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AN INVESTIGATION IN TREATING A GOLD ORE FROM
CUSTER, SOUTH DAKOTA.

BY

THEODORE SAUNDERS DUNN.

A

THESIS

submitted to the faculty of the
SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF THE
STATE OF MISSOURI

in partial fulfillment of the requirements for the

Degree Of

ENGINEER OF MINES

Rolla, Mo.

1915

Approved by _____

Associate Professor of Metallurgy.

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The following investigation was undertaken to determine the adaptibility to amalgamation and cyanidation of a certain ore from the property of Mr. Charles Bush near Custer, South Dakota.

A preliminary sample of the ore was obtained and laboratory tests made upon it. A ton lot of the ore was then put through the ore dressing laboratory at the South Dakota School of Mines.

Upon examination the large sample was found to differ in value and to some extent in character from the preliminary sample, but the scheme of treatment worked out for the first sample was found to work excellently on the main sample.

The preliminary sample was a hard quartz with some iron oxide assaying \$8.88 per ton but the main sample while being principally the same hard quartz contained iron pyrite instead of iron oxide and assayed \$17.98 per ton.

The scheme of treatment however worked admirably on the main sample.

Preliminary Tests.

The preliminary sample was divided into several portions and tested as to its adaptibility to amalgamation and cyanidation.

The method of making these tests was as follows:

Two portions of the ore was crushed to 30 and 80 mesh respectively and treated as follows:

5 A.T. (145.83 grams) of ore was weighed out and placed in an agitator bottle together with 0.25 A.T. (7.29 gms) of Hg and enough H₂O added to make a readily flowing pulp. The bottles and contents were then agitated for four (4) hours on a roller agitator.

The Hg was then separated from the ore and the latter concentrated.

The concentrates and tailings were then dried, weighed and assayed.

Briefly the results were as follows:

Ore - 30 mesh - value recovered by amalgamation 33.4%

Concentrated - 155.9 to 1 - most of the gold going with the tailings.

Ore - 80 mesh - value recovered by amalgamation 47.4%

Concentrated - 63.6 to 1 - the greater part of the gold, as before, going into the tailings.

Detailed tabulations of these two tests will be found on pages 11 and 12, amalgamations tests #1 and #2.

The results of these tests indicated that:

1 - The material must be finely ground to give a good extraction by amalgamation.

2 - It would not be practical to concentrate the ore after amalgamation because of the very small amount of concentrates obtained and also their low value, the tailings carrying most of the gold.

3 - The tailings from amalgamation should be cyanided to recover as much as possible of the remaining gold.

Cyanide Tests.

From the deductions drawn from the amalgamation tests it was decided to try the effect of cyanidation alone on the ore.

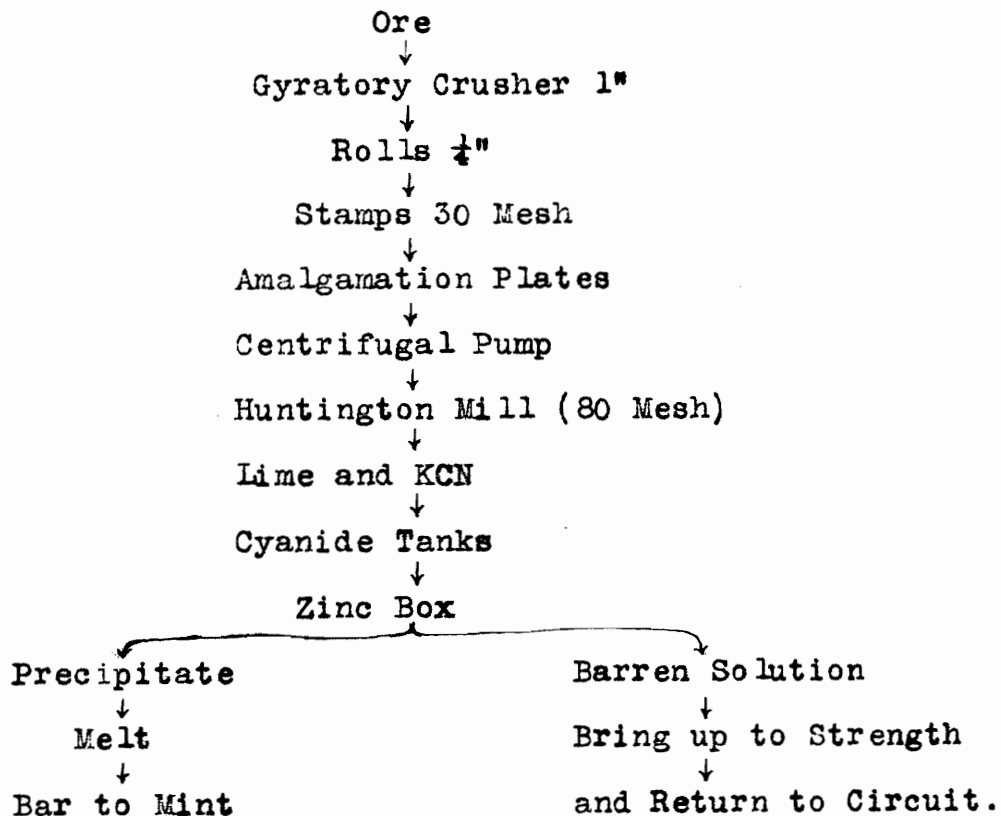
These tests were made on portions of the ore crushed to 30, 50, 80, and 100 mesh with the following results:

Mesh.	Assay of ore.	Amt. ore taken.	#KCN per ton solution.	Ratio sol. to ore.	#Lime per ton.	Time treated.	Extraction. %
30	8.88	100 gms.	2.5#	1 to 1	2#	15 hr.	60.4
50	8.88	100 gms.	2.5#	1 to 1	2#	15 hr.	81.4
80	8.88	100 gms.	2.5#	1 to 1	2#	15 hr.	83.7
100	8.88	100 gms.	2.5#	1 to 1	2#	15 hr.	82.5
80	8.88	100 gms.	2.5#	1 to 1	2#	25 hr.	86.0
80	8.88	100 gms.	2.5#	1 to 1	2#	30 hr.	83.7

For tabulated results of these tests see pages 13 to 18, cyanide tests numbers 1, 2, 3, 4, 5, and 6.

It was seen from these tests that a fair extraction could be made by a straight cyanide treatment without previous amalgamation, also the consumption of cyanide and lime was low indicating a low treatment cost.

Owing however to the fact that the owner of the property desired to use amalgamation before cyanidation if it made a fair recovery without excessive cost it was decided to use the following flow sheet for the mill run using both amalgamation and cyanidation:



As stated before, when received, the main samples differed in value and to some extent in character from the preliminary sample, but owing to shortness of time it was decided to run it according to the foregoing flow sheet.

The Mill Run.

The ore weighing 2265# was dumped from the sacks to gyratory crusher set at about 1" and then put through a pair of 24"x 14" rolls set at $\frac{1}{4}$ ".

From the rolls the ore was shoveled to a Tullock feeder feeding a battery of 3 - 350# stamps with a 30 mesh screen. The stamps made 120-6 drops per minute.

From the battery the pulp flowed over silver plated amalgamating plates. The plates being 30" wide by 12 feet long.

From the plates the pulp was elevated by means of a centrifugal pump to a 3 $\frac{1}{2}$ foot Huntington Mill equipped with 80 mesh screens.

From the Huntington Mill the pulp was run to cyanide tanks, drained of excess water and then leached with cyanide solution by percolation for 36 hours.

During the time the stamps were operating samples were taken every half hour on the material going from the plates to the Huntington Mill. The results of the assays on the samples were:

Oz.per ton.	Value on Dollar.
.36	7.44
.34	7.04
.26	5.38
.35	7.24
.36	7.44
.30	6.21
.40	8.27
.36	7.44
.36	7.44
.38	7.86
.39	8.07
.47	9.73
.30	6.21

These assays showing the amalgamating to be proceeding very uniformly.

The plates required little attention and did not tend to foul in any way, the ore seemingly being very easy to amalgamate.

The tabulated result of this run is as follows:

Results of Mill Run.

Ore - 2265 pounds.

Assaying 0.87 oz. per ton or \$17.98

Stamp Battery Tails 0.46 oz. per ton or \$9.50

Cyanide Tank Tails 0.075 oz. per ton or \$1.55

Per cent of total gold recovered by amalgamation 47.17

Per cent of total gold recovered by cyanidation 44.21

Per cent of total gold recovered 91.38

From the above data the following flow sheet is recommended for a 20 stamp mill treating approximately 100 tons of ore per day and a rough design of a mill is indicated in Plates I and II.

FLOW SHEET AT MILL

Mine Cars

Grizzly - 2" spaces

#3 Gyratory Crusher

Mill Bins

H₂O

20 - 1000 # stamps

Go - 6" drops per minute

Plates - 340 sq.ft.

Dorr Classifier

Sands

Overflow

8'x 30" Hardinge Mill

K C N Tanks
strong

Plates - 165 sq. ft.

Cyanide Tanks

Solution

Sands

Zinc Boxes

Sluice to waste

ppt. sol.

melted and cast

barren sol.
tank

mint

The following is a list of machinery needed for
the above:

- 1 - grizzly
 - 1 - #3 gyratory crusher
 - 1 - conveyor, 17' center to center
 - 1 - conveyor, 31' - center to center
 - 4 - bin grates
 - 4 - challenge feeders
 - 1 - 20 stamp battery complete
 - 4 - 5' x 17' - silver plated amalgamating plates
 - 1 - Dorr classifier
 - 1 - 8'x 30" Hardinge Mill.
 - 1 - 11'x 15' silver plated amalgamating plate
 - 2 - Redwood tanks, 20' diameter, 10' deep
 - 4 - Redwood tanks, 25' diameter, 15' deep
 - 1 - Redwood tank, 20' diameter, 15' deep
- Squirrel Cage Motors - 1800 R.P.M. - 3 phase - 60 cycle A.C.
- | | | |
|----------------------------|-----|------------|
| 2 - 25 H.P. at the rate of | 295 | \$590 |
| 1 - 20 H.P. at the rate of | 230 | 230 |
| 1 - 15 H.P. at the rate of | 200 | 200 |
| 5 - 10 H.P. at the rate of | 155 | 775 |
| 5 - 5 H.P. at the rate of | 72 | <u>360</u> |
| | | \$2155 |

Piping and launders as necessary.

A rough estimate of the cost of this mill erected

and all machinery in place is as follows:

Excavation and concrete	\$8,300
Structural Steel	3,600
Roof, Floors, and Siding	4,180
Machinery	<u>34,000</u>
Total	\$50,000

Power to be purchased of Dakota Power Company.

AMALGAMATION TEST #I

South Dakota State School of Mines

METALLURGICAL LABORATORY

Record of Free Milling Test

Ore Sample	30. mesh	Received	191..
	0.43	{ oz. gold at \$ 20.67 = \$ 8.88 ... oz. silver at \$..... = \$..... Total \$ 8.88 .	
Assay of Ore per Ton (2000 lbs.) .			
.	5	A. T. Ore Amalgamated Using	0.25 A. T. Mercury
Gold in	5	A. T. as per Assay	2.15 gms
Gold Recovered from Amalgam			0.72 gms
Gold Found in Tailings			1.37 gms
Gold Found in Concentrate			0.08 gms
Weight of Tailings			143.1 gms
Weight of Concentrates			0.935 gms
Weight of Ore to Produce One Ton Concentrates			155.9 tons
Extraction by Amalgamation			33.4 per cent.
Value of concentrates		per ton 2.49 oz. or	51.46
Value of tails		per ton 0.28 oz. or	5.78
Dated			191..

Metallurgist

AMALGAMATION TEST #2

South Dakota State School of Mines

METALLURGICAL LABORATORY

Record of Free Milling Test

Ore Sample **80 mesh** Received. 191..

0.43 { oz. gold at \$**20.67** = \$ **8.88** .

Assay of Ore per Ton (2000 lbs.) . { oz. silver at \$..... = \$.....

Total \$ **8.88** .

.....**5**... A. T. Ore Amalgamated Using.. **0.25**..... A. T. Mercury

Gold in**5**.... A. T. as per Assay **2.15** gms

Gold Recovered from Amalgam..... **1.10** gms

Gold Found in Tailings..... **1.02** gms

Gold Found in Concentrate **0.06** gms

Weight of Tailings **136.0** gms

Weight of Concentrates..... **2.2925** gms

Weight of Ore to Produce One Ton Concentrates **63.6** tons

Extraction by Amalgamation..... **47.4** per cent.

Value of concentrates per ton 0.76 oz. 15.70

Value of tails per ton 0.22 oz. 4.54

Dated..... 191..

.....
Metallurgist

CYANIDE TEST #1.

Preliminary Sample

0.43 oz. per ton \$8.88
30 mesh
ore - 100 gms
Solution - 100 cc KCN 2.5# per ton
Lime - 2# per ton
Agitation - 15 hrs.

After Agitation

Solution 2.30# KCN per ton
Consumption 0.2 per ton
Alkalinity - 12 points
Assay of tailings - 0.17 oz. - \$3.51
Extraction 60.4%

CYANIDE TEST #2.

Preliminary Sample

0.43 oz. per ton \$8.88
50 mesh
Ore - 100 gms
Solution - 100 cc KCN 2.5# per ton
Lime - 2# per ton
Agitation - 15 hours.

After Agitation

Solution 2.24# KCN per ton
Consumption 0.26 per ton
Alkalinity - 16 points
Assay of tailings 0.08 oz. - \$1.56
Extraction 81.4%

CYANIDE TEST #3

Preliminary Sample

0.43 oz. per ton \$8.88
80 mesh
Ore - 100 gms
Solution - 100 cc KCN 2.5# per ton
Lime - 2# per ton
Agitation - 15 hrs.

After Agitation

Solution 2.38# KCN per ton
Consumption 0.12# KCN
Alkalinity - 12 points
Assay of tailings - 0.07 - \$1.44
Extraction 83.7%

CYANIDE TEST #4

Preliminary Sample

0.43 oz. per ton \$8.88

100 mesh

Ore - 100 gms.

Solution - 100 cc KCN 2.5# per ton

Lime - 2# per ton

Agitation - 15 hours

After Agitation

Solution 1.66# KCN per ton

Consumption - 0.84# KCN

Alkalinity - 10 points

Assay of Tailings - 0.075 oz. - \$1.54

Extraction 82.5%

CYANIDE TEST #5

Preliminary Sample

0.43 oz. per ton \$8.88

80 mesh

Ore - 100 gms.

Solution - 100 cc KCN 2.5# per ton

Lime - 2# per ton

Agitation - 25 hours

After Agitation

Solution 2.1# KCN per ton

Consumption - 0.4# KCN

Alkalinity - 20 points

Assay of tailings - 0.06 oz. - \$1.24

Extraction 86.03%

CYANIDE TEST #6

Preliminary Sample

0.43 oz. per ton \$8.88

80 mesh

Ore - 100 gms

Solution - 100 cc KCN 2.5# per ton

Lime - 2# per ton

Agitation - 30 hours.

After Agitation

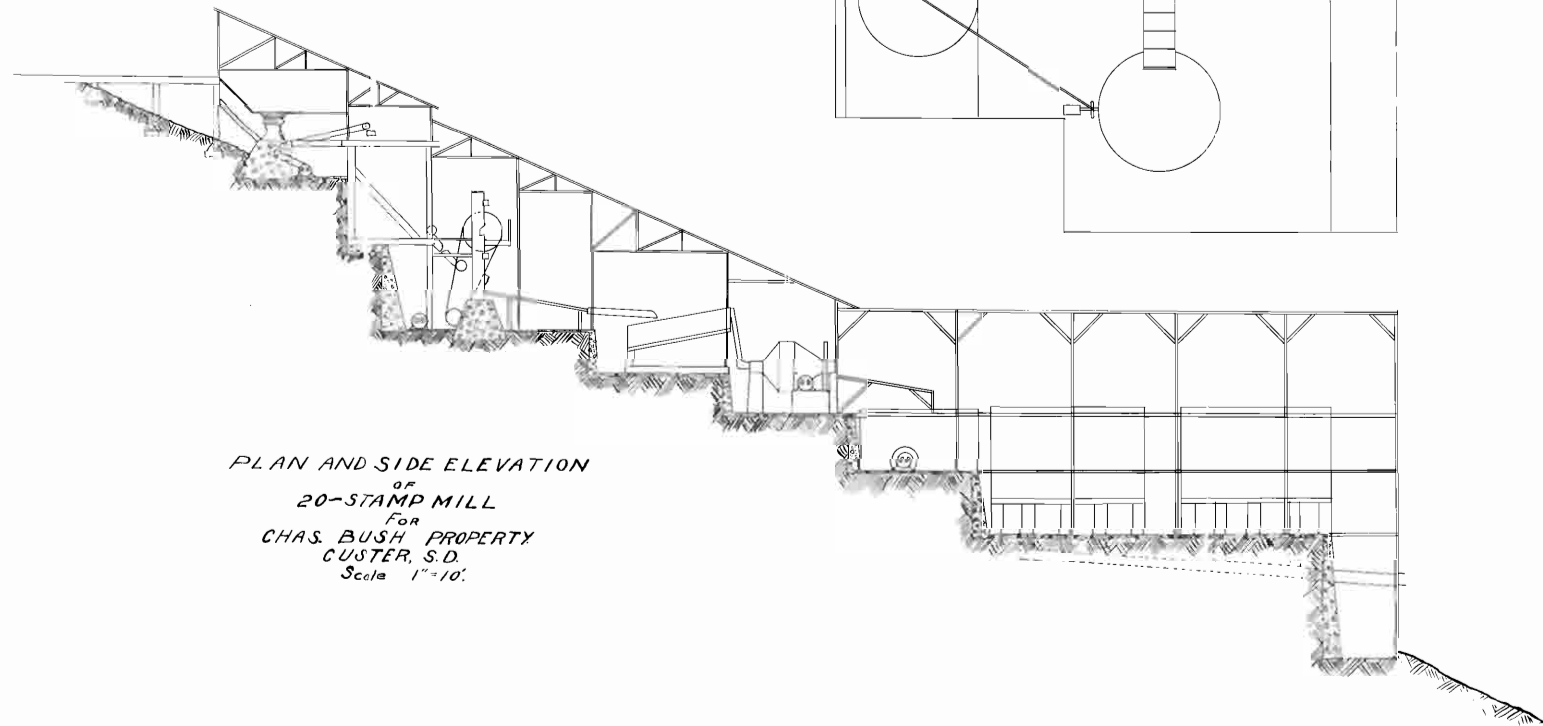
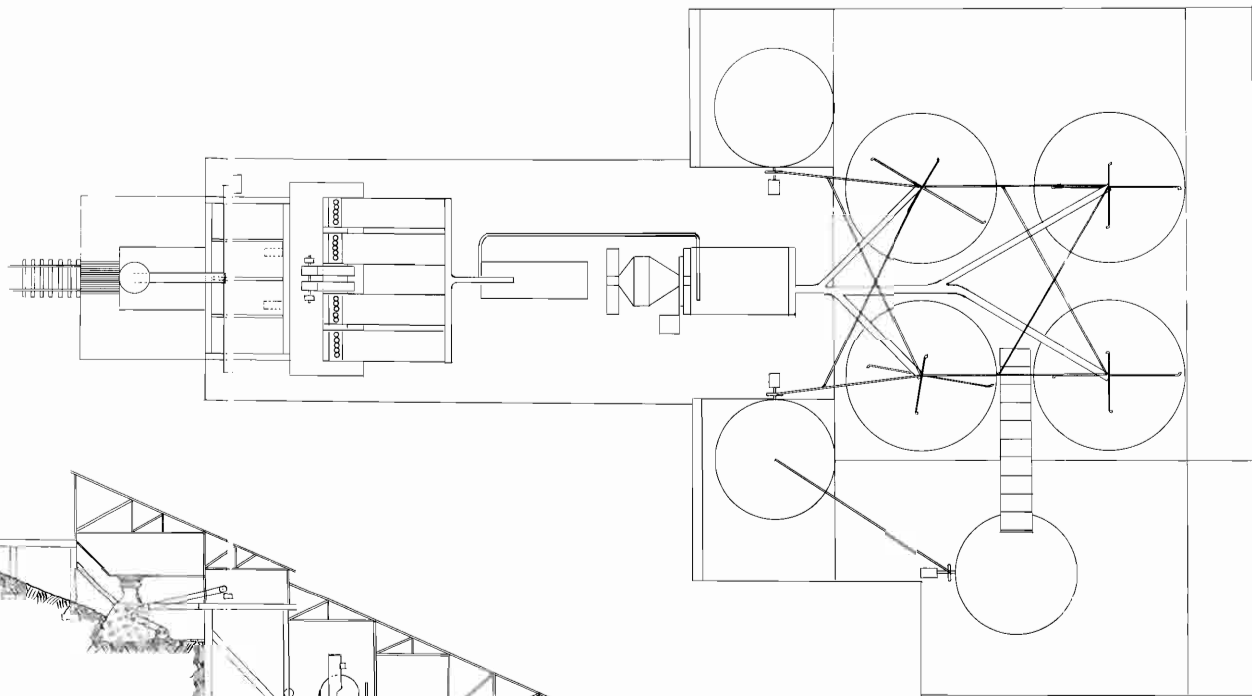
Solution - 2.04# KCN per ton

Consumption - 0.46# KCN

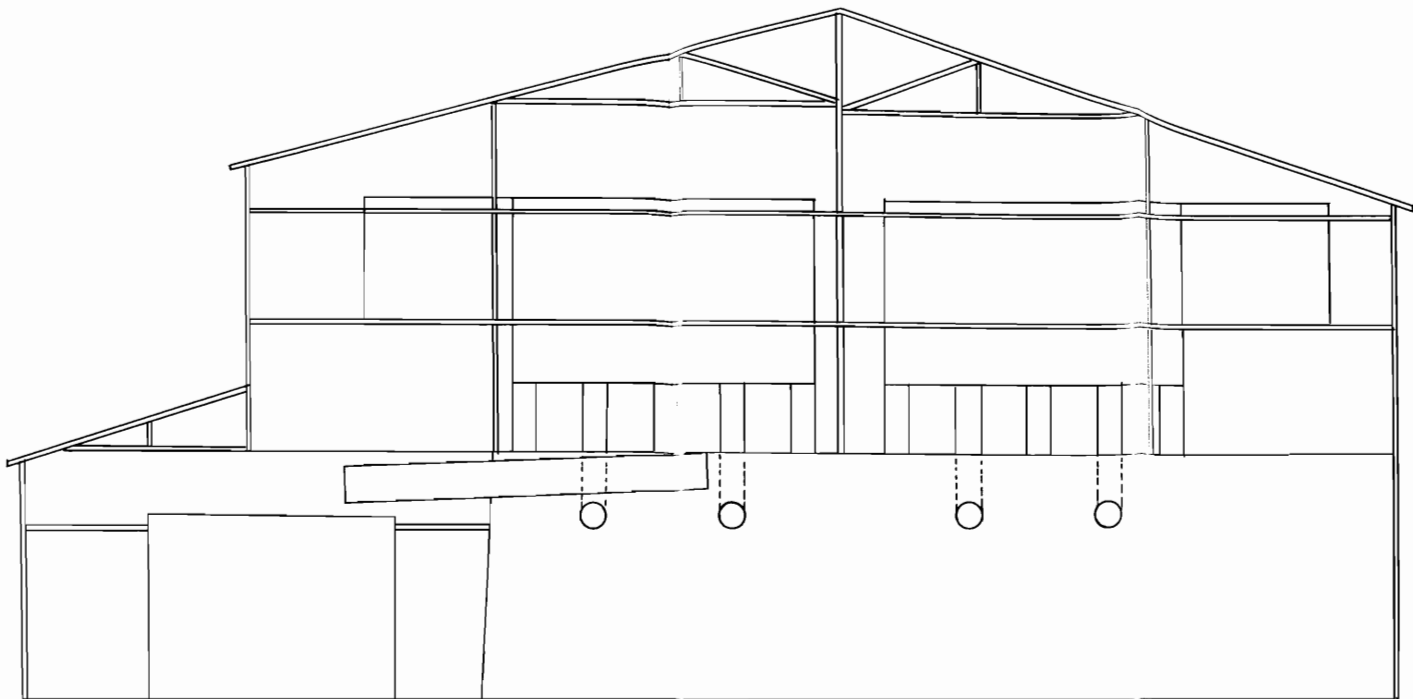
Alkalinity - 10 points

Assay of tailing - 0.07 oz. - \$1.44

Extraction 83.7%



PLAN AND SIDE ELEVATION
OF
20-STAMP MILL
FOR
CHAS. BUSH PROPERTY
CUSTER, S. D.
Scale 1"=10'.



END ELEVATION
OF
20-STAMP MILL
FOR
CHAS. BUSH PROPERTY
CUSTER, S. D.
Scale 1"=10'