0.016 | Pyrite | 0.334 |
| S | 8.830 | Gangue | 35.482 |
| Gangue | 35.482 | | 100.000 |
| | 100.000 | | |

No. 8.

Sp. Gr. 6.979

| | | | |
|---|---|---|---|
| Pb | 54.805 | Galenite | 63.277 |
| Cu | 0.050 | Sphalerite | 0.181 |
| Fe | 0.854 | Chalcopyrite | 0.145 |
| Zn | 0.121 | Millerite | 0.024 |
| Ni+CO | 0.016 | Pyrite | 1.736 |
| S | 9.517 | Gangue | 34.637 |
| Gangue | 34.637 | | 100.000 |
| | 100.000 | | |

The fine and coarse "chats" (the average composition of each of which is given further on) when sufficiently fine are sent to the classificator and when too coarse to the rolls.

They are very poor in galena, but still, some is saved by this treatment.

Coarse chats.

Sp. Gr. 2.969.

| Empirical | | | Rational |
|---|---|---|---|
| Pb | 0.961 | Galenite | 1.109 |
| Cu | 0.125 | Sphalerite | 0.307 |
| Fe | 4.879 | Chalcopyrite | 0.359 |
| Zn | 0.205 | Millerite | 0.011 |
| Ni+Co | 0.007 | Pyrite | 10.221 |
| S | 5.830 | Gangue | 87.993 |
| Gangue | 87.993 | | 100.000 |
| | 100.000 | | |

Fine chats.

Sp. Gr. 3.053

| | | | |
|---|---|---|---|
| Pb | 1.789 | Galenite | 2.065 |
| Cu | 0.392 | Sphalerite | 0.322 |
| Fe | 6.426 | Chalcopyrite | 1.134 |
| Zn | 0.216 | Millerite | 0.117 |
| Ni+Co | 0.076 | Pyrite | 13.028 |
| S | 7.767 | Gangue | 83.334 |
| Gangue | 83.334 | | 100.000 |
| | 100.000 | | |

The classificator, (c, Plate V) or as it is better known, the Rittinger table is the next machine in the concentration that deserves our attention, as well on account

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| Fe | 6.426 | Chalcopyrite | 1.134 |
| Zn | 0.216 | Millerite | 0.117 |
| Ni+CO | 0.076 | Pyrite | 13.028 |
| S | 7.767 | Gangue | 83.334 |
| Gangue | 83.334 | | 100.000 |
| | 100.000 | | |

The classificator, (c, Plate V) or as it is better known, the Rittinger table is the next machine in the concentration that deserves our attention, as well on account of its simplicity and the thoroughness with which it does its work, as of its but recent introduction in concentrating machinery.

On Plate VI is given an end elevation and a plan, in which it will be seen that the double cam c. (Fig. 1) acting on the horizontal bar B causes the whole table to oscillate from side to side, the stroke being 6.35 c.m. (2 ½"), and the return being ensured by means of the rubber spring R. The framework is necessarily compact on account of the number of shocks it has to endure, varying as they do from 50 to 80 per minute, according to the coarseness or fineness of the stuff.

Fig. 2 is a plan of the table, in which O' is the trough delivering the stuff which is distributed by the riffles at D; w, w being the riffles to distribute the streams of water flowing down over the table, it having an inclination of about 2°. The dotted lines s s', m m' & T t' show the courses

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Fig. 2. is a plan of the
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distributed by the riffles at D; w, w
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streams of water flowing down over
the table, it having an inclination
of about 2°. The dotted lines
s s', m m' & T t' show the courses

taken by the washed ore, middlings and tailings respectively.

The ore as it comes off of the table is the purest of all the washed ores, as may be seen from the following analysis:

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 7.616 | | |
| Pb | 72.442 | Galenite | 83.640 |
| Cu | 0.013 | Sphalerite | 0.040 |
| Fe | 0.133 | Chalcopyrite | 0.037 |
| Zn | 0.027 | Millerite | trace |
| Ni + Co | trace | Pyrite | 0.261 |
| S | 11.363 | Gangue | 16.022 |
| Gangue | 16.022 | | 100.000 |
| | 100.000 | | |

The middlings are sufficiently rich to warrant a second treatment on the table whilst the tailings are thrown away.

The following are the compositions of the middlings and tailings: —

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tailings are thrown away.
The following are the
compositions of the middlings
and tailings: --

Middlings –

| Empirical | | Rational | |
|---|---|---|---|
| | Sp. Gr. 3.450 | | |
| Pb | 20.633 | Galenite | 23.822 |
| Cu | 0.395 | Sphalerite | 1.253 |
| Fe | 5.614 | Chalcopyrite | 1.144 |
| Zn | 0.840 | Millerite | 0.135 |
| Ni+Co | 0.088 | Pyrite | 11.281 |
| S | 10.065 | Gangue | 62.365 |
| Gangue | 62.365 | | 100.000 |
| | 100.000 | | |

Tailings.

Sp. Gr. 3.085.

| | | | |
|---|---|---|---|
| Pb | 5.834 | Galenite | 6.735 |
| Cu | 0.516 | Sphalerite | 1.415 |
| Fe | 5.894 | Chalcopyrite | 1.492 |
| Zn | 0.948 | Millerite | 0.047 |
| Ni+Co | 0.030 | Pyrite | 11.654 |
| S | 8.121 | Gangue | 78.657 |
| Gangue | 78.657 | | 100.000 |
| | 100.000 | | |

The water, for all the dressing, is supplied by the pumps of the Sophie shaft, its mouth being on a level with the top of the concentrating house. An iron pipe connecting with the discharge of

Middlings --

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|---|---|---|---|
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| S | 8.121 | Gangue | 78.657 |
| Gangue | 78.657 | | 100.000 |
| | 100.000 | | |

The water, for all the dressing, is supplied by the pumps of the Sophie shaft, its mouth being on a level with the top of the concentrating house. An iron pipe connecting with the discharge of

the pumps leads to a tank in the upper part of the concentrating house and a steady stream, sufficient for the washing of all the ore, is kept flowing. 4535 kilogrammes (10,000 lbs) of ore are dressed per day of 10 hours (there being no night shifts) and this exceeds the smelting powers of the furnace.

There are employed in the concentrating house ten men distributed as follows:

| | |
|---|---|
| Foreman and Engineer | 1 |
| Feeder for the crusher | 2 |
| To attend to the jigs &c. | 4 |
| To carry off chats | <u>3</u> |
| Total | 10 |

<u>Note</u>. On the following page is a table containing the compositions (Empirical and rational) of the raw and washed ores, as also their Specific Gravities to show at a glance how the washing concentrated the ore, the purity and specific gravity increasing alike from step to step --

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Foreman and Engineer 1
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Note. On the following page is a table containing the compositions (Empirical and rational) of the raw and washed ores, as also their Specific Gravities to show at a glance how the washing concentrated the ore, the purity and specific gravity increasing alike from step to step --

# Washed Ores.

| | Raw ores | No 1 | No 2 | No 3 | No 4 | No 5 | No 6 | No 7 | No 8 | From the Rittinger table |
|---|---|---|---|---|---|---|---|---|---|---|
| EMPIRICAL Pb | 42.981 | 51.549 | 52.897 | 53.851 | 55.974 | 63.568 | 60.001 | 55.334 | 54.805 | 72.442 |
| Cu | trace | 0.383 | 0.942 | 0.805 | 0.077 | 0.025 | 0.028 | 0.027 | 0.050 | 0.013 |
| Fe | 0.966 | 1.855 | 0.910 | 0.896 | 0.931 | 0.217 | 0.616 | 0.175 | 0.854 | 0.133 |
| Zn | 1.287 | 0.328 | 0.168 | 0.202 | 0.163 | 0.071 | 0.096 | 0.136 | 0.121 | 0.027 |
| Ni+Co | 0.146 | 0.194 | 0.316 | 0.316 | 0.065 | 0.011 | 0.011 | 0.016 | 0.016 | trace |
| S [by calculation] | 8.462 | 10.249 | 9.475 | 9.681 | 8.903 | 9.804 | 9.440 | 8.830 | 9.517 | 11.363 |
| Gangue [by diff] | 46.158 | 35.442 | 35.292 | 34.249 | 33.887 | 26.304 | 29.808 | 35.482 | 34.637 | 16.022 |
| | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| RATIONAL Galenite | 49.625 | 59.517 | 61.074 | 62.175 | 64.627 | 73.298 | 69.277 | 63.888 | 63.277 | 83.640 |
| Sphalerite | 1.921 | 0.490 | 0.251 | 0.301 | 0.243 | 0.106 | 0.144 | 0.203 | 0.181 | 0.040 |
| Chalcopyrite | trace | 1.108 | 2.725 | 2.517 | 0.224 | 0.071 | 0.080 | 0.068 | 0.145 | 0.037 |
| Millerite | 0.226 | 0.300 | 0.480 | 0.484 | 0.101 | 0.019 | 0.018 | 0.025 | 0.024 | trace |
| Pyrite | 2.070 | 3.143 | 0.178 | 0.274 | 0.918 | 0.202 | 0.653 | 0.334 | 1.736 | 0.261 |
| Gangue | 46.158 | 35.442 | 35.292 | 34.249 | 33.887 | 26.304 | 29.808 | 35.482 | 34.637 | 16.022 |
| | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Specific Gravity | 4.011 | 6.149 | 6.579 | 6.760 | 6.856 | 7.116 | 7.536 | 6.974 | 6.979 | 7.616 |

Washed Ores

| Empirical | Raw Ore | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 | From the Rittinger table |
|---|---|---|---|---|---|---|---|---|---|---|
| Pb | 42.981 | 51.549 | 52.897 | 53.851 | 55.974 | 63.568 | 60.001 | 55.334 | 54.805 | 72.442 |
| Cu | trace | 0.383 | 0.942 | 0.805 | 0.077 | 0.025 | 0.028 | 0.027 | 0.050 | 0.013 |
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| Zn | 1.287 | 0.328 | 0.168 | 0.202 | 0.163 | 0.071 | 0.096 | 0.136 | 0.121 | 0.027 |
| Ni+CO | 0.146 | 0.194 | 0.316 | 0.316 | 0.065 | 0.011 | 0.011 | 0.0106 | 0.016 | trace |
| S [by calculation] | 8.462 | 10.249 | 9.475 | 9.681 | 8.903 | 9.804 | 9.440 | 8.830 | 9.517 | 11.363 |
| Gangue [by diff] | 46.158 | 35.442 | 35.292 | 34.249 | 33.887 | 26.304 | 29.808 | 35.482 | 34.637 | 16.022 |
| | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

| Rational | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Galenite | 49.625 | 59.517 | 61.074 | 62.175 | 64.627 | 73.298 | 69.277 | 63.888 | 63.277 | 83.640 |
| Sphalerite | 1.921 | 0.490 | 0.251 | 0.301 | 0.243 | 0.106 | 0.144 | 0.203 | 0.181 | 0.040 |
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| Pyrite | 2.070 | 3.143 | 0.178 | 0.274 | 0.918 | 0.202 | 0.653 | 0.334 | 1.736 | 0.261 |
| Gangue | 46.158 | 35.442 | 35.292 | 34.249 | 33.887 | 26.304 | 29.808 | 35.482 | 34.637 | 16.022 |
| | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |

| Specific Gravity | 4.011 | 6.149 | 6.579 | 6.760 | 6.856 | 7.116 | 7.536 | 6.974 | 6.979 | 7.161 |
|---|---|---|---|---|---|---|---|---|---|---|

# Smelting.

The ore after having passed the treatment described, in the foregoing pages, is next smelted to extract the lead. For this purpose there are two furnaces, a calcining or roasting and a reducing furnace; both situated in the furnace house, a building 12.19 by 30.48 metres (40' x 100').

The calcining furnace has a hearth of a rectangular form, four working doors on each side and a flat sole with a discharging hole near the fire-bridge as shown in Figs. 1 & 2 Plate VII., which are respectively a longitudinal section and plan. The following are the explanations:–

A – arch.
B – fire-box.
B' – bridge.
D – work doors.
D' – fire-box door.
G – grate-bars.
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O – discharging hole.
f – flue.

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The crushed ore is charged by means of the work doors and is oxydised, the object bing to render it the more easily reducible. The time of elaboration is 10 hours, two men bing employed. As yet, the roasting is far from perfect, but better results are to be expected as the workmen become more skilled. The following are analyses of the washed ore charged and of the roasted ore as withdrawn from the furnace.

Washed ore.

| Empirical | | Rational | |
|---|---|---|---|
| Pb | 54.485 | Galenite | 62.907 |
| Cu | 0.048 | Sphalerite | 0.176 |
| Fe | 0.091 | Chalcopyrite | 0.144 |
| Zn | 0.119 | Millerite | 0.104 |
| Ni + Co | 0.067 | Pyrite | 0.101 |
| S | 8.622 | Gangue | 36.568 |
| Gangue | 36.568 | | 100.000 |
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| S | 8.622 | Gangue | 36.568 |
| Gangue | 36.568 | | 100.000 |
| | 100.000 | | |

## Roasted ore.

| Empirical | | Rational | |
|---|---|---|---|
| $SO_3$ | 2.0434 | $CaO.SO_3$ | 3.4738 |
| $CaO$ | 1.4304 | $ZnO.SO_3$ | trace |
| $ZnO$ | trace | $PbO.SO_3$ | 2.7183 |
| $PbO.SO_3$ | 2.7183 | $PbO$ | 57.9649 |
| $Pb$ | 76.6607 | $PbS$ | 26.3898 |
| $Cu$ | 0.8486 | $Cu_2S$ | 1.0630 |
| $Fe$ | 1.4299 | $FeS_2$ | 3.0640 |
| $Zn$ | 0.8659 | $ZnS$ | 1.2873 |
| $Ni$ | 0.7089 | $NiS$ | 1.0927 |
| $CaO$ | 0.5696 | $CaO.CO_2$ | 1.0171 |
| $MgO$ | 0.8463 | $MgO.CO_2$ | 1.7772 |
| $S$ | 6.1889 | | 99.8381 |
| $CO_2$ | 1.3784 | | |
| $O$ | 4.2589 | | |
| | 99.8381 | | |

The next and final operation is the smelting proper. This is done in a Flintshire reverberatory. The roasted ore is charged by the doors; the fire is at first kept low, it is then gradually raised and the doors closed. When reduction commences fluor spar is added to make the slag that is formed, more fusible.

Roasted ore.

| Empirical | | Rational | |
|---|---|---|---|
| {$SO_3$ | 2.0434 | $CaO.SO_3$ | 3.4738 |
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Finally the lead, having all
collected in the "pond" (sump),
is purified by collecting the
slag, which is done by throwing
in some lime. The lead is
tapped, run into a pot,
there purified with saw dust,
skimmed and run into molds
in the form of "pigs." Such is
the general treatment and the
results obtained with the Flintshire
are claimed to be much more
satisfactory than those obtaina-
ble with the common or I.
furnaces. The hearth area is to
the grate area as 6 to 1.

Plates VIII, IX & X are
respectively the plan, longitudi-
nal and cross section of
the Flintshire of which the
following are the explana-
tions:—

A — arch.
B — fire-box.
B' — bridge.
D — work-door.
D' — fire-box door.
E }
ff} — flues.

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ff} -- flues.

F' – passage under the furnace
for air to circulate.
G – grate bars.
H – hearth.
H' – hopper.
K}
T} (fig 2. Plate X) – tapping holes.
P – furnace pot.

As may be seen from the drawings there are three work-doors on each side and the hearth slopes down towards the pot.

The following are some of the details of the operations with a few of the amounts of the materials used.

The heating is done by means of wood (chiefly oak) which is delivered at the rate of 62.5 cents per cubic metre ($2.25 per cord). The consumption is 3.589 cubic metres (one cord) per 453.5 Kilogrammes (1000 lbs) of raw ore and proportionately less for calcined ore.

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H' – hopper.
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The furnace is not allowed to cool, but immediately after ladling out the lead, and scraping out the slag, a charge is introduced. If roasted ore, 1360.5 Kilogrammes (3000 lbs) are put in by throwing in by the work doors. If, on the other hand, raw ore is introduced, it is put in by the hopper, 1133.75 Kilogrammes (2500 lbs) constituting a charge.

A slow fire is now put on for four hours, to drive off the sulphur; then the heat is increased till the lead runs, when as much heat is put on, as possible. At this stage 12 to 16 Kilogrammes (25 to 40 lbs) of fluor spar are added and afterwards about 10 Kilogrammes (20 lbs) of lime, to collect the slag.

The furnace is then tapped, the clay plugs in K & T (Fig 2. Plate X) being removed and the pot filled with the molten lead. This is then purified (as stated above)

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The furnace is then tapped, the clay plugs in K & T (Fig 2. Plate X) being removed and the pot filled with the molten lead. This is then purified (as stated above)

with sawdust, skimmed of the dross that collects on the surface and cast into pigs. The lead is very pure and has the following average composition:

Sp. Gr. 11.359*

| | |
|---|---|
| Sb | .0001933 |
| As | trace |
| Fe | .0065849 |
| Cu | .0468218 |
| Zn | .0003276 |
| Ni | .0005941 |
| Ag (by cupellation) | .0036666 |
| Pb (by difference) | 99.9418117 |
| | 100.0000000 |

The time of elaboration is 12 hours with raw and 8 with roasted ore. About 2731 Kilogrammes (6000 lbs) of ore are worked off in 24 hours and 52% of this is pig lead; or, in other words, the general product averages 20 pigs, of from 35.4 to 36.3 Kilogrammes (78 to 80 lbs),

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*Corrected for 4° Centigrade.

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per run.

The slag, which is scraped out and hauled off, is about 25% of the weight of the ore and has the following composition:

Sp. Gr. 4.039*

| Empirical | | Rational | |
|---|---|---|---|
| $PbO.SO_3$ | 20.231 | $PbO.SO_3$ | 20.231 |
| Pb | 21.127 | PbO | 20.188 |
| Zn | 10.503 | PbS | 2.756 |
| Cu | 0.715 | $SbO_4$ } | trace |
| Sb } | trace | $AsO_3$ } | |
| As } | | ZnS | 15.673 |
| Fe | 7.405 | FeO | 9.521 |
| Ni+Co | 0.819 | CuO | 0.895 |
| $Al_2O_3$ | 1.259 | (Ni+Co)O | 1.041 |
| CaO | 9.129 | $Al_2O_3$ | 1.259 |
| MgO | 4.048 | CaO | 9.129 |
| CaFl | 0.375 | CaFl | 0.375 |
| $SiO_2$ | 14.618 | MgO | 4.048 |
| S | 5.539 | $SiO_2$ | 14.618 |
| O | 3.966 | | 99.734 |
| | 99.734 | | |

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* Water at 4° Centigrade.

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*Water at 4° Centigrade.

The skimmings or dross of the furnace-pot average about 70 Kilogrammes (150 lbs) per charge, and are re-smelted with the ore. The composition varies exceedingly but the following analysis is from a fair sample.

| Empirical | | Rational | |
|---|---|---|---|
| Pb | 79.821 | PbS | 7.435 |
| Cu | 1.305 | Pb | 73.382 |
| Zn | 0.050 | As} Sb} | trace |
| Sb} As} | trace | Cu | 1.305 |
| Ni+Co | 0.083 | Zn | 0.050 |
| Fe | 0.065 | Ni+Co | 0.083 |
| MgO | 0.764 | Fe | 0.065 |
| CaO | 3.144 | MgO | 0.764 |
| $Al_2O_3$ | 0.815 | CaO | 3.144 |
| $SiO_2$ | 12.771 | $Al_2O_3$ | 0.815 |
| S | 0.996 | $SiO_2$ | 12.771 |
| | 99.814 | | 99.814 |

The flues of the Flintshire connect with a canal .914 by 1.52 metres (3'x5') in section

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| | 99.814 | | 99.814 |

The flues of the Flintshire connect with a canal .914 by 1.52 metres (3' x 5') in section and 91.47 metres (300') long. This has been built to promote the draught of the furnace and it connects with a high stack. The draught is regulated by a couple of fire-brick dampers placed in the flues f, f Plate VIII.

The canal has been found to be coated with fume, which although 5 to 8 centimetres (2" to 3") thick is still of so little weight that it has not been taken out to smelt. The following is its composition.

| Empirical | | Rational | |
|---|---|---|---|
| $SO_3$ | 9.1493 | $PbO.SO_3$ | 53.5070 |
| $ZnO$ | 0.9027 | $PbO$ | 21.4917 |
| $NiO$ | 0.1719 | $ZnO.SO_3$ | 1.7942 |
| $CaO$ | 4.8979 | $NiO.SO_3$ | 0.3656 |
| $MgO$ | 0.7856 | $CuO$ | .03224 |
| $PbO.SO_3$ | 53.5070 | $FeO$ | 0.4578 |
| $CuO$ | 0.3224 | $ZnO$ | 0.4872 |
| $FeO$ | 0.4578 | $CaO.SO_3$ | 11.2918 |
| $ZnO$ | 0.4872 | $CaO.CO_2$ | trace |
| $PbO$ | 21.4917 | $CaO$ | 4.9592 |
| $CaO$ | 4.9592 | $MgO.SO_3$ | 2.3568 |
| $MgO$ | 0.9372 | $MgO.CO_2$ | trace |
| $CO_2$ | trace | $MgO$ | 0.9372 |
| $SiO_2$ | 2.3859 | $SiO_2$ | 2.3859 |
| | 100.3568 | | 100.3568 |

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Two men are employed to work the Flintshire and the shifts, throughout the furnace house, are two in 24 hours.

It may not be out of place here to observe that the lead produced (of which an analysis is given elsewhere) compares very favorably both with Missouri and other leads, as one which can be used chemically. It is what is technically called a "soft" or "chemical" lead and with refining would, perhaps, rank as one of the best in the state.

A. H. Ohmann-Dumesnil.

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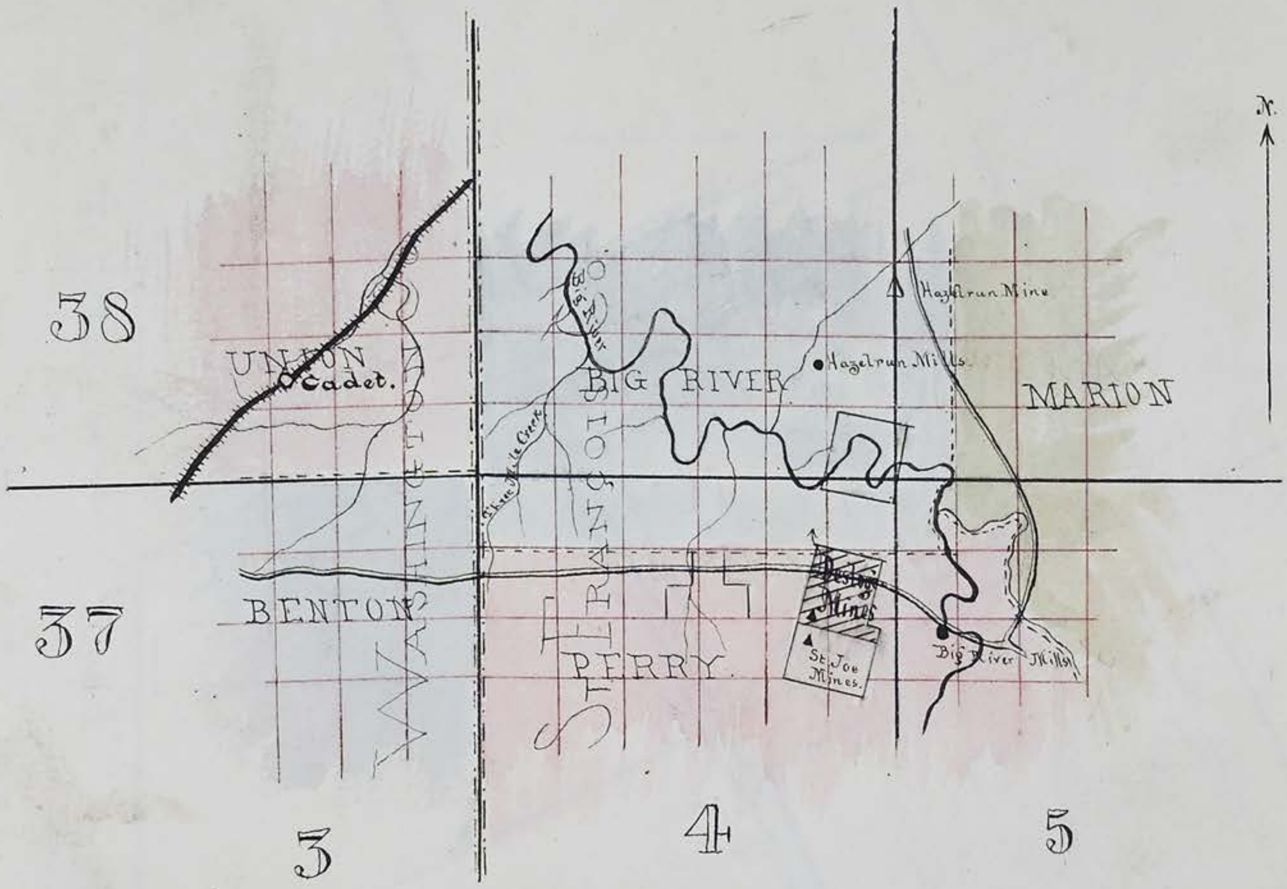
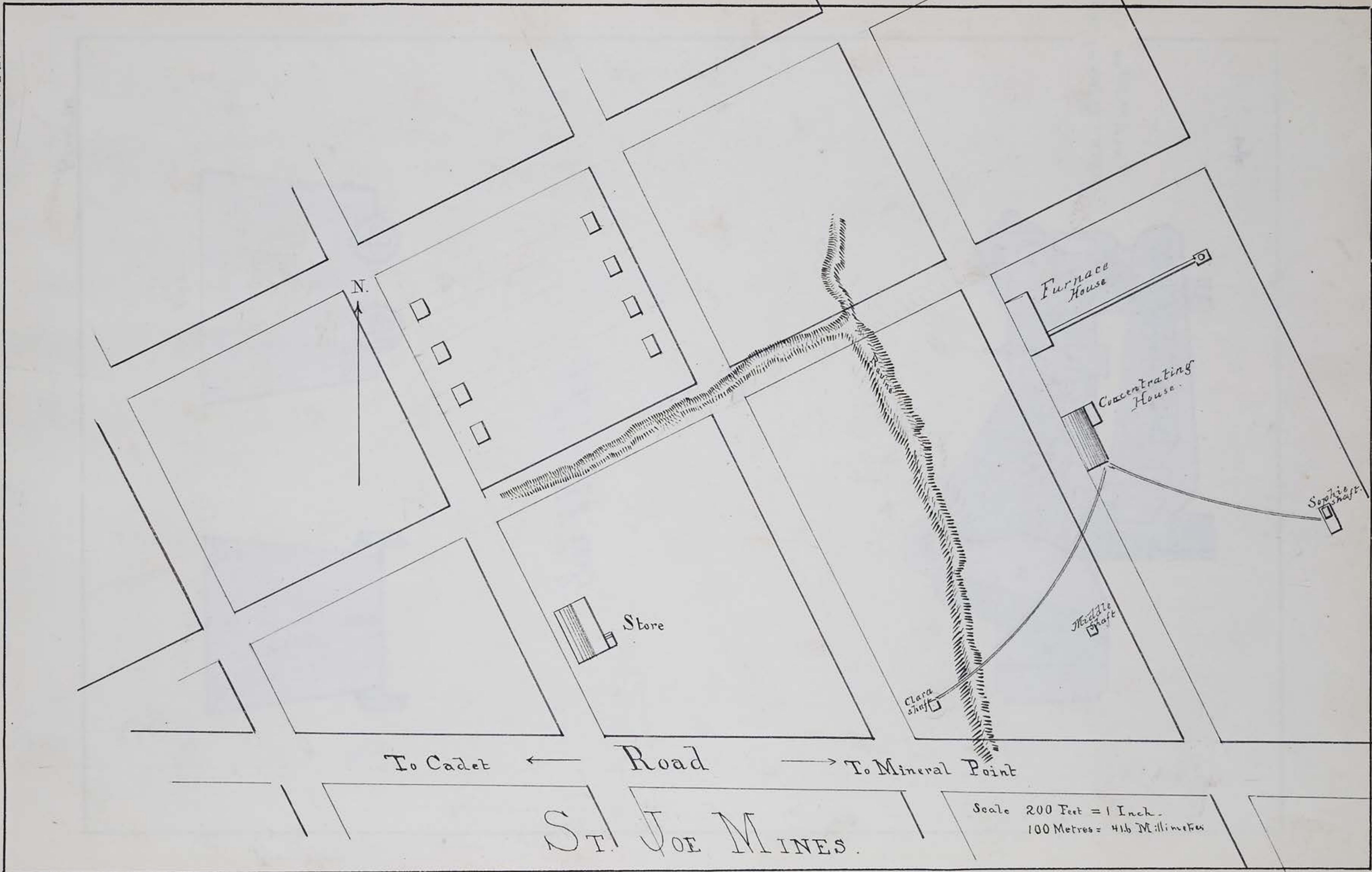
A.H. Ohmann-Dumesnil.

Plate I.




Scale: 3 miles to 1 inch.

Plate II.




ST. JOE MINES.

Fig. 1.

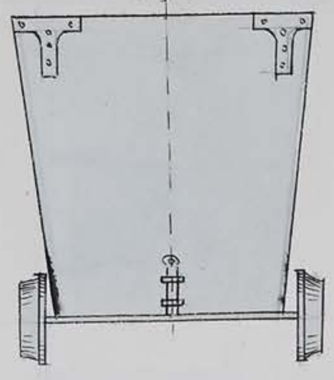
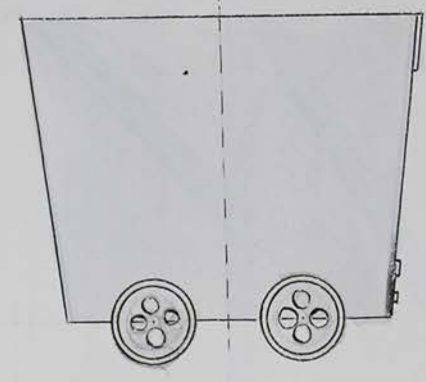
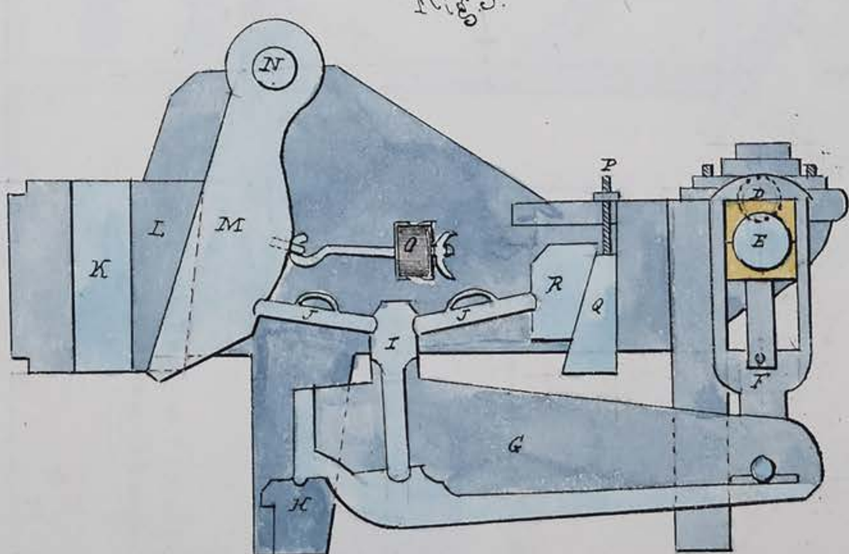


Fig. 2.



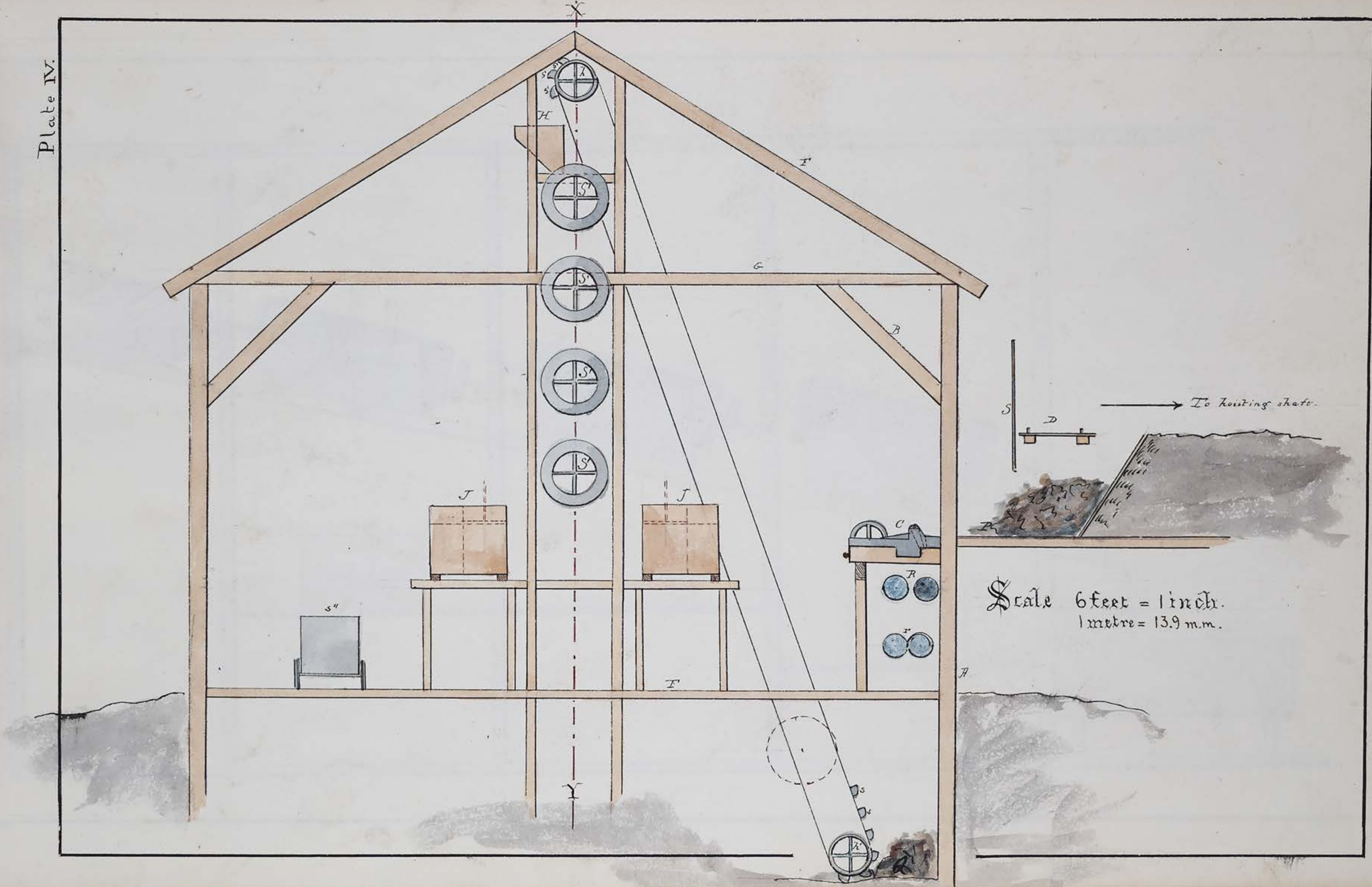
Scale: 2 Ft. = 1 Inch.

Fig 3.




Scale: 2 Feet = 1 Inch.
1 metre = 41.6 m.m.

Plate IV.



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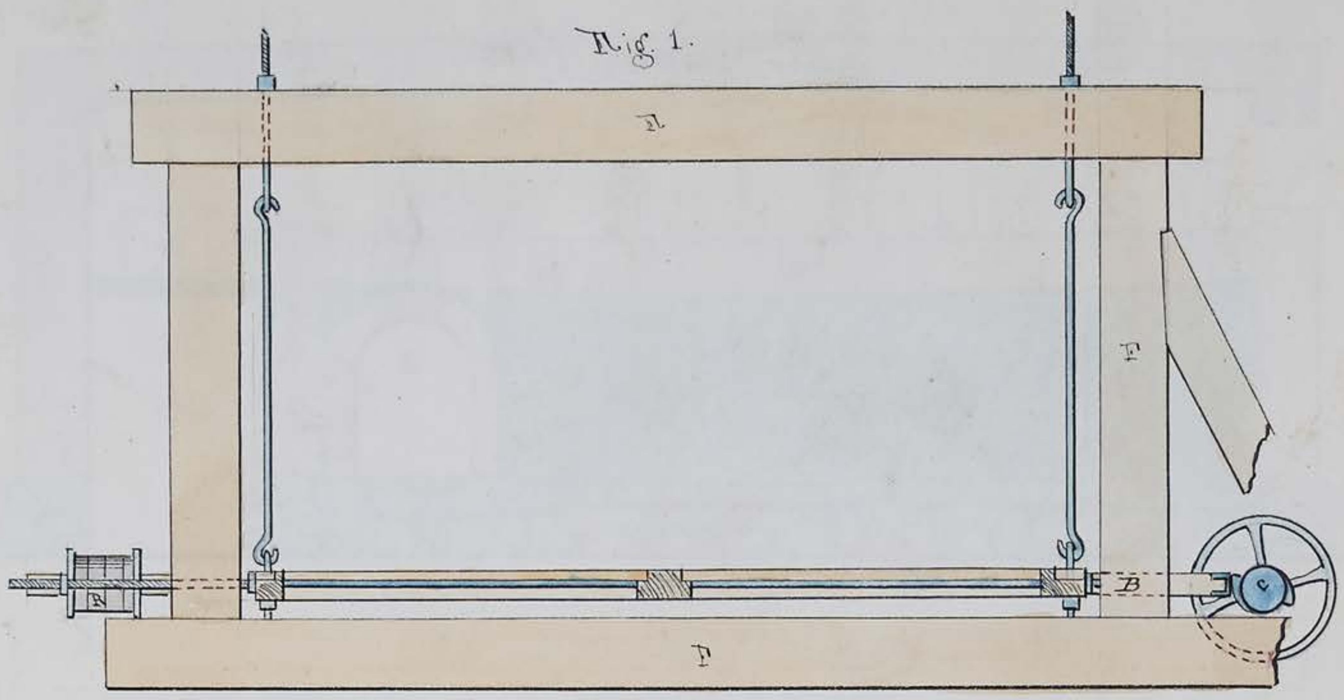
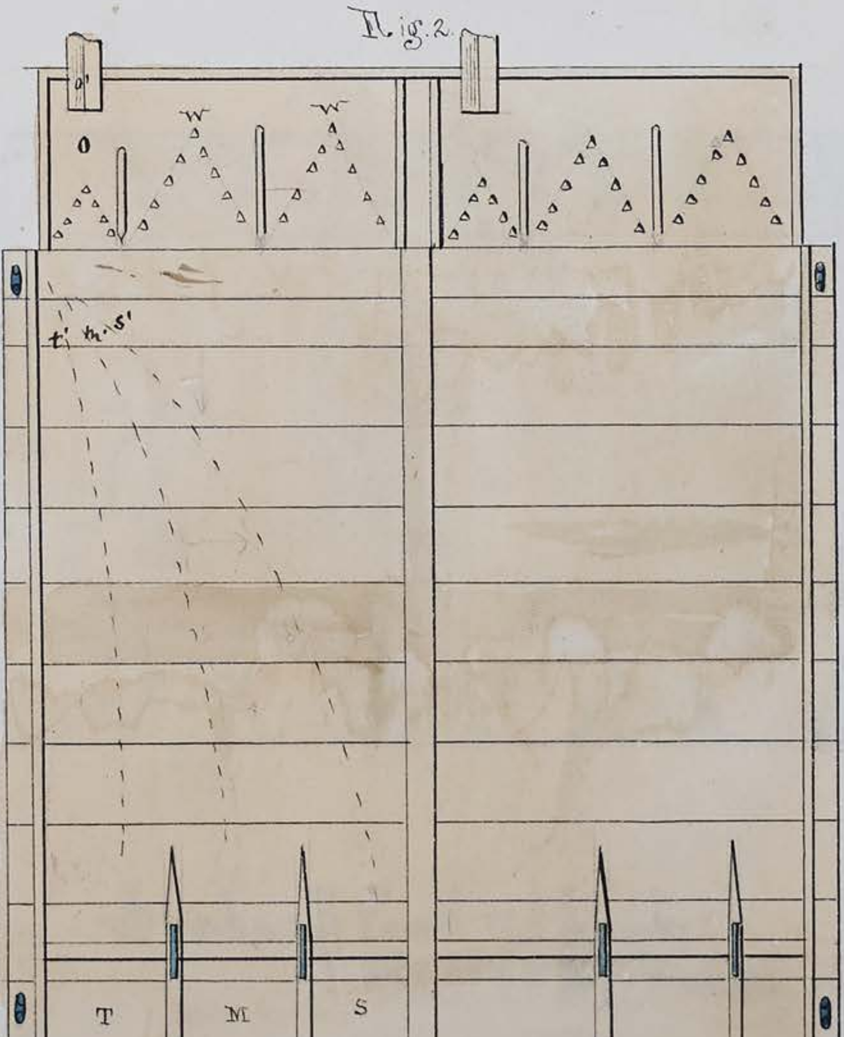



Fig. 2.

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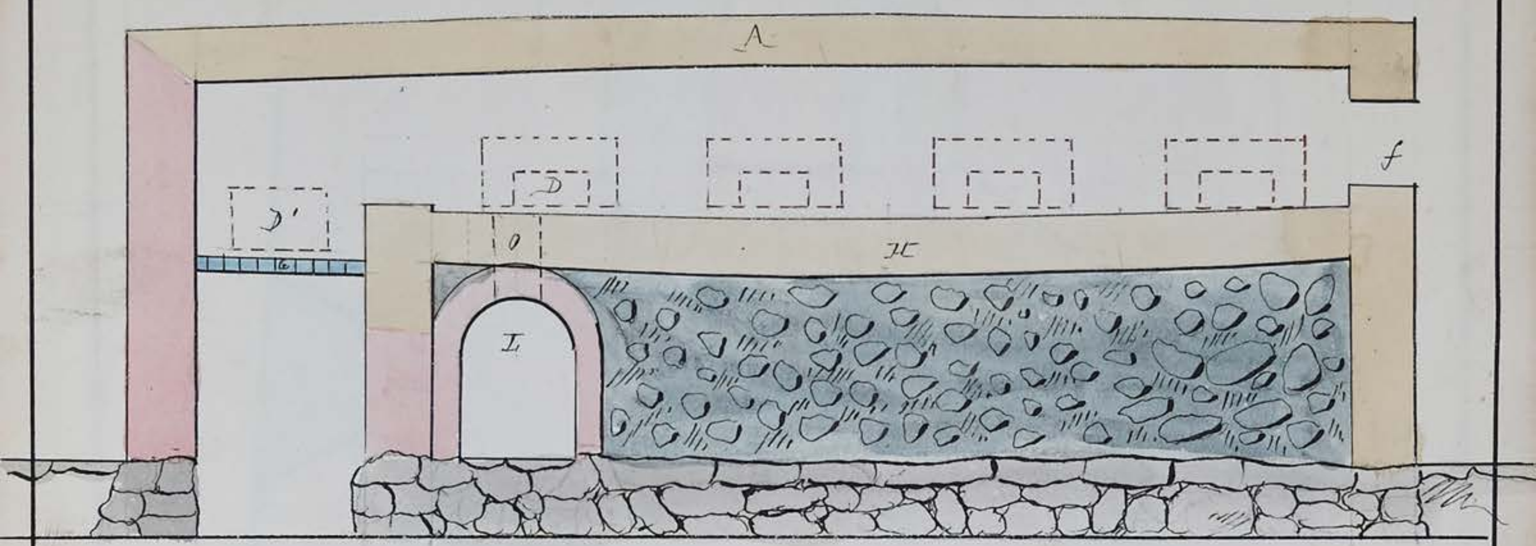
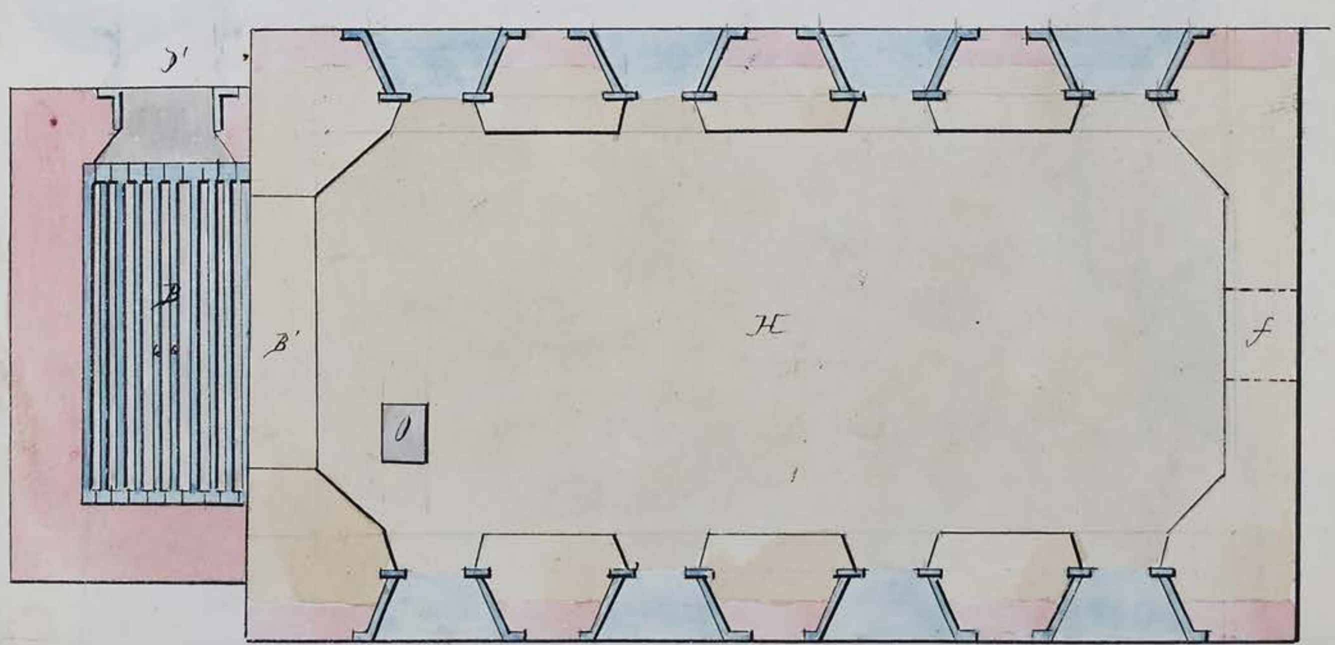



Scale: 3 Feet = 1 Inch.
1 Metre = 27.7 m.m.

Plate V.

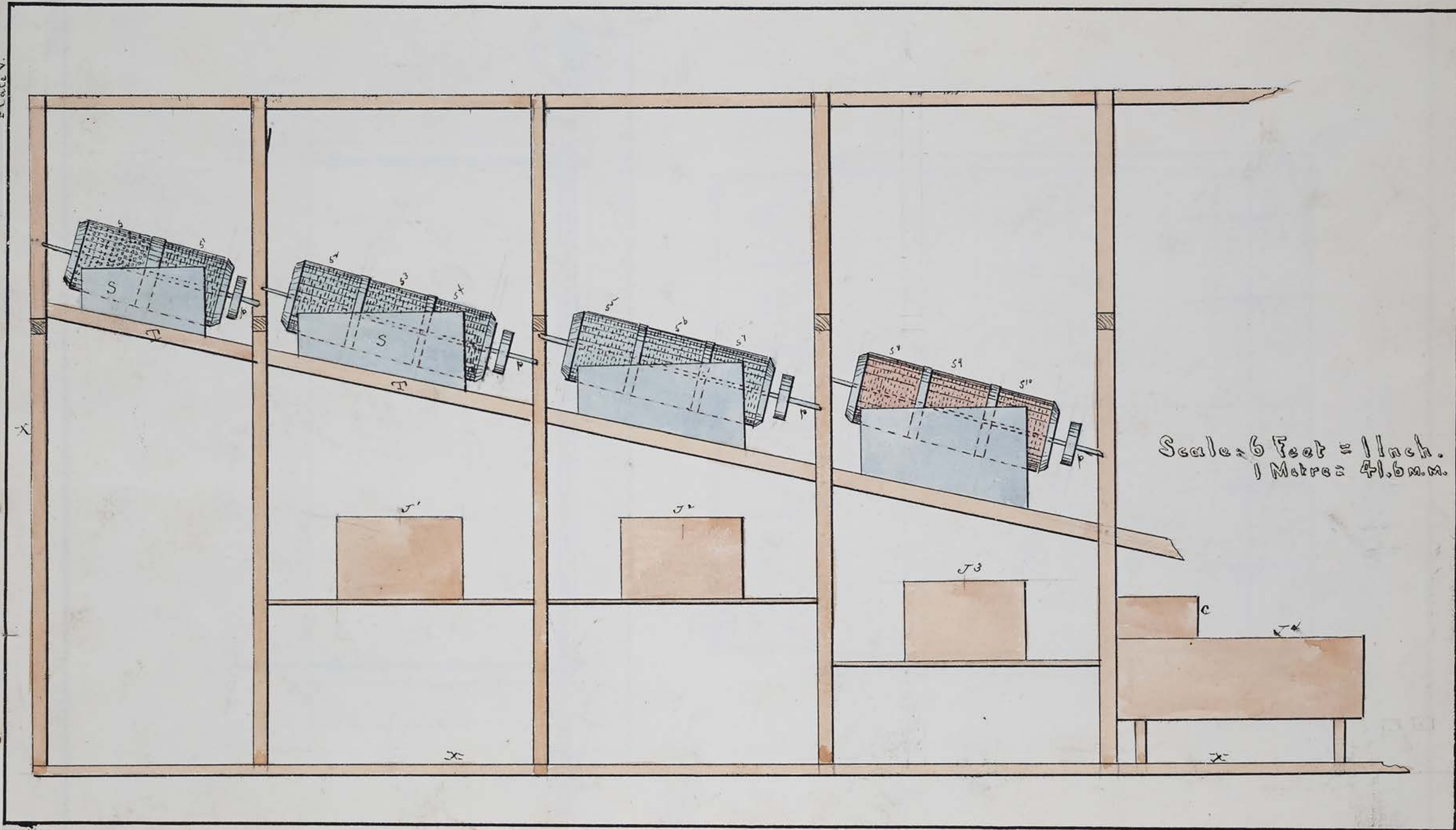


Plate VIII.

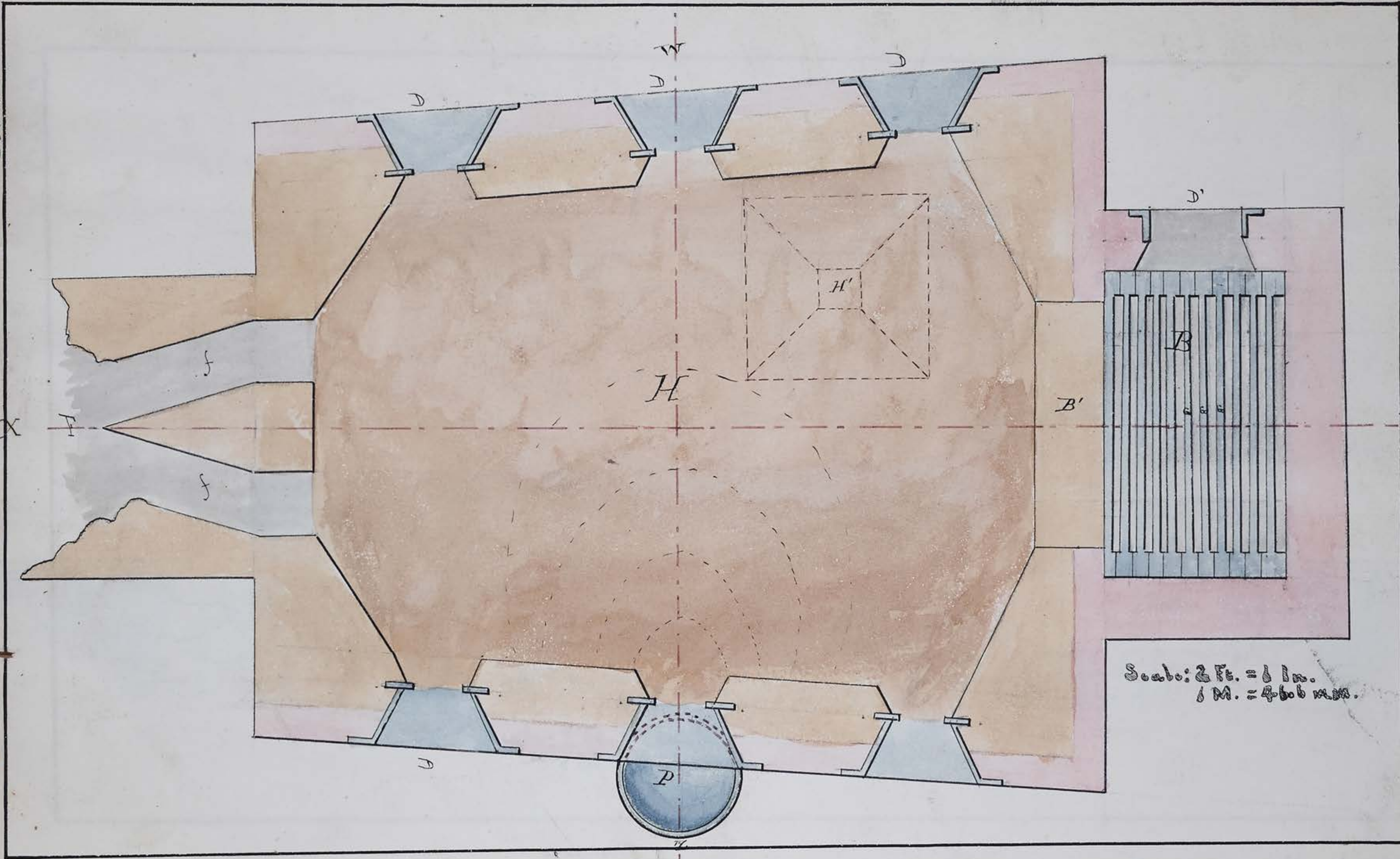
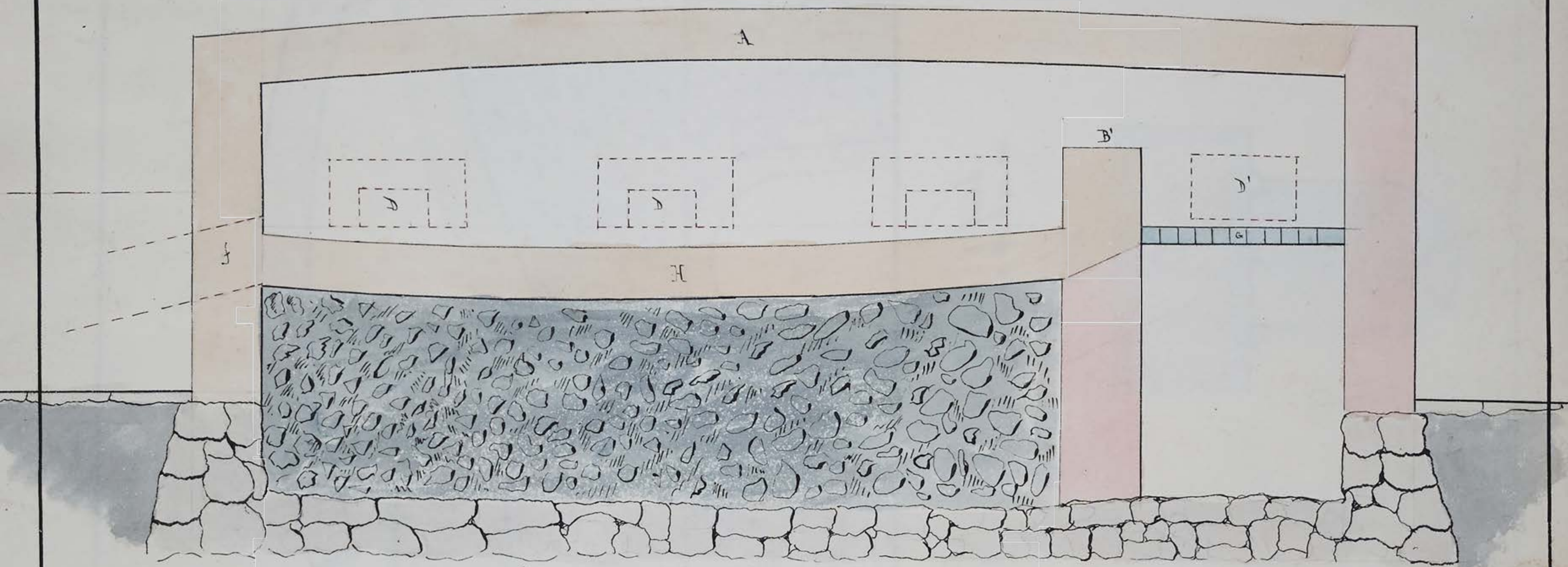


Plate IX.




Scale: 2 Ft. = 1 Inch.
1 M. = 41.6 m.m.

Plate X.

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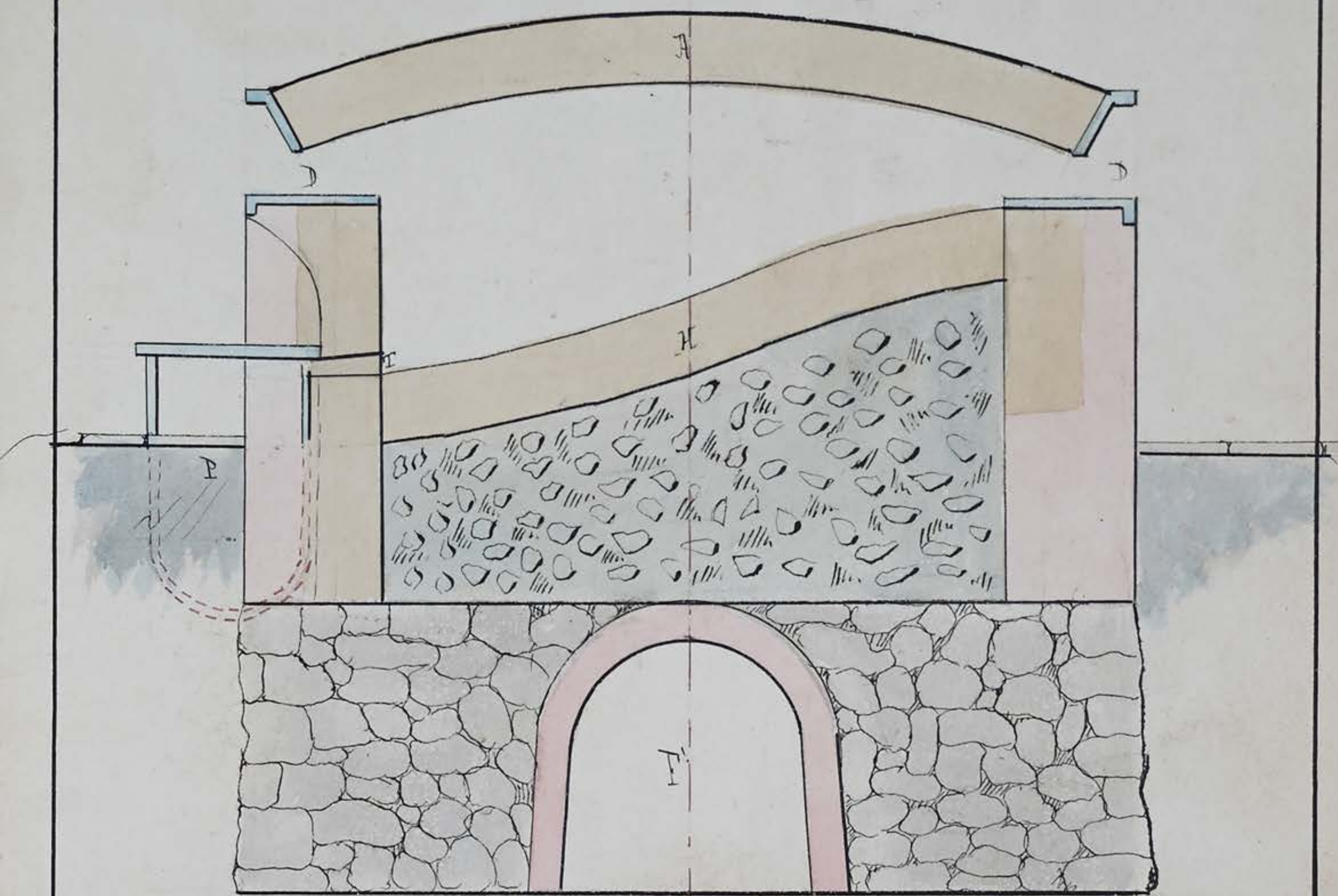


Scale: 2 Feet = 1 Inch.
1 Metre = 41.6 m.m.

Fig. 2.