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The mining & construction of a smelter for the production of zinc-white from western lead-zinc ores

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THESIS

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FOR

DEGREE OF B. S.

IN

MINE ENGINEERING.

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-;Subject:-

THE MINING & CONSTRUCTION OF A SMELTER FOR THE PRODUCTION OF ZINC-WHITE FROM WESTERN LEAD-ZINC ORES.

BIRD'S-EYE VIEW OF SMELTER

On account of the high price of the old Dutch process of making white lead and the undesirability of sublimed white-lead as the bulk of the pigment, the use of zinc-white as an adulterant of the lead-white made by the old Dutch process is now extensively used by all paint manufacturers. The advantages of its use in conjunction with white-lead in the manufacture of white paints is the fact that it does not combine with sulphur as does white-lead itself. The specifications of the U. S. Light-house Dept. require 75% of zinc-oxide and 25% of white lead as a mixture. Over 75% of the zinc-oxide manufactured is used in the compounding of rubber goods. The zinc-oxide mixes well with other pigments, especially with white-lead. The zinc-white made from the ore is more durable and is considerably cheaper than that made from spelter. The zinc-white gives a much purer and a more decided white than lead-white. The absorbant properties of the zinc-white paint are considerably less than that of the pure lead-white paint. The property of flexibility in zinc-white paint gives it quite a demand for use in the manufacture of oil cloth.

The comparitive time employed in the manufacture of zinc-white with that of lead-white gives the former the decided advantage. The time required for zinc-white is from eight to sixteen hours, while that required for lead-white in the old Dutch process is from ninety to one-hundred days. This is a considerable item since a large amount of the capital will lie idle when it may be turned several times when employed in makin the former comodity.

Any ore that may be smelted for spelter may be smelted for zinc-white, but the advantage of the western complex lead-zinc ores over the lead-zinc ores as represented by the ores of the Joplin district lies in the fact that the Joplin ores are comparitively speaking ores low grade ores, which require mechanical concentration while the ores from the Rocky Mountain district run from 25% to 45% lead and zinc mine run and are thus sufficiently high in values to be smelted directly.

In order to smelt the ores profitably a cheap system of mining must be employed as these ores can not be sent to custom smelter, but must be sent to a smelter especially constructed for the production of zinc-white. There are very few smelters of this type in the country as the industry is comparitively new one, hence with the increasing demand for the product there must arise an increasing output which cannot be supplied with the present means of production.

The process of making zinc-white was invented by Wetherill in 1856 and is practically now as it was 40 years ago, but the present indications are that it will be greatly improved upon in the near future , as there are now undergoing a number of new systems for a cheaper method of production.

An epitome of the process of making zinc-white as followed by our plant is given below:-

The ore is ground down to IO-20 mesh and is roasted in McDougall furnaces until about I% of sulphur remains; this is then charged into oxidizing furnaces with fine coal and the zinc and the lead are oxidized and carried off by a draft. The lead compounds are collected in a large settler at the ends of the oxidizing furnaces. A small amount of the lead compounds are carried with the zinc-oxide into a flue and from there through a suction fan and into the bag house. The fan forces the zinc-oxide dust up into the bags where it is seperated from the gasses that come over from the furnaces with it. Most of the dust is collected at the bottoms of the bags in hoppers. The hoppers are emptied at intervals and the finished product is carried to the storage house and packed for shipment to the consumers.

The Rio Grande Mining & Smelting Company own a number of claims in the territory of New Mexico, among which are the Rio Grande Tunnel Claims, it containing ore particularly adapted to the manufacture of zinc-white. This property is situated in the territory of New Mexico, County of Bernalillo, about six miles north of Santo Domingo, N. M., on the east side of the Rio Grande River, and is reached by a wagon road up White Rock Canyon and by a spur of the A. T. & S. F. R. R. from Santo Domingo. The elevation of the mine is about 6000' above the sea level. The claims were staked out and surveyed by a deputy-surveyor from Santo Domingo. The following is a description of the survey made by S. C. Wallace, deputy-mineral land surveyor of Santo Domingo, N. M.;-

Survey No. 2323.

Rio Grande Tunnel Claims.

The soil embraced in this claim consists of decomposed granite and limestone on the mountain slopes and sand and gravel at the bottom of the claim. The mountain sides are covered with a scant growth of sage brush, grass, cactus, scattering pine, spruce, and cotton-wood.

There are no streams on these claims. The nearest stream is the Rio Grande River, about one mile from the mouth of the tunnel.

U. S. L. M. bears from Cor. NO. I S. 45 degrees W., I695.5'

Beginning at U. S. L. M. , an iron pipe set in the ground 4' and projecting above the ground I8", inscribed U. S. L. M. ,whence

Cor. NO. I Sur. NO. 2323 Rio Grande Tunnels Claims bears S. 45 degrees W.,I695.5', thence S. 30 degrees E.,

3000'

To Cor. No. 2, a mound of stone with a pipe set in the ground 4' and projecting out I8" with 2-2323 inscribed on the top, whence

A spruce tree bears S. 60 degrees W. , 203'.

Thence S. 60 degrees W.,

3000'

a pipe set in the ground 4' and projecting out I8", marked 3-

2323 whence

No bearings available.

Thence N. 30 degrees W. ,

3000'

To Cor. No. 4, marked as the previous corners, thence

N. 60 degrees E.,

3000'

To Cor. No. I the place of beginning.

Containing 206.6 acres.

The surveys of the Rio Grande Tunnel Claims are identical with the respective locations, as staked upon the ground.

Application for a patent was made at the land office at Santo Domingo according to U. S. Revised Statutes, Section 2335 and all requirements stated therein were duly performed.
As the ore to be mined was to be sent to the smelter on the Rio Grande River in White Rock Canyon, it was necessary to patent a tract of ten acres for a smelter site and to secure the necesarry right to construct tower stations for an aerial tramway. This land was shown to be non-mineral bearing in character and the patent was applied for and granted at the prescribed limit of time according to U. S. Revised Statues, Section 2337.

Survey No. 2435.

Rio Grande Mill and Smelter Site.

Beginning at corner No. 3, Keystone Tunnel Claims, ground I8", inscribed 3-232I whence

Cor. No. I Rio Grande Mill and Smelter Site bears 38 degrees N. W.,

980.2'

An iron pipe set in the ground 4' and projecting above the ground I8" with I-2435 inscribed on it, whence

S. 60 degrees W., to

660'

To Cor. No. 2, an iron pipe set 4' in the ground and projecting above the ground I8" with 2-2435 inscribed on it, thence N. 30 degrees W.,

660'

To Cor. No. 3, an iron pipe set 4' in the ground and projecting I8" above the ground with 3-2435 inscribed on it, thence N. 30 degrees E. ,

660'

To Cor. No. 4, an iron pipe set 4' in the ground and projecting above the ground I8" with 4- 2435 inscribe on it, thence S. 30 degrees E.,

660'

To Cor. No. I, the place of beginning.

Containing two tracts of five acres each. The surveys of the Rio Grande Mill and Smelter Sites Nos. I & 2 are identical with the reppective locations, as staked upon the ground.

GEOLOGY OF THE CLAIMS.

GEOLOGY OF THE CLAIMS.

The uppermost formation is a blue compact limestone interspersed with a few beds of thin shale. This formation as well as those that lie underneath, lie conformably upon the ore bearing formation. The ore-bearing formation is known as the ~~#A~~ Silver Pipe and consists of a sub-crystalline limestone with compact 5 feet layer calledthe Silver Pipe near ite middle. By reference to blue-print No. 2 the relative position of the different strata may be seen.

The outcrop of the ore-bearing formation occurs at a pt. about I500' back from the mouth of the tunnel and dips at an angle of 4o degrees to the south-west, strike-N. W. -- S. E. At this point of outcrop the thickness of the formation is I25' and does not vary but slightly in the entire width of the claims. From the dip of the ore-body the approximate distance that the tunnel will have to be run back is between 900 and I000 feet.

METHOD OF MINING.

The ore will be reached by a tunnel begun at the point about 40' above the level area at the south-west side of the mountain and run thence in a north-easterly directionto the ore body. The size of the tunnel will be 8' x I2' in the clear which will give sufficient space for a double track for the removal of the ore. The tunnel will be run with a raise of 6" in every I00' for the purpose of drainage, thus doing away with the additional expense that would naturally occur if the water was handled by other means. The hardness of the ground will not necessitate any timbering in the tunnel except at the point of contact of the different rock strata where the loose rock will be apt to give trouble by sluffing off into the tunnel interfering with the hauling of the ore and making it dangerous for the miners. The method of timbering used will be the three piece sets as the floor will be sufficiently solid to dispense with a set of sills. The posts and caps used can be obtained from the mountains a few miles back of the claims and must not be less than 10" in diameter. The lagging used may be short poles or sapplings of a varying diameter, from two inches up to five or six, but where the ground id exceedingly soft and inclines to work very much a tight lagging of cut timber must be used. A small runway is to be dug in the middle of the tunnel for the removal of the mine water. The gauge of the track is 36" and must be laid 2 1/2 feet from the center line of the tunnel to the center line of the tracks. This gives a clearance of two feet between the two tracks and two feet between the outside. The posts will take up about 10" of the space at the sides but the remaining 14" will be sufficient to give plenty of clearance for the cars.

At the point where the tunnel reaches the ore-bodies drifts will be run both ways along the vein. A continuation of the tunnel will be made up the slope of the vein and at intervals of every 50' drifts will be run parallel to the drifts at the endof the tunnel. Every 30' along these drifts shutes following the foot-wall of the vein are to be driven up the vein to the next drift. These shutes will be timbered with h heavy boards running lengthwise so that the ore may run easier. At the bottom of these shutes will be ore-gates for unloading the ore into the cars. The ore is to be mined by overhead stoping, taking one-half of the vein on the footwall on working from the lower drift up to the next drift above. This space is to be properly held by stulls and afterward filled by the waste from the stope. The upper half is now to be stoped down to the lower drift and the ore thrown down the ore-shute which has been kept open. The pillars left at intervals of every 30' may be robbed as soon as all the ore has been stoped out.

This system of mining makes a very economical and quick method of mining the ore and gives the greatest amount of safety to the miners. The amount of timber used is inconsiderable and the greater part of it may be recovered at the end of working. This one item alone will make a great ~~item~~ difference in the running expenses. The gauge of the tracks in the drifts will be the same as that in the tunnel and sidings at every 100' apart will be set so that no delays will be necessary inthe quick delivery of the ore at the tunnel mouth.

TRAMWAY LOADING STATION.

The mine cars filled with ore are run out from the tunnel and over a bin for receiving the ore. The capacity of this bin is 225 tons. The end dump cars are used and the ore falls and is loaded into the teamway buckets by means of a traveling hopper. The design of the loading station is similar to the type made by Broderick & Bascom. The moving buckets pass around an eight feet sheave wheel and engages a hopper. The hopper is brought up to speed of the buckets by means af an accelarater and the ore is let down into the bucket while it passes along on an inclines rail. The rail is I2' long and has a rise of 6" in the I2'. At the end of the rail the hopper is empty and the point of contact of the bucket and hopper is low enough down on the hopper so that it is disengaged. The bucket passes on an and the hopper is returned to its original position by means of gravity. The hopper is filled each time by the station attendant who operated the loading by means of two brakes.

WIRE ROPE TRAMWAY.

Capacity is 200 tons per day.

Length of the tramway is 5040'.

Speed of buckets is 300' per minute.

Length of working day is IO hours.

200 x 2000#=400000#per day.

Capacity of each bucket=600#.

No. of buckets $=\frac{400000}{600}$ = 666 buckets.

Allow one hour per day for delays and repairs,- $\frac{666}{9}$=75 buckets per hour.

$\frac{I}{75}$ x 60=48 seconds between buckets.

With a speed of 300' per minute the distance apart of the buckets will be $\frac{48}{60}$ x 300'=240'.

Buckets on the loaded side at once will be $\frac{5040}{240}$=2I loads.

For 30000' from the mouth of the tunnel a frofile of the ground is approximately level, from this point to the tram terminal at the smelter, a distance of some I700' horizontally, there is a drop of about 400'.

A tension station placed at a point 30808 from the tunnel mouth on the edge of the bluff serves to keep the cable oh both sides at the proper tensein.

The first consideration in the design will be the size of the cable to use. Since the size of the cable necessary can only be determined by calculations in which the weight of the cable is used, our assumptions as to the required size of cable is based on previous knowledge . The assumed size here taken will be a one inch siz strand, I9 wire, hemp center, plough-steel cable, the approximatebreaking strength of which is 44 tons, proper working load 8.8 tons, and the weight per feet is I.58#.

The second consideration is in regard to the height of the intermediate towers in long spans. In designing the tramway a stress of I/4 the breaking strength of the cable is taken, which in this case will be assumed II tons or 22000#, as this is the maximum stress that will be brought to bear on the cable. From the profile of the country towers are placed in prominent positions, taking advantages thereby of all natural elevations, in order to keep the buckets high enough up to clear the ground as these towers may be so far apart that the stress on the towers and cable due to weight of the loaded buckets and the cable itself may become excessive, so intermediate towers are placed between the long span towers and just up to the cable held at I/4 the breaking strength. The cable stress is now reduced to what in good practice is considered asits safe working stress or approximately a stress of I/5 the breaking th strength, in this case 8.8 tons. This stress of 8.8 tonsshould not be exceeded when the cable is loaded to its maximum.

The third consideration is that the cable must be high enough when loaded to its maxmim to clear the ground.

The profile of the ground from the mine tunnel to the unloading station must be made and the position selected as described above. Since a suspended cable assumes the shape of a catenary curve, the fuddamental equations of the catenary by which these results are deduced will be stated.

Summation $F_x = -H + T \cos \theta = 0$ (I)

" $F_y = -ws + \sin \theta = 0$ (2)

For convenience, let C denote a length of cable whose weight equals thetension at C, then $H = Cw$ (3)

Square and add (I) and (2)

$H^2 + (ws)^2 = T^2$ (4)

But $H = cw$, and

$H^2 = (cw)^2$, and

therefore $T^2 = w^2(c^2 + s^2)$ (5)

By calculus the following equations may be deduced,-

$y = \frac{c}{2}(e^{x/c} + e^{-x/c})$ (6)

and

$s = \frac{c}{2}(e^{x/c} - e^{-x/c})$ (7)

Square (6) and (7) and add

Therefor $y^2 = s^2 + c^2$ (8)

Substituting (8) in (5) we have

$T^2 = y^2 w^2$ or $T = wy$ (9)

Expanding (6) we get $y_I = \frac{c}{2}((I + \frac{X_I}{c} + \frac{X^2}{2c^2}) + (I - \frac{X}{c} + \frac{X^2}{2c^2}))$ (I0)

Since (I0) equals $y_I = c + \frac{X_I^2}{2c}$

Likewise $y_2 = c + \frac{X_2^2}{2c}$

Let V = difference in elevation of two towers, therefore

$y_I = V + y_2$ (I2)

Likewise $X_I - X_2 = h$ (I3)

Subtract (II) from (I0) and substitute in $y_I - y_2 = V$, and

in $X_I - X_2 = h$

therefore $y_I - y_2 = \frac{h}{2c}(X_I + X_2)$

therefore $V = \frac{h}{2c}(X_I + X_2)$

and $X_I + X_2 = \frac{2cV}{h}$

since $X_I - X_2 = h$

therefore $X_I = \frac{cV}{h} + \frac{h}{2}$

By (I0) $\frac{T}{w} = \;\; + \frac{(\frac{cV}{h} + \frac{h}{2})^2}{2c}$

Therefore $c^2(\frac{V^2 + 2h^2}{h^2}) + (V - \frac{2T}{w})c + \frac{h^2}{4} = 0$

From the last equation the values of the following may be calculated and the curve of the cable plotted at I/4 the breaking strength tension;- c, X_I, X_2, y_I, and y_2.

Beginning at the span 6--I at the tension station and working toward the mouth of the tunnel the calculations for the span are made thus;-

h=840 feet.

$$\frac{2T}{w} = \frac{2 \times 22000}{I.58} = 27848.$$

Substituting in formula (I4) which is a quadratic equation we have $(c^2 - 6945)^2 = (6939)^2$ and

$c = I3884$

$$X_I = \frac{cV}{h} + \frac{h}{2} = \frac{I3884 \times 70}{840} + \frac{840}{2} = I577$$

$X_2 = X_I - h = I577 - 840 = 737$

$$y_I = c + \frac{X_I^2}{2c} = I3884 + \frac{I577^2}{2 \times I3884} = I3973$$

~~$y_2 = c + \frac{2x_2^2}{2}$ -~~

$$y_2 = e + \frac{X_2^2}{2c} = I3884 + \frac{737^2}{2 \times I3884} = I3903$$

To find the lowest point, subtract from c either y_I, or y_2 and then subtract the result from elevation of the tower, thus;- I3884 - I3903= a minus quantity which shows that the lowest point of the catenary curve made by this span does not lie within the span. The resultant curves for I/4 the breaking stress may be thus calculated and plotted to scale.

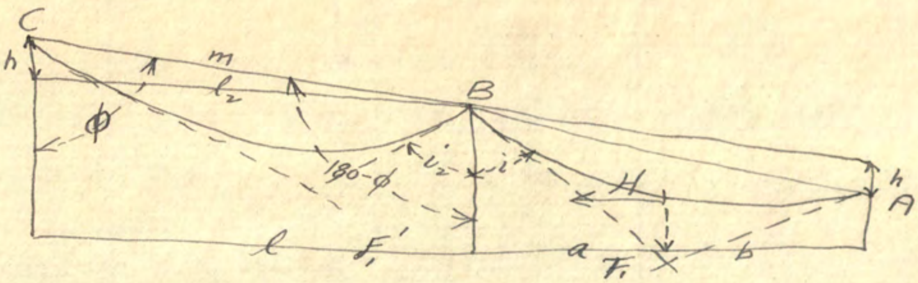
Span	h	V	c	X_I	X_I	y_I	y_I
6--I	840	70	I3884	I577	737	I3973.0	I3903.0
I--3	II20	0	I39I2	560	560	I3923.3	I3923.3
3--5	II20	0	I39I2	560	560	I3923.3	I3923.3
6---7	840	370	I2485	59I9	5079	I3893.0	I3522.0
7--8	560	60	I3892	I768	I208	I4004.0	I3944.0

The placing of the intermediate towers is now considered. The tension is reduced from I/4 the breaking strength to the actual working load.

The end of the cable is fastened at the loading station and also at the unloading station. The tension is maintained at the tension station by means of weights which are so adjusted so as to take up the slack in the cable and still have the required amount of tension on the line. The cable enters the tension station and the weight is attached to the end so that it is free to move up and down. A rail is so arranged that the buckets may be run off of the cable and on to the rail and then again onto the cable on the other side.

In the placing of towers intermediate towers on the level stretch between the first towers that were considered the best place to put them will be at the lowest point of the sag. The sag here is found to be II.3' and the towers are built up to this point so that at the greatest possible tension that the cable is designed for, I/4 breaking strength, will not unseat the cable from its place on the tower.The intermediate tower that is placed between the tension station and the first tower was not placed at the lowest point in the span, but at the point that was nearest the ground, thus eliminating the possibility of the cable ever touching the ground at this point and as the other points that might endanger the buckets on this spa span will be kept in the clear by this tower, this point may be considered as the best position that may be found.

The properties of the sagging cable, at actual working load, will now be determined. A figure like the one below is dr drawn and the unknown elements solved.



Let s=sag.

" h=drop in feet between the intermediate towers.

" a & b=distances of the lowest point in the sag of the cable to the adjacent towers.

Then from the properties of a parabola which are assumed in this case;-

$\frac{s}{s+h}=\frac{b^2}{a^2}$ ------------------------ a & b (I)

Take monents about point A.

$Hs=\frac{wb^2}{2}$ ------------------------------ H (2)

Then $T_I=\sqrt{H^2+(wa)^2}$------------------T' (3)

$\sin i_I=\frac{H_I}{T_I}$ --------------------------- i_I (4)

Then pass over to the next span and since the tension of the cable on the opposite side of the tower must be the same we have T"=T'.

$\tan\phi=\frac{l_2}{h}$ ----------------------------------ϕ (5)

$m=\frac{l_2}{\sin\phi}$ -------------------------------m (6)

Taking moments about C.

$T''m\sin((I80-\phi)-i_2)=\frac{wl_2^2}{2}$ ------------i_2 (7)

$H_2=T''\sin i_2$ ---------------------H_2 (8)

$T''' =\sqrt{H''^2+(wa)^2}$ -----------------a" (9)

$b''=l''-a''$ -------------------------b" (I0)

$T''' =\sqrt{H''^2+(wb)^2}$ -------------------T"" (II)

$\sin i''''=\frac{H''}{T''''}$ ------------------------i"" (I2)

$\frac{s''}{s''+h''}=\frac{b''^2}{a''^2}$------------------------s" (I3)

This calculation is for the loaded side but will apply to the empty side as well as for the loaded side for everthing but the H, T', and T". The load is considered as uniformily distributed. The maximum load on the loaded side is 2I loads of I000# each. Therefore the total load of 2I000# will give a load of $\frac{21000}{5040} + 1.58\# = 5.75\#$ per foot.

The calculations for span (8--7) are given;-

Let sag = I0'.

" h = 60'.

Then by (I) $\frac{10}{10+60} = \frac{b^2}{(560-b)^2}$ and b = I53.5', and a = 406.5'.

a b = horizontal length of the span = 560'.

Then by (2) $H' = \frac{5.75 \times 153.5^2}{2 \times 10} = 6774\#$.

" " (3) $T'' = \sqrt{6774^2 + (5.75 \times 406.5)^2} = 7166\#$.

" also $T' = \sqrt{6774^2 + (5.75 \times 153.5)^2} = 6838\#$.

" by (4) $\sin i'' = \frac{6774}{7166} = 70^\circ 58'$.

" " (5) $\tan \theta = \frac{l'}{h'} = \frac{840}{370} = 66^\circ 14'$.

" " (6) $m = \frac{l'}{\sin \theta} = \frac{840}{\sin 66^\circ 14'} = 917.8'$.

" " (7) $\sin((180-\theta)-i''') = \frac{5.75 \times 840}{2 \times 917.8 \times 7166} = 17^\circ 58'$.

" " (8) $\sin i''' g \frac{H''}{T'''} = H'' = 7130\#$.

" " (9) $T''' = \sqrt{7130^2 + (5.75 \times b'')^2}$ and b" = 338, and a" = 807

1" = a" b" = 840.

Then by (II) $T'''' = \sqrt{7130^2 + (5.75 \times 807)^2} = 8507\#$.

" " (I2) $\sin i'''' = \frac{7130}{8507} = 56^\circ 57'$.

" " (I3) $\frac{s}{s+370} =$ [illegible] $= \frac{33^2}{803^2} = 0.62'$.

The remaining spans are calculated in the same manner and are given in the table below;-

Span	h	s

Span

Span									
8-7	60.0	I0.00	406	I53	6774	6837	7I66	82 II'	70 58'
7-6	370.0	0.62	807	33	7I30	7I66	8507	95 44'	56 57'
6-I'	20.0	5.00	290	I30	97I7	9725	9742	87 34'	85 53'
I'-I	50.0	0.00	420	0	9742	9742	9809	89 42'	83 20'
I-2	II.3	I.66	3I6	244	9642	9809	974I	79 24'	8I 42'
2-3	II.3	I.66	3I6	244	9642	974I	9809	8I 42'	79 24'
3-4	II.3	I.66	3I6	244	9642	9809	974I	79 24'	8I 42'
4-5	II.3	I.66	3I6	244	9642	974I	9809	8I 42'	79 24'

The curves are plotted and from these it is determined whether the intermediate towers are in the proper places, and they are notthey must be placed in the proper places in order to give sufficient clearance for the buckets.

ON THE RETURN SIDE.

A smaller cable will be used on the return side. A I/2" six-strand, I9 wire, hemp center cable, approximate breaking strength=II.4 tons and working load=2.3 tons, weight per foot 0.39#.

The cable is assumed as uniformily loaded. In the 240' which is the distance of the buckets apart;-

Tension of cable=240 x 0.39#= 93.6#

One bucket =400.0# =400.0#

Transmission cable =240 x 0.39#= 93.6#

587.2#

Load per foot=$\frac{587.2}{240}$=2.44# or practically 2.50# per foot.

Since the angles are the same in the case of the smaller cable as in the case of the larger one the tensions only need to be calculated over again. The tension at the lowest point of each span, H, and the tension at the towers, T' and T" are calculated and arranged in the following table;-

Span	H	T'	T"
8-7	2403	2423	2543
7-6	2530	2543	3020
6-I'	3464	3467	35I4
I'-I	35I2	35I4	3538
I-2	3478	3538	35I4
2-3	3478	35I4	3538
3-4	3478	3538	35I4
4-5	3478	35I4	3538

POWER.

It is now necessary to find out whether or not the tramway will run by gravity or whether there will have to be an outside source of power supplied to run it.

The force due to gravity is assumed to be 30# per ton of load for each percent of grade. This force is either a plus or a minus according to whether the grade is plus or minus. The frictional resistance on the cable is assumed to be 30# per ton and is always a minus quantity. The weight of the moving load per foot is 5.75# - I.58#=4.I7# per foot. On the empty side the weight is 2.44# - 0.39#=2.05# per foot.

Each span is taken seperately and the percentage of grade is found. The force due to gravity is then found with its corresponding sign, then the force due to frictional resistance which is always minus. These are tabulated and the algebraic sum is taken as the total force either plus or minus. Then the algebraic sum of the forces on the loaded side and on the return side is found and the excess with the plus sign denotes that the tramway will run by gravity.

Let F_g = force due to gravity.

" F_f = " " " friction.

Span	1	2	3	4	5	6	7	8
% grade	~~I~~4	4	4	4	II.9	4.8	44.I	IO.7
F_g	I40	I40	I40	I40	3II.0	I25.0	2600.0	385.0
F_f	-35	-35	-35	-35	-26.0	-26.0	-59.0	-36.0
Total^{1}	I05	-I75	I05	-I75	285.0	99.0	254I.0	249.0
F_g	-56	56	-56	56	-I25.0	-50.0	-I042.0	-54.0
F_f	-I4	-I4	-I4	-I4	-I0.5	-I0.6	-24.0	-I4.0
Total^{2}	-70	42	-70	42	-I35.5	-60.6	-I066.0	-68.0

Total^{1} =3034

Total^{2} =-I386

I684# excess.

It is shown by the possitive excess of power that the tramway will run without outside power. The spans are taken from left to right in order. A friction brake must be used on the tramway to take up the excess of power. The size of sheave wheel used is 8' in diameter.

Towers acting as tension or supporting stations rest on concrete piers at the base of leg or corner. The legs of the tower of a batter of I:4 and consist of beams 6" x 6" in cross zon

zontally as shown. A 4" x 4" timber supports the guide sheaves. The four legs are connected at the top by bolts running through a 6" x 6" timber, the arms of which support a cable or track. The legs are braced and properly supported by two 2" x 2" timbers put on diagonally, and two 2" x 2" timbers put on horizontally as shown. The tension stations require more timber and must be built as in figure. It requires a good foundation and timbers 6" x 6" in cross section to act as supports as well as braces. Strength is added by putting on horizontal members and a well made support for the weights is essential to good construction.

The unloading station is at the crushing plant where the ore is dumped automatically into the coarse ore bin. The method is shown in blue-print No. 6.

ORE BINS AND THE CRUSHING PLANT.

The crushing plant is to have a capacity of 200 tons per day. It consists of a fine and coarse ore bin, each having a capacity of 250 tons per day. The dimensions are as given on blue-print No. 5. The flow sheet of the plant is shown on the same blue-print.

SPECIFICATIONS FOR MACHINERY.

Two underdraft ore-gates, 202 x 20" openings.

One Gates breaker.

10" x 20", set on a 1-3-6 cement foundation.

Four elevators.

I2' between centers, - belt is I2" wide. Speed of buckets 300' per minute.

No. 2,- from first set of rolls, center to =24', belt is I2", buckets set I8" apart. Speed of buckets is 300' per minute.

No. 3,- from second set of rolls to second trommel, I5' between buckets are I8" apart, belt I2" wide, and speed of buckets is 275' per minute.

No. 4,- from third set of rolls to fine ore bin, 25' between centers, belt I2" wide, buckets I8" apart. Speed of buckets is 250' per minute.

Three sets of rolls.

No. I,- I2" x 26", I00 revolutions per minute. Nos. 2 & 3, I0" x 202, I00 revolutions per minute.

Two trommels.

Nos. I & 2,- 66" x 30" in diameter, 20 revolutions per minute. Perforations of No. I trommel, 3/4". Of No. 2 trommel, 3/8".

Elevator buckets.

Dimensions,-I0" x 6" x 6". Made of No. I0 steel.

Line shaft.

2 7/I6" in diameter, by 36' long hung from supports dropped down from the cross pieces. R. P. M. 60.

Pulleys.

Size to fit as per blue-print No. 5.

Power.

One Direct Current moter, 600 R. P. M. ,60 H. P.

Building.

37' x 45' outside. Made of seasoned yellow pine timber with a cement foundation. Measurements may be had by reference to blue-print No. 5.

ROASTING FURNACES.

After the ore has been crushed to 10-20 mesh, it is taken from the fine ore bin and transported by means of ore cars holding I I/2 tons, to the roasting furnaces, where it is roasted down to the proper amount of sulphur for treatment in the oxidizing furnaces. The amount of sulphur remaiming is gene-erally in the neighborhood of I%.

The roasting house contains four McDougalls Roasting furnaces, I8' in outside diameter and having six decks. The ore is fed in from above by means of a hopper and an elevator, which raises the ore as it is transported from the crushing plant. The furnaces are fired by means of gas made by three gas-producers which will be described later. The two top decks are not run as hot proportionally as the four lower decks, which is to keep the ore from sintering too much at the start. The gas is fed by means of pipes set around the circumference at intervals of 4' apart. When the ore has reached the bottom, it has attained the proper percentage od sulphur for charging into the oxidizing furnaces. It is rabbled from the lower deck by mechanical rabbles out into a calcine car, where it is

The escaping gases from the roasting furnaces are collected by means of a down take and the accompanying dust that is carried along with the gases falls to the bottom of the flue. The gases are allowed to escape from the flue by means of a brick stack IOO' high and with and 8' diameter at the bottom and a I2' diameter at the top. The collected dust may be taken out by means of doors placed at intervals of every 20' in the dust flue.

A 25 H. P. motor, 775 R. P. M., is used as power for each two McDougall furnaces and by means of pulleys the speed of the furnaces is reduced down to a revolution every two minutes. The pulleys are so arranged in order that the furnaces may both be cut out, or one or the other may be cut out at will, without stopping the motor.

All dimensions necessary are on the blue-prints NOS. 7 & 8. The dimensions of the buildings are 40' x I20' long, with a height of 33' 6" under the eaves, pitch of roof is I:3. The roof has a ventilator which provides for the escape of gases that may collect in the top of the roasting house. The building is made of well seasoned yellow pine lumber set on a foundation of I-3-6 cement.

In conjunction with the roasting furnaces is a water cooler for the cooling of the water used in the rabbles of the McDougall furnaces. As the temperature of the roasting is as high as 750 degrees Centigrade and the water is to be used over again, a quick means of cooling the same is attained by pumping the angle of 30 degrees and allowing the exposure of the water to the air to cool it. This means has been found to be a very effective manner of reducing the temperature of the water so that it may be pumped back and used again in avvery short time. The height of the tower as it is called is 25' high x 2I' square. The distributing pipes are perforated at intervals of every I/2 inch so that water may get an equal distribution over the area of the boards. It runs down the boards and falls from one to the other until it reaches the bottom whence it is collected in a trough and run by this means into a large resevoir, 40' square made of brick. It is further cooled here as the depth of the trough is only four feet, and its short stay in the resevoir permits it to radiate a considerable amount of heat. From this resevoir it is again pumped back to the reasting furnaces and used over again. For details and dimensions see blue-print No. I5.

OXIDIZING FURNACES.

The oxidizing furnaces are 32 in number and receive the ore after it has been roasted. In these furnaces the roasted ore is mixed with fine coal and charged into the furnaces where it is first reduced and subsequently oxidized to the oxides of the metals present. The natural draft assisted by the suction of the fan situated at the bag-house draws the fine dust through the flues, through the settler and the dust flue into the bag-house.

The sulphur that remains in the ore after it had been roasted serves to hold down the lead present as it forms a basic lead sulphate which is not volatile and remains on the grate. This is hoed out and sold to the lead smelters as a lead concentrate. The settler collects the lead that is oxidized as it is too heavy to be carried over to any great extent into the dust flue. It also collects the small amounts of blue-powder that are formed inthe process. The settler may be cleanes out at necessary intervals by means of small doors in the sides. The white pigment is carried over to the bag-house by the fan suction and deposited in the hoppers and the bags.

Each furnace is I3.5' high over all, 6' x 6' inside measure with two furnaces back to back and one foot wall of fire brick all around. There is an arched span between the furnaces that are set back to back. The grates are 2 I/2' above the bottom of the ash pit. The ore id charged into the furnaces by means of a door I8" x I2" situated at each end of the double furnaces. This door is raised and lowered by means of a weight attached to the top of the door.

The grates are each 8" x 3' long and I/4" thick supported on strong 3" bars. The grates have perforations I/8" in diam. through which the draft is secured. There are 36 of these to a double furnace. The ore is charged onto the grates to a depth of two to three inches. The fumes are drawn through a common flue which passes over the tops of the seperate furnaces to the settler. The settler is 60' long by 20' high. The draft of the furnaces is regulated by opening and closing the ash pit doors and the furnace doors. The walls of the furnaces are braced by buck stays spaced at intervals of two feet from each end of the furnaces and four feet between.

The building is made of sheet iron both for the sides and the roofing. The angle of pitch of the roof is 30 degrees. The total length of the building id I35' over all by 30' wide and 20?5' from the top of the roof to the ground. Sliding doors are placed at intervals apart for ease in placing the cha charges and the removal of ashes.

DUST FLUE.

The dust flue consists of an iron pipe 6' in diameter and 700' long supported at intervals of I2' by three inch pipe set up on one-three-six cement foundations. The iron is bent in the shape of a circle with the two ends at anangle of 50 degrees to the horizontal and I0" apart at the bottom. The flue is supported on the iron pipes by means of a pipe cross ( ) with two three inch nipples screwed into the horizontal ends and th these ends or nipples are run through two holes in a plate that is riveted to the gas flue and turned at right angles to the gas flue. The steel is a No. I0 that is five feet wide. Every section of the steel plate has a slanting trough at the bottom from which the fallen dust is collected by means of a small hoe that may be inserted in the trough and the dust pulled out of a door at the end. A car 3' high and 4' I0" long, gauge of the track,-36", runs along underneath and serves to collect the dust.

the dust.

At intervals of every 75' expansion joints are placed to take up the expansion due to the heat of the enclosed gases. The joints consist of two pieces of No. IO steel riveted to the main flue at an angle of 70 degrees to the horizontal. The width of the joint is eight inches and the depth to the center of the first rivet is IO". There is a souble row of rivets areu around the joints which are staggered at intervals of every 3" apart.

The gas flue is divided into two parts at a point near the bag-house so that the whole product of the oxidizing furnaces may be turned into one section of the bag-house or the other at will. There is a damper which is adjustable and may be turned, thus switching the dust flow from one to the other. This is necessary in case there are any repairs to be made and does not necessitate the whole plant being shut down at once. Fro further and dimensions reference may be had to blue-print No. 9.

DESIGN OF THE FAN.

The fan is constructed entirely of steel, set up on a hammered steel shaft which revolves in cast iron hubs well made and rigidly braced. The hood of the fan is mounted on a concrete foundation, while the axle rests on hubs set on top of concrete stands which are built on either side of the fan. In designing the fan the maximum is required, the water gauge, power used, rate at which the gas enters the fan, head of the air column in feet, tangential speed, etc. The fan used at the bag-house is so designed as to admit of an increase in speed in case of an emergency.

If the fan is designed at a low speed or at a medium speed, a demand for an increase of speed can be readily met with. The fan used is for a medium spedd. It was found from actual practice that a I2' fan having a speed of 250 R. P. M. will do the work satisfactorily. We assumed that the gas in the main had an average velocity of I800' per minute, this velocity being given to it cheifly by the suction of the fan. With an intake of I6 square feet, it was found that about 24000 cubic feet of air entered the fan per minute.

In the fan the air received a tengential velocity sufficient to make it leave at the throat with a speed of 3000' per minute. The throat area was made I.25 of the area of the intake or 20 square feet. We assumedthe water gauge to be about I" whichwe found later to be about correct. Our fan was calculated for low speed of 200 R. P. M., throat area of 20 square feet, and the velocity given to the air as 3000' per minute. With the above velocity and area the fan gave a volume of 60000 cu. ft. per minute. The theoretical pressure due to the fans is given by the following equation. Let U equal the tangential speed in feet per second, g is gravity or 32.I6 ft. per second and h equals the head of air column in feet, i equals the water gauge in inches.

$$i = \frac{U^2 \times I.2 \times I2}{g \times I000} = \frac{2500 \times I.2 \times I2}{32.I6 \times I000} = I.I2\text{" water.}$$

$(U = \frac{3000}{60} = 50)$

To get the size of the motor required to drive the fan;- Multiply the number of cubic feet of air delivered by the factor 0.00026. The product will be the H. P. of the motor for ordinary conditions of ventilation. Twenty H. P. was installed to cover the conditions which might arise in the fan, although by actual calculation only I8 H. P. was required.

60000 x I.I2 x 0.00026 = I8 H. P.

Blue-prints Nos. IO and II show the arrangement of the fans at the bag-house.

BAG-HOUSE.

The bag-house receives the zinc-white at the last stage of the process just before being packed ready for storage and shipment. The zinc dust after being conveyed through a long dust flue, the purpose of which being to cool the gases, finally enters the fans of each section of the bag-house. The dust by the time that it reaches the fan has not sufficient force back of it to enter the bag-house, so the fan at this stage forces it on into a 4' pipe which runs the length of each section. This pipe is tapped at various points by 3' pipes which cinduct the dust into sets of hoppers. Each hopper has 5 bags suspended over it which finally collect the zinc-white. All the hoppers of a set are connected in series.

The building should be so constructed as to be practically fire-proof. It should be made of brick with iron columns to support the trusses. There are two sections, eachsection being 84' wide and I56' long and divided by a brick fire-wall. Fink trusses support a roof which covers both sections and also supports the weight of the suspended bags. In the design of the Fink truss all the forces were considered

The heppersin the building aremade of No. IO steel as are the dust mains alse. The building is made up of practically non-inflamable material with the exception of the bags. Arrangements are made for the proper lighting of the bag-house at intervals of every IO' between the hoppers, bothaat the top and bottom of the building.

The bags which collect the dust are two feet in diameter and 25' long and are made of muslin. At the top they are suspended from the Fink trusses, while at the bottom they are fitted over an iron cylinder which conducts the dust from the bags to the hopper below. Care must be taken so as not ignite the bags by hot dust or fumes. The bags receive the dust continuously, even when they are empties of the adhering zinc-white this being done several times a day. The hoppers into which the zinc-white falls are 6' 3" long x 4' 6" wide. The bags hang from 3" to 6" apart whichis sufficient space for the workmen to shake them. By reference to blue-print Nos. IO and II a better idea can be had of the bag-house construction and the method of working.

The dust is collected from the hoppers and wheeled to the packing and storage house. It is here packed in barrels holding 500# a piece, and in this shape it is shipped to the consumer.

GAS PRODUCERS.

Each McDougall roaster has a capacity of 30 tons of crushed. The amount of coal required to roast this amount in 24 hours is about 75% of the weight of the ore. About 24 pds. of air will be required to burn one pound of coal, assuming the

the excess air to be equal to that actually required, so that the products of combustion from one pound of coal will weigh about 25#, and the volume may be taken as being about I2 cu. ft. at 32 degrees F for each pound of air passing into the producer. The coal used in the producer has 50% combustible elements. By comparison of the gas and the coal in calorific power its was found that only 75% as much fuel was consumed in the roasters when they were gas fired. The reason for the saving is due to the use of hot gases and the high heat of combustion of the gas, and to the use of steam. I00# of coal may be taken as the equivalent of I000' of gas. We assumed that the producer gas made here had an equivalent value to the coal used. By calculation it was found that two gas producers, having a total of 20 tons capacity, was enough to supply the roasters with the necessary gas. To compute the amount of gas yieldedper pound per pound of fuel it is necessary to know the ultimate analysis of the coal. The heat which a producer receives comes not only from the coal but partly from the steam. The producer receives one pound of steam for every three pounds of coal, therefore 2 I/2 times the amount of fuel must be added to ontain the full amount of the heat that the producer has to account for. The volume and the weight of the gases delivered vary with the analysis of the coal. The volume varies within the limits of 55 to 70 cu. ft. and the weight from 3.4# to 4.8# of gas per pound of coal taken at 60 degreesF. Each pound of gas has a volume of from I5 to I6 cu. Ft. at 60 F. The combustive energy of a cubic feet of producer gas varies from I50 to 225 B. T. U.

and is used in the roasters while it is hot.

Construction of the Gas Producers.

It consists of a cylindrical shell contracted at the bottom, which sets into a water filled pan. Sight holes are provided so asto see the zone of fusion. The lining is made of hard fire-brick. The top of the producer is covered by a cast iron pan filled with water. Tuyere comes up fromthe center of the ash pan and from it steam and air is blown. The flues should have a net area not less than I/I6 the area of the gas making surface. Devices should be attached to the flue for the proper cleaning of the same from dust and soot.

Operation of the Gas producers.

Keep the fire solid by liberal use of the poker; keep a uniform thickness; and keep fire about on the same level. A constant pressure of about I/2" of water is maintained in the gas main. A layer of incandescent coal from 2'to 3' lies on a level with the sight holes. At this poit the red-hot carbon coming in contact with the air and steam, seizes the oxygen from both giving CO_2 and H. The CO_2 passing up gets another atom of C from the fuel and is changed to CO. The H from the steam combining with some of the C making CH_4 or other hydro-carbons.

Advantages.

The advantages of gas firing are as follows:-

First,- Perfect combustion of the fuel and the attainment of steady heat. Anydesired temperature may be had and maintained.

Secon,- There is a saving of fuel/

Third,- No delays in the operation of firing.

Less chance for poor roasting.

Fourth,- Saves labor.

POWER PLANT.

The power plant consists of two D. C. generators each of 250 K.W. which are directly connected to compound Corliss engines. A battery of four Atlas boilers of 75 H. P. each supplies the power for the engines. Thses boilers are fed by a small pump, 3 I/4 x 3 I/4 x 6, which pumps the water used from the Rio Grande River. The boilers are fired by coal which is supplied from the bin at the front of the boilers.

As the dynamos are in continous use the plant has been designed in duplicate, as any shut downs would seriously hamper the successful operation of the plant. The building is 8I' 6" x 46' 6" outside and I7' 6" under the eaves, pitch of the roof is I:3.

Design of Chimney for Roaster Plant.

In the design of the chimney several assumptions had to be made to fit the conditions. We assumed 25 sq. ft. as a cross-section area of our furnace, which area was in the propertion to the amount of gas burned and to the grate area. The gas ente entered the chimney at 500 C, this beibg considered the temp. o of the chimney gases. The temp. outside the stack being 60 C. I It is good practice to have water gauge at least 0.75" when McDougal roasters are gas fired and dust collected from the gas as in this case.

Data for calculation:

Temp. of gas inside chimney=500 C.

" " " outside " =60 C

Altitude is 6000'.

Barometric pressure in inches of Hg. is 23.86"

" " per square in. is II.73#

Weight of one cu. Ft. of air at standard conditions of 0 C, 760 mm. pressure is I.293 oz. or 0.0766#

one inch=25.4 mm.

Specific gravity of the air taken as 0.79, and and that of the gas from the roasters as 0.86.

It was found by trial calculation that a chinmey 85' high with a cross section area of 26 sq. ft. is large enough to produce the required water gauge.

Calculations:)

I. Volume of the gases in chimney:

85 x $(3.5)^2$ x 3.1416=I48.8 cu. ft.(Water is 772 times as heavy as air).

2. Weight at 0 C at 606 mm. pressure.

I48 x (84÷I6) x 0.86=I40#

3. Weight when temp. is 500 C

I40 x 273 ÷ 500 +273=49#

4. Weight of equal volume of air outside at 60 C

I48 x (0.84÷I6) x 273 ÷333=II4#

5. Difference of weight=ascensive force,

II4-49=65#

6. Ascensive force per sq. ft.,

65÷26 sq. ft. =2.45#

7. Total head in terms of cold air at 0 C and 606mm. pressure,

$2.45+(0.84 \times 16)=49'$

8. In terms of water gauge pressure,

$\frac{49 \times 12}{772} = 0.75''$

An analysis of the zinc-white pimenht is as follows;-

ZnO	60.75%
$ZnSO_4$	0.61
PbO	3.87
$PbSO_4$	34.25
SO_2	.064
H_2O	00.450%
	99.994%

References:)

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Johnson & Armstrong, Thesis for 1908.

Ozark Zinc-Oxide Co.