Oroya Stack Losses and Smoke Damage

22

August 29, 1928

Dracco Bag House

Cerro de Pasco Copper Corp.,

Lima

Gentlemen:

We are sending you herewith, for your information, copy of Mr. Spilsbury's letter of August 17 on the above subject, together with letter of July 9 from the Dust Recovery & Conveying Company addressed to Mr. A.B. Young.

Yours truly,

EJF/K
Enc.

Cc:Mr.Addicks
Mr.Hamilton

C
O
P
Y

Hotel Utica
Salt Lake City
August 17, 1928

Dear Mr. Drew:

Enclosed is information regarding the Dracco bag house system. It seems to me that this system is well worth investigating. The U.S.Metals could give us some data on the Carteret installation. I understand that the unit at East Chicago Refinery of the International Lead Co. is working satisfactorily on lead carbonate.

Mr. Young sent for this information and thought that it might be of some value to us.

Sincerely,

Ray

THE DUST RECOVERING & CONVEYING CO.
ENGINEERS AND MANUFACTURERS
HARVARD AVENUE & EAST 116TH STREET
DRACCO
CLEVELAND
CABLE ADDRESS
DRACCO-CLEVELAND

July 9, 1928

Mr. A. B. Young, Ass't. Mgr.,
Anaconda Copper Mining Company,
Kearns Bldg.,
Salt Lake City, Utah.

Dear Sir:

Our Mr. C.W. Traughber has just returned from the trip on which he visited you at Salt Lake City and the writer notes with great pleasure and appreciation the kind consideration and courtesies shown him and we hope that we may be able to reciprocate.

Mr. Traughber, our engineers, and the writer have very carefully gone over the proposition which was discussed between you in regard to fume recovery for the proposition in South America.

Several unusual angles have been taken fully into consideration by us after we tried fully to understand the exact problem which has to be solved. It should first be noted that we have, in the past, put one item before anything else, namely, the filtration efficiency and we have, in the past, selected our cloth and our volumes of gases per square foot of filter surface with the view of getting practically 100% collecting efficiency. It is fully noticed that on the South America proposition, there is no reason for this particular high efficiency, first, because the product is of no special value, and second, because it is mainly only a nuisance which has to be taken care of.

It is apparent that drawing a certain volume of gas through a clean baghouse can as readily be done in one form of baghouse as in another and the advantage in this direction of the "Dracco" system is that it can always stays clean and that the total cleaning on a job like the one in question, according to our estimate, will consist of possibly four seconds every hour, or in other words, the total cleaning period for the entire house irrespective of size, would actually be only one minute out of twenty-four hours. To make this entirely clear, let us figure that you will need 150 filter compartments erected as shown on one of the attached blueprints. Each of these filter compartments will be shaking for about four seconds every hour, one at a time and in rotation. This, of course, means that practically your entire house is on the line at all times as on account of cleaning, only one filter compartment is out of line out of 150 and this only for four seconds. Therefore, you need no extra baghouse lying idle for cleaning and the same conditions practically prevail in regard to repairs because if a filter bag has to be replaced, the one filter compartment is simply cut off the main line by closing the outlet

THE DUST RECOVERING & CONVEYING CO.

damper, the doors of said filter compartment are opened, the hook of the bag is pulled out of a hole in the top and a fastening clamp loosened at the bottom, the bag is removed and another bag replaced, an operation which only takes a few minutes.

The general construction and description of this is shown in bulletin No. 2, which, with other bulletins, are being forwarded to you today under separate cover.

The mental picture of the baghouse, as far as the labor and attention is concerned, we believe, will be clear when you look at the photograph on the front page of bulletin No. 14, which is part of a unit which collects 12-1/2 tons of zinc oxide per day for the U.S. Metals Refining Company at Carteret, N.J. The actual attention for your entire house should not require more than one man. This man will be a reliable intelligent man who will handle the job on the same plane as an oiler in an engine room and you will be relieved of the ordinary scrub labor which otherwise are the only ones that can be employed for the ordinary baghouse work. There is no cleaning inside of the baghouse as the bags are reached through manholes without having to reach farther in than 3/4 an arms length.

In regard to repairs, there are practically no mechanical repairs on our filters with the exception of the changing of a spring once in a great while, which spring changing only means shutting the outlet damper, taking off a washer, replacing spring and putting on the washer and the operation, which on the outside, will not take over 5 or 6 minutes. This is because our springs in our shaking cylinders are on the top as shown on attached print instead of on the bottom as shown in bulletin No. 2, and is an improvement which was made universal 6 months ago.

In regard to bag material, you would, as writer proposes to analyze this individually, for 650,000 cubic feet of gas per minute, use 144 filter compartments, each with a filter surface of 300 square feet, or you would have a total of 45,000 square feet of filter material against a somewhat larger amount in an ordinary baghouse where provisions have to be made for the idle part which is under cleaning. This will give you the same filter surface in actual operation per cubic foot of gas as you would have in the ordinary house.

It should be noted that on account of the fact that our filter cloth can be kept clean completely, or in part, to any degree wanted, by the easy regulation of the shaking periods, that it most likely will prove, after trying out a pilot plant, that you will most likely find one or two things, namely, that denser cloth can be used than your standard cloth for the same volume of gas or that we can pull through more gas per square foot of filter surface than you can pull through the average house.

As the desired cleaning efficiency on this job depends on the demands made by authorities on the outside, it would be desirable to have an easily regulated leeway when building this house. The writer will try to make this plainer although he realizes he is using considerable space for this discussion.

THE DUST RECOVERING & CONVEYING CO.

Let us assume that if you started up a house with 100 or 120 filter compartments instead of 150 and the authorities again unexpectedly should make further demands, it would be a very simple matter to add another 10, 20 or 30 filter compartments without having to go through a new lot of building construction. When the writer originally recommends 150 filter compartments, he is figuring with a very high percentage of safety in comparison with the active filter surface which you are figuring with yourself for an ordinary baghouse and he has no hesitation in claiming that we can regulate our filters so at least 50% more gas can be pulled through the same filter surface and give the same filter efficiency as the old style baghouse. It will be plain to you that on account of the periodical and quick cleaning of one filter compartment at a time, that the static, which again means the gas volume handled and the draft to your furnaces, remains constant with our equipment which it is impossible to obtain with less efficient cleaning apparatus or methods otherwise used.

Now, when going over your entire proposition, the question of cost of installation may possibly enter into this matter and the writer believes that the changing in modern demands in connection with labor conditions, health, etc., should be remembered in this connection. We realize that equipment shipped complete to South America must be considered in a little different way than we have to consider same in the States and the writer will assume that building material in one form or another, such as concrete, brick or rock of some kind, can readily be obtained. For this reason, we are suggesting to arrange the permanent installation as shown on attached print, which will eliminate the bulgy shipment of individual dust hoppers underneath each filter compartment and we are suggesting a simple foundation be built forming the usual dust chambers in an ordinary baghouse and we are suggesting a very small conveyor of some kind, a 6" screw conveyor running very slowly underneath each 2 rows of filter compartments. This screw conveyor will automatically take the dust to the outside and according to local conditions, this could be discharged into cars or into a main conveyor picking up the discharge from each of these 6 or 7 cross conveyors, which main conveyor, on account of the small estimated amount of material we handle, namely 40 tons in 24 hours, again only needs to be a very small, slow running 6" or 8" conveyor or we could also suggest the use of one of our pneumatic conveying installations to take the material from these points or pull the material directly out of the chambers and convey it automatically to the point of discharge if this is within reasonable distance.

The filter housings constitute the walls of a building and there is absolutely no need of any kind of walls around, in fact, we believe it would be a great advantage to leave them in the open and only have a few uprights which carries the light roof just to protect the shaking mechanism on top of the filter compartments. This, we have roughly outlined as shown on prints.

For your information, we would advise that even in this climate, we have, at the Ford Motor Company, which company is one of the most particular concerns we are dealing with in the country, several hundred of these units operating for various purposes, installed in the open on top of their 6 or 7 story buildings in Detroit, without any covering whatever.

THE DUST RECOVERING & CONVEYING CO.

This, however, we do not recommend as it tends to make men neglectful in keeping the machinery parts in proper shape. The Ford Motor Company have a couple of thousand of these units in operation and while we know that some of the largest smelters have had the impression that Dracco has principly been used for smaller installations, it is, of course, apparent that there is no limit to the volume of gas which can be handled as it only means that proper number of compartments be used. There is no equipment or system that can possibly be installed with so great a flexibility in regard to operation. In bulletin No. 6, you will note 180 filter compartments which have been put in the Ford Motor Company's plant at River Rouge, where the filter efficiency must be so great that the air filtered can be discharged back into the machine shops and founderies in order to preserve heat in the winter time. We are here handling about 250,000 cubic feet of air per minute and Dracco was selected on account of its reliability and flexibility and on account of the assurance of the least possible interruption to the operation of the actual equipment for which they serve.

We are enclosing a preliminary blueprint which shows the space that will be required for 144 - AAA compartments and you will also note that we have marked the space for 120.

In regard to fans, the entire unit can be connected up to one fan but for real modern consideration which allows for flexibility all the way through, you could, of course, put in a separate fan for, say, each two rows of filters. This would possibly add a comparatively small amount to the actual installation cost but at the same time, if you, for instance, only should run 8 of your plants, the proper corresponding fans and equipment could be shunted off the line and power saved. It would be impossible for you, under any conditions, to have a breakdown at any point which could be felt at your furnaces and if any additions should be needed, it would be very simple to add additional units.

In each said filter compartment will be 18 bags, 9 ft. 7 in. long, 8" diameter at the bottom and 7" diameter at the top and we figure with using woolen cloth of the standard cloth as used by the American Smelting & Refining Company in accordance with their specifications, which, we believe is the cloth which you would figure with on your ordinary baghouses.

For your estimating purpose, we now again beg to call to your attention that 120 filter compartments will more than equal the filtration efficiency that you could get with the same active filter surface in an ordinary baghouse and if this is sufficient for you, we would have to use this figure and we would roughly estimate that the complete equipment for erecting on foundation as shown on drawing without outlet manifolds to individual fans or to main trunk line to fan and otherwise complete with filter bags, automaticpneumatic filter cleaning mechanism, motor driven timers with automatic adjustment on timers so filter shaking can be adjusted to take place as often as every three minutes or as seldom as every two hours, will cost approximately $800.00 for each filter compartment, f.a.s. Atlantic Ports, crated for export shipment. In other words, the entire baghouse, short of what practically amounts to an ordinary light foundation and not including the main flues which you, of course, would build locally anyway, would be approximately $100,000.00 f.a.s. Atlantic Ports. The weight will be approximately 250,000 pounds.

If you desire to be extra safe as far as the local authorities are concerned, 150 filter compartments would, at the same rate, cost you approximatsely $120,000.00 f.a.s. New York.

We believe this gives you sufficient information for your preliminary figures and we shall consider it a great favor if you will express yourself in regard to this matter so we will get sufficient time to discuss all details and take locality and everything else into consideration and also, in this way, give us sufficient time to execute and give delivery.

RECOMMENDATIONS FOR GENERAL PROCEEDINGS.

We would now suggest that your client order a 12 compartment AAA Perfecto filter, dimension print of which is given, said filters to be complete with filter bags, automatic pneumatic filter shaking mechanism, timing equipment, inlet and outlet manifold, dust hoppers and fan, all as shown in general outlines on front page of bulletin No. 100 with exception that no screw conveyor underneath hoppers would be needed on this pilot plant, and have this filter connected up to your present flue pulling about 50,000 to 55,000 cubic feet of gas per minute through said filter with cloth as outlined above and make determination in regard to collecting efficiency. We would suggest that for the making of these determinations, that an extra set of filter bags of a closer weave be kept on hand and we would then be prepared to let our Mr. Traughber go to South America to supervise the entire performance and be of whatever other assistance he could be there. It would, however, be understood that Mr. Traughber would not be sent for before the equipment was in sight so no time would be lost after his arrival in getting this matter cleaned up. It should be understood that Mr. Traughber would be immediately released so that he again could be returned here as it will be a handicap to us to send one of ouf metallurgical field men away for this length of time. It would further be agreed that he again would be available to install the larger plant if we are given the order for same.

It should here be noted that the 12 filter compartments, of course, can be used as part of the finished complete installation and we beg herewith to quote you on:

One (1) 12 compartment Perfecto Filter installation complete with dust hoppers, filter bags, automatic, pneumatic, filter cleaning mechanism and timer for same, each filter compartment having 18 filter bags 9 ft. 7 in. long, 8 in. diameter at the bottom and 7 in. diameter at the top.

Also, channel iron supports for same which are ready to be placed direct on a small foundation of most any kind.

The filter cloth furnished in said filter compartments ~~are~~ to be of the standard comparatively open woolen cloth as used by the American Smelting & Refining Co., but with our quotation, we are including one set of 216 extra woolen bags of a closer weave.

THE DUST RECOVERING & CONVEYING CO.

Price for all of same.

Ten Thousand, Seven Hundred Fifty Dollars ($10,750.00)
f.a.s. Atlantic Port, crated for export shipment.

It is understood that our metallurgical engineer, Mr. C.W. Traughber shall be made available to supervise this installation and be of whatever other assistance he can supervising the starting and adjustment of this operation, he, however, not to be kept more than 2 months on the job and not to be sent for before equipment is ready for operation. For Mr. Traughber, the charges willbe his cost to us, namely, $500.00 per month and expenses.

We trust we have suggested a base from which to approach this problem and that same is agreeable to you and we shall be pleased indeed to be favored with your business and shall do everything in our power to get this problem solved to your entire satisfaction.

Very truly yours,

THE DUST RECOVERING & CONVEYING COMPANY.

President.

FLJ:K

P.S. You would require a fan as outlined above, which fan we have not figured with as you may have one on hand, otherwise, we shall be pleased to quote on same and select the proper fan to be included in our shipment when you are ready to act.

P.S. By running the pilot plant, the gas volume which can be handled through each filter compartment with the various types of cloth could, on this pilot plant, be firmly established and the local authorities' acceptance of efficiency obtained which would enable them then to fully determine the smallest number of filter compartments that would be required to fill these local authorities' demands and the final plant worked out accordingly. It might even pay for the pilot plant to have even one set of filter bags made of our special fine woven cloth for high efficiency work and have this tested out too. The writer expects that on account of the small dust content per cubic foot of gas contained, when this is compared with the ordinary conditions, may lower the total amount of filter compartments required finally and it is perfectly clear that this pilot plant will be the easiest and quickest and safest means that can be obtained to secure this information

THE DUST RECOVERING & CONVEYING CO.

and get the local authorities' acceptance, which latter, already at the stage of performance, may be of the most far reaching consequences in connection with the entire future of this proposition.

6

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copy to N. York
+ adv.

FIRST CARBON
WITH ORIGINAL
MAILED S/S ACONCAGUA
AUG 29

La Oroya
August 20, 1928

Roaster Cottrell - Tests 12 and 13

CERRO DE PASCO ... NEW YORK
RECEIVED
SEP 10

Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sirs:

Attached hereto you will please find copy of Mr. Colley's letter to me of August 20th transmitting Tests Nos. 12 and 13 with the experimental roaster Cottrell.

By the final paragraph of Mr. Colley's letter you will note that the experimental Cottrell is now running at a velocity of from 4 to 5 feet per second in the hope that by using a slower speed than in the tests sent herewith a better mechanical separation will be made of the copper and arsenic.

As soon as these tests have been completed results will be mailed.

Yours truly,

Original signed by
Harold Kingsmill,
General Manager.

encls.

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La Oroya,
August 20, 1928.

Mr. Harold Kingsmill,
General Manager,
Lima.

Dear Sir:

Experimental Roaster Cottrell

You will remember that tests No. 7 and 8 made with the experimental Roaster Cottrell were run without power on the Cottrell precipitations and resulted in the recovery of 83.7% and 84.8% of the solids. The remarkable feature of this test was that most of the valuable fume was recovered while the arsenic escaped.

To test out this result more thoroughly, an experimental brick dust chamber 42 ft. by 8 ft. 6 in. was constructed ahead of the Cottrell treater, the idea being that the values would be recovered in the dust chamber while the arsenic free from values would be caught in the Cottrell. There would thus be obtained a cheap method of separating the arsenic which would be thrown away without incurring the cost of resubliming it in arsenic kitchens, etc.

There are now attached the first two tests, Nos. 12 and 13, made with this apparatus and with the above explained object in view. Both tests were made under as nearly identical conditions as possible, so as to have the second test check the results of the first.

The results are satisfactory as regards total recovery but the separation of the values has not been definite enough, that is to say some of the mechanically carried dust containing copper and silver has been pulled through the dust chamber and over into the Cottrell section and thus mixed with the arsenic. This has been entirely due to the speed of the gas which was over 8 ft. per second in both experiments.

It is hoped that by slowing the speed of the gas to 4 or 5 ft. per second and perhaps less a well defined separation could be made between valuable dust and valueless arsenic fume and the experimental plant is now running on a test with slower gas speed in an effort to attain this result.

Yours very truly,

Sgd. B. T. Colley.

EXPERIMENTAL ROASTER COTTRELL

Test No. 12

Object: To determine the recovery with a 42 ft. dust settling chamber ahead of the treater, and with power on each of the four treaters.

Test started 1:20 P.M. July 14th.
Test stopped 8:00 A.M. July 23rd.
Actual operating time 163 hours.

Operating Data:	SHort Tons
Solids aspirated from sampling stack by the experiment department	0.219
Dust recovered from treaters	13.287
Total feed to treaters	13.506
Recovery	98.4%

Temperature:	
Down comer from roaster flue	170° C.
Settling chamber average	140° C.
Inlet to treaters	133° C.
Outlet from treaters	116° C.
Treater average	124° C.
In sampling stack	82° C.

Volume:	Cu.ft. per min.
Inlet pipe to settler at sampling station at 170° C.	23,460
Outlet at sampling station in stack at 82° C.	25,440

Velocity:	Ft. per sec
Inlet pipe to settler at 170° C.	55.3
Outlet at sampling station in stack at 82° C.	43.4
Velocity in treater at average temperature of 124°C.	9.7
Velocity in settler at average temperature of 140°C.	8.6

Power:			
Kilovolts range	41 - 47	Average	45
Milliamps range	135 -145	"	143
Amperes	39 - 48	"	43

Dust per cu. ft. of gas:	
Inlet	.053
Outlet	.0008

Dust recovered from hoppers:

Hopper No.		Lbs.	%	Total Dust in Smoke %	Total Dust to Treater %
1	Settling chamber	2,604	9.9)		
2	" "	3,055	11.4)	27.2	-
3	" "	1,564	5.9)		
4	Treater No. 1	7,026	26.4)	45.0	61.7
5	" 1	4,916	18.6)		
6	Treater No. 2	2,658	10.0)	17.3	23.8
7	" 2	1,947	7.3)		
8	Treater No. 3	1,041	3.9)	7.4	10.2
9	" 3	931	3.5)		
10	Treater No. 4	564	2.1)	3.1	4.3
11	" 4	269	1.0)		
Total		26,575			

Analyses:

	Cu.	Ag.	Pb.	As.
Hopper No. 1	6.38	11.9	3.1	6.3
2	6.26	12.0	2.9	6.3
3	5.98	11.3	3.3	6.8
4	4.55	10.3	4.2	11.4
5	3.26	7.6	5.0	14.7
6	2.73	5.5	5.3	17.7
7	1.51	5.0	6.3	18.2
8	1.35	4.8	5.1	20.9
9	0.52	3.8	7.1	22.8
10	0.40	3.3	7.3	22.6
11	0.20	3.2	6.7	18.4
Fam house cleanings	0.20	1.8	3.5	15.2

Oroya, Peru,
July 25, 1928.

W. E. King.-

9

EXPERIMENTAL ROASTER COTTRELL

Test No. 13

Object: To check Test No. 12

Test started 1:00 P.M. July 25th.
Test Stopped ':00 A.M. July 31st.
Total operating time 105 hours.

Operating data:	Short Tons
Solids aspirated from sampling stack by the experimental department	0.246
Dust recovered from treaters	7.213
Total feed to treaters	7.459
Recovery	96.7%

Temperature:

Down comer from roaster flue	168° C.
Settling chamber average	137° C.
Inlet to treaters	128° C.
Outlet from treaters	105° C.
Treater average	116° C.
in Sampling stack	73° C.

Volume:	Cu. Ft. per min
Inlet pipe to settler at sampling statation at 168° C.	22,620
Outlet at sampling station in stack at 73° C.	22,140

Velocity:	Ft. per sec
Inlet pipe to settler at 168° C.	53.3
Outlet at sampling station in stack at 73° C.	37.8
Velocity in treater at average temperature of 116° C.	8.5
Velocity in settler at average temperature of 137° C.	8.2

Power:

Kilovolts range	41 - 47	Average	44
Milliamps range	122 - 150	"	141
Amperes	38 - 45	"	41

Dust per cu. ft. of gas:

Inlet	.048
Outlet	.0016

Dust recovered from hoppers:

Hopper No.		Lbs	%	Total Dust in smoke %	Total Dust to Treater %
1	Settling chamber	1,555	10.8)		
2	" "	1,839	12.7)	28.7	-
3	" "	752	5.2)		
4	Treater No. 1	4,094	28.5)	46.2	64.5
5	" 1	2,553	17.7		
6	Treater No. 2	1,226	8.5)	15.2	21.3
7	" 2	969	6.7)		
8	Treater No. 3	501	3.4)	6.9	10.0
9	" 3	503	3.5)		
10	Treater No. 4	287	2.0)	3.0	4.2
11	" 4	148	1.0)		
Total		14,427			

Analyses:

	Cu.	Ag.	Pb.	As.
Hopper No. 1	5.92	12.4	3.5	7.79
2	5.52	10.6	3.1	7.52
3	5.60	11.7	3.4	7.73
4	4.16	9.6	4.6	11.55
5	2.90	7.7	5.4	14.76
6	2.35	6.2	5.3	16.50
7	1.10	3.7	8.8	22.26
8	0.67	3.1	7.2	23.39
9	0.31	2.4	9.1	25.55
10	0.20	3.4	9.6	26.05
11	0.08	2.9	8.2	22.14

W. E. King.-

Oroya, Peru,
August 3, 1928.

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5

FIRST CARBON
WITH ORIGINAL
MAILED S/S ACONCAGUA
AUG 29

La Oroya
August 20, 1928

Roaster Cottrell

CERRO DE PASCO COPPER CORP. NEW YORK
RECEIVED
SEP 10

Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sirs:

Attached hereto you will please find copy of Mr. Colley's letter to me of 13th August on an experiment on the volatilization of arsenic from the dust caught by the experimental Cottrell from the roaster gases.

Yours truly,

Original signed by
Harold Kingsmill,
General Manager.

encl.

1

Copy

La Oroya,
August 13, 1928

Mr. Harold Kingsmill,
General Manager,
Lima.

Dear Sir:

Attached please find the tabulated results of an experiment which had for its object the volatilization of arsenic from the dust caught by the experimental Cottrell from roaster gases. You will note that by this method it is possible to eliminate from 51.0% to 74.2% of the arsenic.

In view of the fact that this operation calls for reverberatory smelting and that there would seem to be a better method for the separation of arsenic, consisting of attaching a dust chamber or hot Cottrell ahead of the Cottrell designed for arsenic recovery, this reverberatory smelting method can be set aside for the present.

Yours very truly,

(Signed) B. T. Colley

Y

Copy

Oroya, Peru,
August 6, 1928

Mr. R. Spilsbury,
Superintendent,
Oroya.

Arsenic Elimination - Roaster Stack Dust

Dear Sir:

Experiments on the above subject were made in the experimental furnace at the Cottrell plant after the furnace had been converted into a single hearth roaster.

The operation of the roaster is as follows: Dust and reagent (coal and pyrite) are charged through the roof on to the hearth, stirred with suitable rabbles and raked down the hearth to the end of the furnace opposite the fire, where the roasted product is discharged, weighed and sampled. Six charges per shift were roasted and discharged.

The addition of coal and pyrite to the dust charge was beneficial, besides producing heat and taking some work off the oil burner during the early stages of the roasting it kept the bed of dust on the hearth in a more or less reduced condition and so increased the elimination of the arsenic.

The attached tables show the results in detail. The different periods correspond to the various proportions of coal and pyrite used.

The process may be summarized briefly as follows:

Feb.	8-14	Dust alone roasted	Arsenic eliminated	32.2%
"	15-17	Dust and 10% coal	"	60.6%
"	18-20	Dust and 5% coal	"	70.0%
"	21-22	Dust and 2-1/2% coal	"	51.0%
"	23	Dust and 10% pyrite	"	55.8%
"	24	Dust and 15% pyrite	"	67.6%
"	25	Dust and 20% pyrite	"	74.2%

Table No. 1 gives complete assays of dust, reagents and product.
Table No. 2 shows the amount of metals volatilized during the roasting.

Table I

Assays of Dust and Reagents

	SiO2	Al2O3	Fe	CaO	S	Zn	Pb	Cu	Ag	As	Sb	Bi
Roaster Stack Dust	15.3	3.6	14.3	1.4	10.6	1.1	2.15	6.43	9.4	7.9	3.7	.35
Roasted Product	22.8	5.5	21.6	4.0	1.4	1.2	2.95	8.44	13.9	5.8	2.8	.47
Pyrite	27.7	1.0	26.3	0.3	27.3	0.6	5.11	.46	4.6	.18	.25	.09

	Vol.	F.C.	Ash
Tinyahuarco Coal	32.1	40.4	27.5

TABLE II

Metals Volatilized during
- Roasting -

	Wt. Lbs.	% Cu	Lbs. Cu	Ag	Oz. Ag.	% Pb	Lbs. Pb	% As	Lbs. As	% Sb	Lbs. Sb
Dust	44704	6.43	287	9.4	210	2.15	96	7.9	353	3.7	165
Pyrite	919	.46	4	4.6	2	5.11	47	.18	2	.25	2
			291		212		143		355		167
Product	31466	8.44	266	13.9	219	2.95	93	5.8	183	2.8	88
Volatilized		8%			+ 3%		25%		48%		47%

It will be noted that the silver value of the roasted product is higher than the total silver in the charge. This may be accounted for by the fact that the furnace had been previously used for partial reduction experiments on Cottrell dust or to errors in sampling.

Other Data:		
	Hearth dimensions 3' X 12'	36 sq. ft. area
	Temperature range	750° - 920° C.
	Total dust roasted	22.352 short tons
	Oil used	11.820 short tons
	Total As in charge	4,757 lbs.
	Total As in product	2,530 lbs.
	Elimination	47.2%

- Dust Roasted Alone -

Date	Charge Lbs.	% As	Lbs. As in Charge	Product Lbs.	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 8	2268	10.14	230	962	4.39	42	188	81.7
Feb. 9	2142	9.80	210	1424	8.10	115	95	45.2
Feb. 10	2772	10.00	277	2016	9.61	194	83	30.0
Feb. 11	3276	9.71	318	2268	9.53	216	102	32.1
Feb. 12	3150	10.23	322	2368	9.97	236	86	26.7
Feb. 13	3024	8.25	249	2142	7.53	161	88	35.3
Feb. 14	2772	9.72	269	2016	9.58	193	76	28.3
Totals	17136		1645	12234		1115	530	
Average % elimination of arsenic								32.2

On Feb. 8th the dust was roasted at too high a temperature and a fused product resulted.

Dust Roasted with 10% Coal

Date	Charge Lbs.	% As	Lbs. As in Charge	Coal Lbs.	% Ash	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 15	2268	10.37	235	227	29.9	19.8	1512	6.15	93	142	60.4
" 16	2394	9.94	238	239	29.1	19.9	1890	5.79	109	129	54.2
" 17	2368	10.48	248	236	29.0	19.5	1764	4.68	82	166	67.0
Totals	7030		721				5166		284	437	
Average % elimination of arsenic											60.6

Dust Roasted with 5% Coal

Date	Charge Lbs.	% As	Lbs. As in Charge	Coal Lbs.	% Ash	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 18	2394	9.90	237	54	30.1	20.0	1512	6.12	92	145	61.2
" 19	2520	12.90	325	57	30.4	19.8	1638	5.40	88	237	72.9
" 20	2394	13.10	314	54	30.8	20.5	1638	5.05	83	231	73.6
Totals	7308		876				4788		263	613	
Average % elimination of arsenic											70.0

Dust Roasted with 2-1/2% Coal

Date	Charge Lbs.	% As	Lbs. As in Charge	Coal Lbs.	% Ash	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 21	2394	12.60	302	27	30.0	19.0	1638	6.48	106	196	65.0
" 22	2394	10.75	257	27	30.0	19.8	2142	7.85	168	89	34.6
Totals	4788		559				3780		274	285	
Average % elimination of arsenic											51.0

Dust Roasted with 10% Pyrite

Date	Charge Lbs.	% As	Lbs. As in Charge	Pyrite Lbs.	% As	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 23	2142	11.60	249	214	.61	6.0	1512	7.25	110	139	55.8

Dust Roasted with 15% Pyrite

Date	Charge Lbs.	% As	Lbs. As in Charge	Pyrite Lbs.	% As	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 24	2016	11.90	241	302	.36	6.0	1512	5.15	78	163	67.6

Dust Roasted with 20% Pyrite

Date	Charge Lbs.	% As	Lbs. As in Charge	Pyrite Lbs.	% As	% H2O	Lbs. Product	% As	Lbs. As in Product	As Elimination Lbs.	As Elimination %
Feb. 25	2016	11.62	236	403	.43	6.0	1512	4.03	61	175	74.2

Yours very truly,

(Signed) W. E. King

La Croya
August 21, 1928

FIRST CARBON
WITH ORIGINAL
MAILED S/S ACONCAGUA
AUG 29

Experimental Roaster Cottrell

Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sirs:

Attached hereto please find self-explanatory letter from Mr. Colley regarding the tests recently made on the Roaster Cottrell, together with data mentioned therein.

Yours truly,

Original signed by
Harold Kingsmill,

General Manager.

CONTENTS NOTED
13 1928
LAWRENCE ADDICKS

3✓

Copy

Oroya, Peru,
August 13, 1928

CERRO DE PASCO COPPER CORP. NEW YORK
RECEIVED
SEP 10

Mr. Harold Kingsmill,
General Manager,
Oroya.

Experimental Roaster Cottrell

Dear Sir:

While Mr. King and the Cottrell organization made the tests on the roaster smoke through the experimental roaster Cottrell plant Mr. Winn and the organization of the experimental department made the velocity determinations and measured the quantity of fume escaping from the stack after the gases had passed through the experimental Cottrell plant.

There are now attached data gathered by Mr. Winn which have been used by Mr. King in his various reports.

Yours very truly,

S/ B. T. Colley.

EXPERIMENTAL PILOT ROASTER COTTRELL

Experimental Dept. Sampling Data

Two sampling stations were used in the series of tests made on the Experimental Cottrell. One station, at which only velocity readings were made, was located on the inlet flue. The other station, where both velocity and dust losses were determined, was placed on the outlet stack as shown on drawing No. 5289

The first four tests are not included in this summary, due to operating troubles, etc. The remaining tests are divided into three groups, as follows :-

1.- Tests 5 & 6. Power on all treaters.

2.- Tests 7 & 8. No power used. Considered as settling chamber only.

3.- Tests 9, 10 & 11. First half used as settling chamber. Power on last two treaters.

Following are the assays of the dust lost from the sampling stack, corresponding to the above three conditions.

	SiO_2	Fe	CaO	S	Zn	Pb	Cu	Ag ozs	As	Sb	Bi
1	0.8	18.8	0.2	12.0	3.4	8.4	0.20	Tr	8.8	1.56	-
2	2.4	8.1	0.4	14.7	0.3	3.5	1.11	2.4	22.8	2.23	0.39
3	0.4	25.3	0.4	13.0	3.0	1.2	0.28	2.4	11.0	1.02	0.23

OPERATIONS

The losses were determined by measuring the velocity of the gas and calculating the volume emitted per minute, and by filtering known volumes of the same gas to determine its dust content.

The velocity of the gas was measured by means of a Pitot tube and differential draft gage graduated to a hundreth of an inch of water.

In the intake, a round flue of 36 inch diameter, the Pitot tube was fixed at the point of average velocity. In the outlet, a wooden stack approximately three feet square, readings were taken at nine different points.

The average velocity was calculated using the formula:

$$V - 4.85 \times \sqrt{h} \times \sqrt{t}$$

Where
V - Velocity in feet per second
h - Velocity head of the stack gases, measured with a Pitot tube.
t - Absolute temperature in degrees Centigrade of the gases measured.

The amount of dust carried per cubic foot of gas in the outlet stack was found by aspirating measured volumes of the gas thru paper thimbles. The volumes, measured by a Sprague gas meter, were corrected for temperature and pressure to correspond to conditions in the stack. At the end of each test all the dust collected was weighed, mixed and analysed.

The amount of dust carried per cubic foot of gas in the inlet flue was calculated from the total volume of gas treated during the test and the weight of dust recovered plus the loss from the outlet stack.

D A T A

Table No. 1 Tests Nos. 5 & 6 Velocities & Gas Volumes, Gas Filtrations & Dust Losses.
Table No. 2 Tests Nos. 7 & 8 Velocities & Gas Volumes, Gas Filtrations & Dust Losses.
Table No. 3 Tests Nos. 9, 10 & 11 Velocities & Gas Volumes, Gas Filtrations & Dust Losses.

Oroya Perú, July 12th, 1928.

Experimental Department.

Table No. 1

TESTS Nos. 5 & 6

Power on all Treaters

VELOCITY & VOLUME DETERMINATIONS

Sampling Station	Test No.	Gas Temp. °C	Avg. Vh	Velocity Ft/Sec.	Gas Volumes - Cubic Feet per Second	Minute	Test
Intake	5	135	.511	50.0	353	21180	145400700
Outlet		88	.454	41.8	408	24480	168055200
Intake	6	131	.525	51.2	362	21720	154972200
Outlet		88	.459	42.3	413	24780	176805300
Averages							
Intake		133	.518	50.6	358	21480	150360000
Outlet		88	.456	42.0	410	24600	172200000

GAS FILTRATIONS & DUST LOSSES

		Dust "Met.Tons °Grams	Meter Temp °C	Meter Vac "Hg	Meter Volumes Cubic Feet Aspirated	Meter Volumes Cubic Feet Corrected	Dust/ Cu.Ft. of Gas Gram	Dust Losses Metric Tons	Dust Losses Short Tons
Intake	5	" 11.027	Total	Dust	Treated during	Test	.076	-	-
Outlet		° 4.565	19	5.8	20450	17762	.0002	0.034	.037
Intake	6	" 6.074	Total	Dust	Treated during	Test	.041	-	-
Outlet		°35.448	19	4.5	21405	20356	.0017	.300	.331
Averages									
Intake		" 8.550	-	-	-	-	.057	-	-
Outlet		°20.006	19	5.2	20928	18974	.0011	.189	.208

Table No. 2

TESTS Nos. 7 & 8

NO POWER

VELOCITY & VOLUME DETERMINATIONS

Sampling Station	Test No.	Gas Temp. °C	Avg. Vh	Velocity Ft/Sec.	Gas Volumes- Cubic Feet per Second	Minute	Test
Intake	7	133	.486	47.5	336	20160	90014400
Outlet		97	.448	41.8	408	24480	109303200
Intake	8	132	.340	33.2	235	14100	60136500
Outlet		84	.331	30.3	296	17760	75746400

Averages

Sampling Station	Test No.	Gas Temp. °C	Avg. Vh	Velocity Ft/Sec.	Gas Volumes- Cubic Feet per Second	Minute	Test
Intake		132	.413	40.3	285	17100	74641500
Outlet		90	.390	36.0	351	21060	91926900

GAS FILTRATIONS & DUST LOSSES

Sampling Station	Test No.	*Dust *Met. Tons °Grams	Meter Temp. °C	Meter Vac "Hg	Meter Volumes Cubic Feet Aspirated	Corrected	Dust/Cu.Ft. of Gas Gram	Dust Losses Metric Tons	Short Tons
Intake	7	* 4.433	Total Dust Treated during Test				.049	-	-
Outlet		°87.798	18	4.3	13395	13276	.0066	0.721	0.795
Intake	8	* 2.941	Total Dust Treated during Test				.049	-	-
Outlet		°72.308	16	4.5	12795	12158	.0059	0.447	0.493

Averages

Sampling Station	Test No.	*Dust *Met. Tons °Grams	Meter Temp. °C	Meter Vac "Hg	Meter Volumes Cubic Feet Aspirated	Corrected	Dust/Cu.Ft. of Gas Gram	Dust Losses Metric Tons	Short Tons
Intake		* 3.687	-	-	-	-	.049	-	-
Outlet		°80.053	17	4.4	13095	12693	.0063	0.579	0.638

Table No. 3

TESTS Nos. 9, 10 & 11

Power on second half of treaters

VELOCITY & VOLUME DETERMINATIONS

Sampling Station	Test No.	Gas Temp. °C	Avg. Vh	Velocity Ft/Sec.	Gas Volumes - Cubic Feet per Second	Minute	Test
Intake	9	127	.477	46.3	327	19620	120859200
Outlet		88	.425	39.2	382	22920	141187200
Intake	10	108	.497	47.0	332	79920	115137600
Outlet		86	.421	38.7	378	22680	131090400
Intake	11	137	.499	49.0	346	20760	132448800
Outlet		78	.434	39.4	384	23040	146995200
Averages							
Intake		124	.491	47.4	335	20100	122750700
Outlet		84	.427	39.1	382	22920	139972440

GAS FILTRATIONS & DUST LOSSES

Station	Test No.	Dust " Met. Tons ° Grams	Meter Temp. °C	Meter Vac "Hg	Meter Volumes Cubic Feet Aspirated	Meter Volumes Cubic Feet Corrected	Dust/Cu.Ft. of Gas Grams	Dust Losses Metric Tons	Dust Losses Short Tons
Intake	9	" 6.539	Total	Dust	Treated during	Test	.054	-	-
Outlet		°24.958	17	4.5	18480	17695	.0014	0.198	0.218
Intake	10	" 5.684	Total	Dust	Treated during	Test	.049	-	-
Outlet		°20.476	21	5.5	17340	15202	.0013	0.170	0.187
Intake	11	" 6.648	Total	Dust	Treated during	Test	.052	-	-
Outlet		°25.393	16	5.7	21692	18645	.0014	0.206	0.227
Averages									
Intake		" 6.290	-	-	-	-	.051	-	-
Outlet		°23.609	18	5.2	19171	17247	.0014	0.196	0.216

Copy to W.J.H. + adv
also also
to Spistory

FIRST CARBON
WITH ORIGINAL
MAILED S/S ACONCAGUA
AUG 29

La Croya
August 21, 1928

Sintering Plant - Stack Losses
Test No. 59

CERRO DE PASCO COPPER CORP. NEW YORK
RECEIVED
SEP 10

Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sirs:

Attached hereto you will please find copy of Mr. Colley's letter to me of 13th August under above heading, together with copies of Test No. 59.

Yours truly,

Original signed by
Harold Kingsmill,
General Manager.

1V

COPY

Cerro de Pasco Copper Corporation

Oroya, Peru,
August 13, 1928

Sintering Plant Stack Losses

Mr. Harold Kingsmill,
General Manager,
Oroya.

Dear Sir:

Please refer to Mr. Spilsbury's letter of May 29th reporting a test on sintering plant stack losses when the gases were being sent through the converter Cottrell and promising tests to show the losses when the gases were discharged through the sintering plant stack.

The test promised by Mr. Spilsbury was started on May 19th and finished on June 3rd and is numbered 58. The losses shown by this test are so much higher than those shown by Test No. 56 which accompanied Mr. Spilsbuy's letter of May 29th that it was deemed advisable to check the results before reporting them. Therefore Test No. 59 was started on June 19th and finished on July 12th and the results obtained confirm the higher losses of Test 58.

It will be seen that the daily losses from the sinter plant stack as shown by these tests are as follows:

	Test 58 Losses		Test 58 Values	Test 59 Losses		Test 59 Values
Lead	3655 lbs.	at 2.4¢	$ 87.72	4211 lbs.	at 2.4¢	$101.06
Copper	80 "	at 10.0¢	8.00	116 "	at 10.0¢	11.60
Silver	136.4 oz.	at 54.0¢	73.66	184.7 oz.	at 54.0¢	99.74
Gold	0.004 "	at $20.00	.08	0.014 "	at $20.00	.28
Total values			$169.46			$212.68
If 80% is recovered			$135.57			$170.14
Less 10% metallurgical loss			13.56			17.01
Recoverable value			$122.01			$153.13
Dust to be recovered			2.87 tons			3.61 tons
Cost of treatment per ton of dust including Cottrell plant				$20.00		
Cost to treat			$57.40			$72.20
Daily profit			64.61			80.93

The average of these is around $70.00 a day above all costs for Cottrelling, smelting and refining.

Yours very truly,

S/ B. T. Colley.

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TEST No.58

SINTERING PLANT STACK LOSSES

This test was run from May. 19th. to June. 3rd, 1928. All smoke passed out thru the sintering plant stack. The cross-over flue to the converter flue was tightly dampered so that no converter smoke was drawn thru. All stack datas were taken at the test station on the stack.

The test showed that the stack losses were approximately 0.535 short tons of dust per machine day.

No. Machines	Charge Treated Short Tons Mach.Day	Charge Treated Short Tons Total	Sinter Produced per day Short Tons	Stack Losses per 24 hrs, - D.S.T. Total	Stack Losses per 24 hrs, - D.S.T. Machine	Stack Losses Percent of Charge Treated	Draft D. & L. Inches H2O
6.7	62	375	-	3.589	0.535	0.96	6.6

Analyses	SiO_2	Al_2O_3	Fe	CaO	S	Zn	Pb	Cu	Ag Ozs	Au Ozs	As	Sb	Bi
Sinter Feed	11.4	1.4	19.2	9.6	11.4	6.4	21.3	2.96	63.1	.006	0.27	0.62	0.03
Sinter	12.2	1.4	21.4	13.5	3.5	6.2	22.1	3.26	73.8	.008	0.35	1.10	0.03
Stack Dust	1.2	0.5	3.9	2.2	20.2	3.8	50.9	1.11	38.0	.001	2.60	1.45	0.15

DAILY METAL LOSSES

	SiO_2	Al_2O_3	Fe	CaO	S	Zn	Pb	Cu	Ag Ozs	Au Ozs	As	Sb	Bi
Pounds	100	36	280	160	1450	273	3655	80	136.4	.004	187	104	11
% of Feed	.12	.34	.19	.22	1.70	.57	2.29	.36	.58	.177	9.23	2.23	4.87

The average conditions in the stack during the test were:-

Temperature of gas - ° C	71
Velocity of gas - ft. per sec.	13.9
Volume of gas at avg. temp.- Cu. ft. per min	134580
Dust in gas - gr. per cu. ft.	.0168

14

TEST No. 58

SINTERING PLANT STACK LOSSES

Operations:

The losses were determined by measuring the velocity of the gases in the stack to find the volume of gases emitted daily, and by filtering known volumes of the same gases to calculate the amount of dust carried per cubic foot of gas. From this data the daily losses were calculated.

The velocity of the gases in the stack was measured by means of a Pitot tube and a differential gauge graduated to a hundredth of an inch of water.
The cross section of the stack was divided into four equal areas, and readings were taken with a Pitot tube at twenty-four different points on these areas.

The average velocity was calculated using the formula:

$$V = 4.85 \times \sqrt{h} \times \sqrt{t}$$

Where
V = Velocity in feet per second
h = Velocity head of the stack gases, measured with a Pitot tube.
t = Absolute temperature in degrees Centigrade of the gases measured.

The amount of dust carried per cubic foot of gas was found by aspirating measured volumes of the gas thru paper filters. The volumes, as measured by a Sprague gas meter, were corrected for temperature and pressure to correpond to conditions in the stack. Each twenty-four hours all the dust collected was weighed, mixed and analysed.

D A T A

Table No.1. Comparisons with other Tests.
Table No.2. Daily Stack Losses.
Table No.3. Velocity and Gas Volumes in Stack.
Table No.4. Gas Filtrations and Daily Dust Losses.

Oroya, Peru.

Experimental Department.

Table No. 1

TEST No.58

COMPARISONS WITH OTHER TESTS

	This Test (Stack)	Nº 56 (Cross-Over Flue)
Machines Operating	6.7	5.6
Daily Stack Losses - D.S.T.		
Total -	3.589	2.910
Per Machine	0.535	0.520
Analysis of Dust		
Lead, Percent	50.9	51.3
Copper, "	1.11	0.65
Silver Ounces	38.0	25.0
Percent Losses		
Lead Lost of Lead Treated	2.29	2.026
Copper " " Copper "	0.36	0.125
Silver " " Silver "	0.58	0.256
Stack Data		
Average Temperature of Gas - ° C	71	92
" Velocity of Gas - ft. per sec.	13.9	23.2
" Cubic Feet per min at avg. Temp.	134580	116760
" Dust in Gas - gr./cu. ft.	.0168	.0157
Machine Data		
Daily charge treated per Machine Day - S. T.	62	55
" " " in Sintering Plant	375	302
" Sinter Produced	-	-
Sulfur in Feed - Percent	11.4	11.4
" " Sinter - "	3.5	4.2

Table No. 2

TEST No. 58

DAILY STACK LOSSES

Date 1928	No Machines	Stack Losses D. S. T.	Assays % Pb	Assays % Cu	Assays Ozs. Ag.	Contents lbs. Pb	Contents lbs. Cu	Contents Ozs. Ag.
May. 19	5	1.982	55.5	0.67	26.4	2200	26	52.3
20	4	2.141	54.6	0.98	34.7	2338	42	74.3
21	6	3.521	47.5	1.47	41.4	3345	104	145.8
22	6	2.698	53.2	1.11	34.5	2871	60	93.1
23	6	3.850	51.5	1.34	40.2	3966	103	154.8
24	6	4.756	47.1	1.46	43.8	4480	139	208.3
25	7	3.677	48.2	1.26	38.9	3545	93	143.0
26	7	4.723	47.5	1.26	39.2	4487	119	185.1
27	7	2.290	63.1	0.43	23.2	2890	20	53.1
28	8	4.559	47.1	1.26	38.3	4294	115	174.6
29	8	4.836	49.0	1.13	39.1	4739	109	189.1
30	8	4.831	52.2	1.21	39.6	5044	117	191.3
31	7	5.452	48.1	0.87	44.3	5245	95	241.5
June. 1	8	2.903	52.4	0.80	30.2	3042	46	87.7
2	8	2.982	56.3	0.72	31.0	3358	43	92.4
3	6	2.596	50.8	0.87	37.2	2638	45	96.6
Average	6.7	3.589	50.9	1.11	38.0	3655	80	136.4

Table Nª 3

TEST No. 58

VELOCITY & GAS VOLUMES

Date 1928	No. Machines	Stack Temp. °C	Avg. √h	Velocity Ft./sec.	Gas Volumes - Cubic Feet pe Second	Minute	24 hours
May. 19	5	58	.140	12.4	2001	120060	172886400
20	4	62	.145	12.9	2081	124860	179798400
21	6	68	.150	13.4	2162	129720	186796800
22	6	72	.148	13.3	2146	128780	185443200
23	6	71	.149	13.4	2162	129720	186796800
24	6	74	.148	13.4	2162	129720	186796800
25	7	71	.151	13.6	2194	131640	189561600
26	7	72	.157	14.1	2275	136500	196560000
27	7	74	.153	13.8	2227	133620	192412800
28	8	76	.159	14.4	2324	139440	200793600
29	8	79	.159	14.5	2340	140400	202176000
30	8	82	.173	15.8	2549	152940	220233600
31	7	75	.161	14.6	2356	141360	203558400
June. 1	8	55	.171	15.0	2420	145200	209088000
2	8	78	.170	15.4	2485	149100	214704000
3	6	69	.148	13.3	2146	128760	185414400
Average	6.7	71	.155	13.9	2243	134580	193795200

Table Nº 4

TEST No. 58

GAS FILTRATIONS & DUST COLLECTED

Date 1928	No. Machines	Dust per 24 hrs. Grams	Meter Temp. °C	Meter Vac-"Hg	Gas Vols. - Cu. Ft. Aspirated	Gas Vols. - Cu. Ft. Actual	Gr. Dust per cu. ft.
May. 19	5	18.1792	15	2.3	1728	1752	.0104
20	4	19.2015	15	2.3	1728	1773	.0108
21	6	30.6996	16	2.3	1728	1798	.0171
22	6	24.3237	15	2.2	1728	1836	.0132
23	6	33.9280	18	2.2	1728	1812	.0187
24	6	42.1767	17	2.3	1728	1824	.0231
25	7	31.9429	16	2.3	1728	1814	.0176
26	7	38.9083	18	2.5	1728	1786	.0218
27	7	19.5125	18	2.4	1728	1807	.0108
28	8	37.8094	17	2.3	1728	1834	.0206
29	8	39.9513	18	2.3	1728	1844	.0217
30	8	36.8510	18	2.4	1728	1848	.0199
31	7	44.0081	18	2.4	1728	1812	.0243
June. 1	8	21.4616	18	2.4	1728	1708	.0126
2	8	23.0298	17	2.4	1728	1834	.0126
3	6	22.9211	14	2.4	1728	1806	.0127
Average	6.7	30.3065	17	2.3	1728	1808	.0168

TEST NO. 59

SINTERING PLANT STACK LOSSES

The test was run on the Sintering Plant Stack from June 19th. to July 12th. The results check the data obtained in Test No. 58.

No. Machines	Charge Treated Short Tons Mach.Day	Charge Treated Short Tons Total	Sinter Produced per day Short Tons	Stack Losses per 24 hrs. - D.S.T. Total	Stack Losses per 24 hrs. - D.S.T. Machine	Stack Losses Percent of Charge Treated	Draft D. & L. Inches H20
7.3	62	371	-	4.513	.618	1.21	7.3

Analyses	SiO_2	Al_2O_3	Fe	CaO	S	Zn	Pb	Cu	Ag ozs	Au ozs	As	Sb	Bi
Sinter Feed	9.9	1.9	17.7	11.0	10.9	6.7	23.0	3.07	70.3	.006	0.45	1.20	0.030
Sinter	11.6	1.4	20.7	14.3	4.2	6.2	21.2	3.30	71.9	.008	0.35	1.20	0.025
Stack Dust	1.4	0.6	3.2	1.9	22.2	6.4	46.6	1.28	40.9	.003	2.50	1.40	0.10
DAILY METAL LOSSES													
Pounds	126	54	289	171	2004	578	4211	116	184.7	.014	226	126	9
% of Feed	.17	.38	.22	.21	2.48	1.16	2.47	.51	.17	.628	6.77	1.42	4.04

The average conditions of the gas in the stack during the test were:-

Temperature - °C	77
Velocity - Ft. per sec.	13.6
Volume - cu. ft. per min. at avg. temp.	131640
Dust - gr. per cu. ft.	.0216

TEST No. [illegible]

SINTERING PLANT STACK LOSSES

Operations:

The losses were determined by measuring the velocity of the gases in the stack to find the volume of gases emitted daily, and by filtering known volumes of the same gases to calculate the amount of dust carried per cubic foot of gas. From this data the daily losses were calculated.

The velocity of the gases in the stack was measured by means of a Pitot tube and a differential gauge graduated to a hundredth of an inch of water.
The cross section of the stack was divided into four equal areas, and readings were taken with a Pitot tube at twenty-four different points on these areas.

The average velocity was calculated using the formula:

$$V = 4.85 \times \sqrt{h} \times \sqrt{t}$$

Where
V = Velocity in feet per second
h = Velocity head of the stack gases, measured with a Pitot tube.
t = Absolute temperature in degrees Centigrade of the gases measured,

The amount of dust carried per cubic foot of gas was found by aspirating measured volumes on the gas thru paper filters. The volumes, as measured by a Sprague gas meter, were corrected for temperature and pressure to correspond to conditions in the stack. Each twenty-four hours all the dust collected was weighed, mixed and analysed.

D A T A

Table No. 1 Comparisons with other Tests.
Table No. 2 Daily Stack Losses.
Table No. 3 Velocity and Gas Volumes in Stack
Table No. 4 Gas Filtrations and Daily Dust Losses.

Oroya Peru

H C Winn.
Experimental Department

Table No. 1

TEST No. 59

COMPARISON WITH OTHER TESTS

	This Test (Stack)	No. 58 (Stack)	No. 56 (Cross-over Flue)
Machines Operating	7.3	6.7	5.6
Daily Stack Losses - D. S. T.			
Total	4.513	3.589	2.910
Per Machine	0.618	0.535	0.520
Analysis of Dust			
Lead, Percent	46.6	50.9	51.3
Copper, "	1.28	1.11	0.65
Silver, Ounces	40.9	38.0	25.0
Percent Losses			
Lead Lost of Lead Treated	2.47	2.29	2.026
Copper " " Copper "	0.51	0.36	0.125
Silver " " Silver "	0.71	0.58	0.256
Stack Data - Averages			
Temperature of Gas - °C	77	71	92
Velocity of gas - Ft. per sec.	13.6	13.2	23.2
Cubic Feet per min. at avg. temp.	131640	134580	116760
Dust in Gas - Gr. per Cu. Ft.	.0216	.0168	.0157
Machine Data			
Daily charge treated per machine day	62	62	55
" " " in Sintering Plant	371	375	302
" Sinter Produced	-	-	
Sulfur in Feed - Percent	10.9	11.4	11.4
" " Sinter "	4.2	3.5	4.2

Table No. 2

TEST No. 59

SINTERING PLANT STACK LOSSES

Daily Stack Losses

Date 1928		No. Machines	Stack Losses D. S. T.	Assays % Pb	Assays % Cu	Assays Ozs Ag	Contents lbs Pb	Contents lbs Cu	Contents Ozs Ag
June	19	9	4.358	55.4	0.97	32.6	4829	84	142.1
	20	9	4.891	52.4	1.26	42.2	5126	123	206.4
	21	8	3.668	51.8	1.22	40.6	3800	89	148.9
	22	9	3.944	54.8	1.02	35.8	4323	80	141.2
	23	7	3.622	52.1	1.14	37.0	3774	83	134.0
	24	8	2.545	50.8	0.79	38.1	2586	40	97.0
	25	8	2.487	51.8	0.75	34.1	2576	37	84.8
	26	7	2.100	50.2	0.91	35.0	2108	38	73.5
	27	7	3.082	51.9	0.87	38.2	3199	54	117.7
	28	7	2.832	48.6	1.10	40.6	2753	62	115.0
	29	6	4.582	43.5	1.43	40.6	3986	131	186.0
	30	7	5.644	47.8	1.42	43.5	5396	160	245.5
July	1	7	3.836	48.0	1.58	43.5	3682	121	166.9
	2	6	3.823	54.6	1.06	36.8	4175	81	140.7
	3	7	3.556	57.3	0.63	29.9	4075	45	106.3
	4	6	3.802	53.5	0.55	27.5	4068	42	104.6
	5	6	3.559	48.6	1.19	42.5	3459	85	151.2
	6	7	4.602	46.5	1.55	47.1	4280	143	216.8
	7	7	5.164	41.2	1.39	40.0	4255	144	206.6
	8	7	6.936	40.6	1.39	40.6	5632	193	281.6
	9	7	7.035	40.7	1.62	47.6	5726	228	334.9
	10	7	8.256	39.1	1.69	50.0	6456	279	412.8
	11	8	6.328	35.5	1.43	39.0	4493	181	246.8
	12	8	7.845	40.2	1.66	47.5	6307	260	372.6
Average		7.3	4.513	46.6	1.28	40.9	4211	116	184.7

Table No. 3

TEST No. 59

VELOCITIES & GAS VOLUMES

Date 1928		No. Machines	Stack Temp. °C	Avg. $\sqrt{h}$	Velocity Ft/sec.	Gas Volumes - Cubic Feet per Second	Minute	24 hours
June	19	9	82	.170	15.5	2501	150060	216086400
	20	9	78	.168	15.3	2469	148140	213321600
	21	8	78	.168	15.3	2469	148140	213321600
	22	9	77	.166	15.1	2436	146160	210470400
	23	7	77	.156	14.2	2291	137460	197942400
	24	8	79	.152	13.8	2227	133620	192412800
	25	8	76	.150	13.6	2194	131640	189561600
	26	7	78	.147	13.4	2162	129720	186796800
	27	7	65	.122	10.9	1759	105540	151977600
	28	7	81	.140	12.8	2065	123900	178416000
	29	6	80	.152	13.8	2227	133620	192412800
	30	7	80	.158	14.4	2324	139440	200793600
July	1	7	76	.143	13.0	2098	125880	181267200
	2	6	79	.137	12.5	2017	121020	174268800
	3	7	76	.144	13.0	2098	125880	181267200
	4	6	76	.147	13.3	2146	128760	185414400
	5	6	75	.142	12.8	2065	123900	178416000
	6	7	77	.141	12.8	2065	123900	178416000
	7	7	74	.137	12.4	2001	120060	172886400
	8	7	78	.162	14.7	2372	142320	204940800
	9	7	69	.160	12.9	2081	124860	179798400
	10	7	79	.148	13.5	2178	130680	188179200
	11	8	73	.132	11.9	1920	115200	165888000
	12	8	77	.148	13.4	2162	129720	186796800
Average		7.3	77	.150	13.6	2194	131640	189561600

Table No. 4

TEST No. 59

GAS FILTRATIONS & DUST COLLECTED

Date 1928		No. Machines	Dust per 24 Hrs. Grams	Meter Temp. °C	Meter Vac. "Hg	Meter Volumes Cubic Feet Aspirated	Meter Volumes Cubic Feet Collected	Dust/Cu. Ft. Of Gas Gram
June	19	9	33.2857	20	2.6	1728	1814	.0183
	20	9	37.5114	19	2.6	1728	1800	.0208
	21	8	27.9904	19	2.6	1728	1800	.0156
	22	9	30.5765	18	2.6	1728	1801	.0170
	23	7	29.6989	19	2.7	1728	1784	.0166
	24	8	21.4324	20	2.7	1728	1788	.0120
	25	8	21.0019	20	2.8	1728	1763	.0119
	26	7	18.3712	17	2.7	1728	1802	.0102
	27	7	30.9823	23	2.9	1728	1680	.0184
	28	7	25.5306	24	2.7	1728	1774	.0144
	29	6	38.1566	23	2.8	1728	1765	.0216
	30	7	44.9289	20	3.0	1728	1762	.0255
July	1	7	33.7074	21	2.8	1728	1757	.0192
	2	6	35.6996	19	2.7	1728	1795	.0199
	3	7	32.0436	18	2.6	1728	1796	.0178
	4	6	32.7429	20	2.8	1728	1763	.0186
	5	6	32.2820	19	2.6	1728	1785	.0181
	6	7	41.4872	19	2.8	1728	1774	.0234
	7	7	47.7492	19	2.8	1728	1759	.0271
	8	7	54.5611	19	2.8	1728	1779	.0307
	9	7	63.0855	17	2.5	1728	1776	.0355
	10	7	71.4892	17	2.8	1728	1796	.0398
	11	8	60.7562	19	2.8	1728	1754	.0346
	12	8	68.0312	17	2.8	1728	1786	.0381
Average		7.3	38.4629	19	2.7	1728	1784	.0216

OROYA SMELTER SMOKE QUESTION

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Report by

A. B. YOUNG

LA OROYA, PERU

April 12, 1928

La Oroya, Perú,
April 12, 1928

Mr. C. V. Drew, Vice-President,
Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sir:

I am handing you herewith my report on the Oroya Smelter Smoke Question. In brief it may be summarized as follows:

1. The smelter lies in the bottom of a deep canyon system that has cut its way through a plateau to a depth of about 2000 feet. The smoke finds its way up and down these canyons, rolling over the pampas between and is not disseminated properly into the atmosphere.

2. Smoke has damaged the country in two ways: sulphur dioxide killing off vegetation in an inner zone surrounding the smelter, and solids (lead and arsenic) injuring stock and sheep in an outer zone where vegetation may be slightly affected but not seriously.

3. There is no feasible method of eliminating sulphur dioxide. An acid plant would do it but the resulting sulphuric acid, amounting to possibly 2700 tons daily, would have to be wasted into the river which is out of the question.

4. High stacks might disseminate smoke, but this is by no means certain. The chances are far too great to warrant the expenditure.

5. Solids can be eliminated by means of Cottrell Treaters and baghouses. The latter should be used where feasible, but their employment is limited by temperature, acidity and combustibility of smoke to be treated.

6. <u>RECOMMENDATIONS</u>: (The estimates for treater costs are based upon figures given me by Mr. Spilsbury for the cost of the present Converter Cottrell Installation.)

A - <u>Converters</u>: Doubling of present treater at approximate cost of $350,000.00 When the refining problem of high bismuth lead is solved, this dust should yield $380,000.00 annually.

B - <u>Roasters</u>: Installation of Cottrell Treater in accordance with results obtained from pilot treater. The yield from dust will be about $38,000.00 per year.

C - <u>Reverberatory and Copper Blast Furnace Stack</u>: Move experimental baghouse from converters and pilot treater from roasters to test gases from these furnaces. Cottrell Treater and baghouse are tentatively estimated at about $960,000. and $880,000. respectively, with the possibility of cutting the latter amount in two pointed out.

Possibility of not attempting to treat blast furnace smoke pointed out for your consideration.

The dust caught from this stack will be a waste product unless market conditions are materially changed for the better.

D - <u>Sintering Plant and Lead Blast Furnace Smoke</u>: A treater is recommended for the former to cost about $240,000. for handling the smoke from seven machines, the yield from which will be possibly $30,000. annually.

For the latter a baghouse is finally recommended to cost $100,000. to $125,000. for two blast furnaces. I do not think it worth while to do anything for one blast furnace as major part of this smoke is dropped in present dust chamber.

Complete dust catching equipment to handle all of the smoke now being emitted by the Oroya stacks will cost somewhere between $1,600,000 and $2,600,000. It is for the purpose of reducing this as closely to the former figure as possible that I have recommended such an elaborate program of experimentation.

In the case of sintering plant smoke, data exists so that an accurate estimate can be made of the size of treater necessary. Oroya roaster smoke, containing as it does high amounts of arsenic, has no counterpart elsewhere, and hence its Cottrell properties must be determined by thorough testing. Likewise, while I believe that the baghouse is the solution of the treatment of the smoke from the reverberatory stack, nevertheless the amount of money involved is so great that I think the only wise thing to do is to find out definitely beforehand by means of experiment.

Yours very truly,

A. B. Young

A. B. Young

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THE OROYA SMELTER SMOKE QUESTION

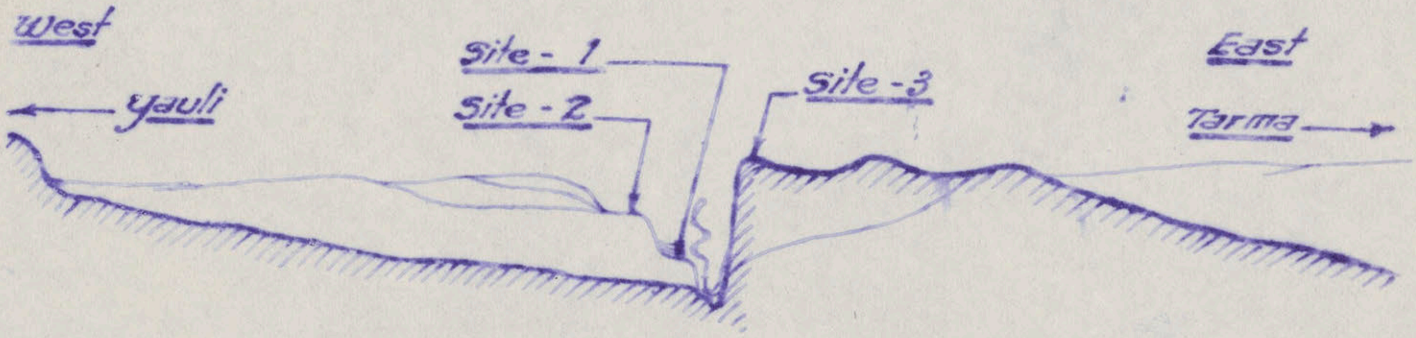
A - PRESENT SITUATION

Topography of Smoke Affected District

The district in which the Oroya smelter lies may be considered as a high plateau or pene-plain of a general elevation of 14,000 to 14,500 feet, approximately seventy-five miles long by thirty wide. The major axis runs north-north-west and south-south-east. The eastern and western boundaries of this plateau are formed by high mountain ranges called the West and East Cordilleras. Toward the northern extremity lie Lake Junin and the Junin Pampa, while to the south there is a rather abrupt break-off into the Huancayo Valley. Running down the middle is the Mantaro River, having its origin in Lake Junin. On either side are tributary streams and gulches, forming a plan which might be likened to the veins of a leaf, with the Mantaro itself as the midrib. Where these streams have cut through the plateau there are deep box canyons or gorges with rugged precipitous sides, between which are pampas of rolling country, smooth ravines and low hills and ridges compared to the general elevation. The gorges gradually deepen toward the main canyon. One of the principal tributaries of the Mantaro River is the Yauli River coming from the west in about the geographical center of the plateau. The Oroya smelter is situated on the Mantaro just below this junction in the bottom of the canyon.

The elevation of the smelter is about 12,200 feet or some 2,000 feet below that of the plateau. Between the entrance of the Yauli and the smelter is a gulch entering from the east in which the old town of Oroya is located. A road leading up this to the top drops down into the Tarma Valley, another canyon cutting the plateau but not tributary to the Mantaro.

Immediately at the smelter site the eastern rim of the canyon is somewhat higher than the western which may be illustrated by the following rough cross-section:



Distribution of the Smoke

To understand smoke travel and distribution properly the following factors must be borne in mind:

1. The smelter is down in the bottom of what may be called a huge trench system.

2. There is no real prevailing wind, although the general trend is down the river.

3. Wind velocities are relatively low.

As it comes from the stacks the smoke usually remains in a fairly solid stream flowing up or down the main canyon or up the tributary forks, acting like a heavy vapor with semi-liquid properties. There are times when it will rise over the side of gulch and roll down into the canyon adjacent. With such a condition it is readily seen that it is liable to reach a distant locality in a rather concentrated form.

If one stands on one of the higher points above the smelter, say at Site No. 3 (14,600 feet elevation) in the morning, and looks up and down the Valley of the Mantaro he will see a heavy pall lying in the bottom of the canyon and up the tributaries. Later in the day this will rise and begin to roll up the gulches and on to the plateau.

This smoke pall is more or less present all the time as while there is enough air current to feed it, there is not enough to blow it away and disseminate it properly. It does not get into the upper air currents and scatter as in the case of the smelters erected in large open valleys or along the slopes of mountain ranges.

Effects of Smoke

The report of José J. Bravo and associates dated March 31st, 1925 is very comprehensive and goes into this subject in great detail, giving a large number of atmospheric analyses for SO_2 and soil analyses for lead and arsenic. Most of this systematic sampling work was done along the main avenues of travel out of Oroya: to the north up the line of the Cerro de Pasco Railway along the Mantaro River as far as Casaracra; to the east up the gulch on the road leading down to Tarma; to the south down the Mantaro toward Jauja; and to the west up the Yauli River along the main line of the Ferrocarril Central del Perú toward Lima. Thus is formed almost a cross with Oroya at the center.

In regard to damage by SO_2 to vegetation, in a general way, it may be stated that it decreases with the distance from Oroya, but is more pronounced south down the Mantaro than in the other three directions. To the south I have seen bad SO_2 bleachings a distance of 40 kilometers (25 miles); in fact in the early morning the smoke is visible from Jauja coming out of the mouth of the gorge of the Mantaro into the Huancayo Valley where, of course, it is soon dissipated. The inner zone around Oroya, taking in Haciendas Quiulla, Antahuaro, Huaymanta, Tallapuquio, etc., has of course been rendered useless by the destruction of vegetation by SO_2.

Regarding solids, a study of the data in Sr. Bravo's report (most of which was gathered by the staff of the Corporation) shows the following to be generally true:

1. A rapid dimunition of arsenic content of the soil as distance from the smelter increases;

2. A much slower dimunition of lead content as the distance increases, so that while the soil contents are preponderantly arsenic near the smelter, lead becomes the chief impurity farther away;

3. The fume deposition seems to be fairly the same at equal distances to the north, east and west, but much more intensive to the south.

As a consequence the damage due to solids (particularly lead) has been carried to the haciendas of Pachacayo, Consac, etc., 40 to 60 kilometers to the south as easily as to the much closer ones of Punabamba, Atocsaico and Casaracra.

An idea of the amount of damage done to the cattle and sheep business in this district can be had from the following table:

Year	Death-Rate Cattle	Death-Rate Sheep
1913-22	3.65%	5.89%
1924	52.40%	68.90%
1925	8.60%	46.40%
1926	12.00%	30.20%
1927	12.90%	23.80%

For detailed information see statements attached to Mr. Colley's letter to Mr. Kingsmill on "Haciendas" dated December 22nd, 1927. In this letter Mr. Colley estimates annual total losses due to smoke as £p 37,000.- or $148,000. in round numbers. He states that the haciendas are now breaking even financially; hence if the smoke situation be cleared up the above figure stands as operating profit, after they are restocked by some 10,000 head.

Smoke Produced

The operations of the Oroya smelter are fluctuating, varying as to number of furnaces used for smelting and roasting and the number of converters running as well as to the composition of the ore charge being treated. The amount of sulphur entering the atmosphere daily varies from 600 to 900 tons depending upon the number of furnaces in operation. In terms of SO_2 this represents 1200 to 1800 tons per twenty-four hours.

The following table, based upon various tests on the different stacks during the past year, shows the approximate amount of the gas volumes and solid content emitted from each stack under general operating conditions as they are at present:

Department	Tons Dust per 24 hrs. Avg.	Max.	Min.	Gas Vols. (#) in thousands cu. ft. per Min. Avg.	Max.	Min.	Approx. Temp. ° C.
Roaster	20	27.5	15	443	521	377	145
Reverberatory and Blast Furnace	30	46.5	16	537	674	373	260
Converter (##)	55	65-70	35-40	400	500	300	60
Total Copper Plant	105			1380			
Lead Furnace (one)	3			20			
Sinter Plant	5			150			
Total Copper & Lead	113			1550			

(#) Based on actual conditions of temperature and pressure.
(##) At the present writing 40 tons per day is being caught by converter treater.

Following are approximate analyses of the dusts in the above table:

Department	% Cu	% Pb	Oz. Ag	Oz. Au	% As_2O_3	% Sb	% Bi
Roaster	4.5	4.5	10.5	.01	20.0	1.7	.5
Reverberatory and Blast Furnace	.6	14.5	3.0	.007	29.0	2.5	1.6
Converter	1.4	48.5	14.9	-	6.0	1.5	2.2
Lead Furnace		40.0					
Sinter Plant		40.0					

Recapitulating the above it is seen that there is an average daily production of lead and arsenic (As_2O_3) fume and dust from the various stacks as follows:

	Tons Pb Daily		Tons As_2O_3 Daily
Roasters	.1		4.00
Reverberatories and Blast Furnaces	4.3		8.70
Converters	27.0		3.30
Lead Furnace	1.2	variable	(1/2 to 1)
Sinter Plant	2.0	"	(1/2 to 2)
Totals	34.6		16.00

In round numbers say from 30 to 35 tons of lead and 15 to 20 tons of arsenic.

B - REMEDIES

Among the remedies that have been suggested are a high stack for all the smoke produced, to be set on a hill or bluff near the smelter. Three places have been mentioned and are designated in your files as Sites I, II and III.

Site I is on top of a bluff on the west side of the river just behind the smelter and about 600 feet higher. Behind Site I and somewhat down the river on a higher eminence is Site II about 1200 feet above the river, while directly across the river is Site III, some 2400 feet above the smelter. The cross section on Page 2 gives a relative idea of these three sites. There have been many tests made regarding probable flow of smoke from these locations - in fact a small stack was first put up on Site I and regular observations made over a period of some time. However, no definite conclusions have been reached, nor can they be reached, in my opinion, except by the erection of the actual smelter stack itself and seeing what happens. If a stack on any site would carry the smoke away it must certainly be Site III which is slightly higher than the general elevation of the surrounding plateau. There is not enough known about the higher air currents of this region to be at all certain or even to hazard a guess of what would happen to smoke discharged at this point. If it by chance should wander down the Tarma Valley trouble surely would arise from that direction, and a new crop of smoke farmers would need pacifying. The necessary flues to any of these sites would cost a great deal of money - increasing from several hundred thousand dollars at Site I to probably two million or more at Site III. I do not believe you are justified in putting a stack on any of these sites nor any other nearby eminence because of the uncertainty of results and the high cost of so doing.

Smoke damage has been caused by two agencies: (A) Gases, principally SO_2, which injure vegetation; and (B) solids, principally lead and arsenic. It has been pointed out that except for the territory surrounding Oroya for a few miles the principal damage to the whole district has been from solids.

(A) There is only one known feasible remedy for the elimination of sulphur dioxide, namely: the building of a plant for the manufacture of sulphuric acid, which would amount to about 2700 tons of pure acid daily when operating at full capacity. As it would be impossible to dispose of it (except negligible quantities) then this acid would have to be turned into the river, which, of course, the Government of Perú would not allow.

(B) Elimination of Solids. In metallurgical plants there are two generally accepted means for the elimination of solids from smoke: the baghouse and the Cottrell treater and, in the opinion of the writer, the former is better where it can be employed. However, its use is limited by temperature, by acid content of the smoke, and by the combustibility of the solids in the smoke. A baghouse also takes considerably more ground space than a Cottrell treater of equivalent capacity, which is a factor when limited to room. Excess acid content may be overcome by the addition of lime to the smoke stream, but I would not advise this with an extremely acid smoke, except after a long period of test work to determine life of bags and the amount of lime necessary (a quantity that might become prohibitive.) On the other hand, a baghouse takes all of the solids out of the smoke and leaves merely an invisible gas, while a treater leaves enough of the solids to be seen. The above advantages and disadvantages will be borne in mind in making the recommendations that are to follow.

Converter Smoke: Not only from the standpoint of damage done to the surrounding country but also on account of the value of the metals being lost, the proper handling of this smoke is of more importance than any other. In considering the relative merits of the Cottrell treater and the baghouse for this work I have recommended the former for the following reasons:

1st, the operations from early February of this year on have proved conclusively that these gases can be successfully treated by a Cottrell at a speed of 10 feet per second (See letter of Mr. W. E. King to Mr. Spilsbury dated March 12, 1928);

2nd, the converter smoke enters the conditioning chamber at from 400° to 450° C. For baghouse work this must be cooled to from 90° to 110° C. and to effect such cooling would require an enormous installation.

3rd, preliminary tests show that converter dust would require with the Sprague process a great amount of lime to obtain the necessary degree of protective alkalinity.

4th, baghouses require far greater ground space than treaters and the erection of a baghouse for this smoke would use up valuable room now reserved for possible future metallurgical installations or extensions.

Quoting from my letter of March 20th to Mr. Kingsmill:

"Operations during the month of February and the first half of this month have shown that four units handling 300,000 cubic feet per minute have caught 90% of the fume and dust delivered to them. This means an average treatment of 75,000 cubic feet per unit of a speed of 10 feet per second through the treater. We may expect when operations are at a normal maximum the amount to be treated will be approximately 500,000 per minute which will require seven units. Inasmuch as this smoke is acid and corrosive there will be considerable time down on each unit for necessary repairs during operations. To take care of these there should be a spare unit which will bring the number necessary up to 8 all told or 4 units in addition to those now existing. Therefore, the installation of four units, in addition to and similar to those now in place, with corresponding electrical equipment and to be erected in the space now occupied by the radiation chamber is recommended.

"I would, however, suggest the following modifications in design: (a) treater walls would be of acid resisting brick and it might be better to gunite the outside to obviate leakage, and (b) that the suspension of the plates be redesigned so that they may be much more readily replaced, this design to follow the lines of the new Tooele sintering plant treater, blueprints of which have been left with Mr. Spilsbury.

"In order to take care of the extra 200,000 cubic feet of gas I believe it will be necessary to increase the present fan capacity by the addition of one more fan. It may also be necessary to increase the conditioning chamber capacity by 50% of the present. This, however, I would leave until its necessity was determined by actual operations.

"Below I am giving an approximate estimate of the cost of this increased converter treater installation based upon costs of the present installation:

<u>Converter Treater Addition</u>

<u>Estimated Cost</u>

4 units at $60,000.00	$240,000.00
1 fan at $30,000.00	30,000.00
	$270,000.00
Plus 10% for contingencies	27,000.00
	$297,000.00
If conditioning proves necessary add	55,000.00
	$352,000.00

"Roughly speaking, we may assume that the total treater installation will catch an average of 50 tons a day of fume and dust of the following analysis:

Lead	48.5%
Silver	14.9 ozs.
Copper	1.4%

"This material may be roughly calculated per ton as follows:

Recoverable copper, 20 pounds at 10¢	$2.00
Recoverable lead, 873 pounds at 1.5¢ (including smelting cost)	13.10
14.9 ounces of silver at 50¢ (this will include loss in smelting)	7.45
	$22.55

"50 tons daily at $22.55 = $112.75 per day, or $411,500. per year."

From this should be deducted treater operating expenses, say $30,000.00, leaving approximately $380,000.

The present treater without the radiation chamber cost approximately $445,000. which if added to the estimated cost of the addition would bring the total converter Cottrell treater installation to $797,000. The dust caught, therefore, would pay for this in about two years.

After writing this Mr. Kingsmill has pointed out that the above calculation is predicated upon the final solution of the bismuth problem, in which he is quite right. However, I have no doubt that a way out of this problem will be found.

Roasters: For the purpose of treating this smoke I recommend a Cottrell treater because of its high acidity. Some years ago I directed a baghouse test on this kind of gas. As I recall, the bags lasted less than a week. With a pilot treater now erected to test these gases it must first be determined whether or not water conditioning is necessary. If so, what degree of relative humidity must be maintained under the conditions.

Second: Gas velocity for efficient catch must be ascertained.

Third: In case of non-conditioning the effect of treater temperatures should be obtained to see whether it is cheaper to put in a cooling arrangement ahead of the treater or build more treater. This can be done by heat insulating the intake flue on the experimental treater.

Fourth: See whether advantage can be taken of selective precipitation. There will be more dust containing principally copper and silver caught in the first part of the treater and more fume (arsenic and lead) in the second part. It may be that that caught in the second part will be so high in arsenic and so low in copper and silver that it can be thrown away at this stage.

Fifth: Power input under the various conditions above cited. It may be that this smoke will not require as much power as that from the converters, in which case a saving can be effected in sub-station installation.

The dust and fume from the roaster treater, or at least a portion, will require reverberatory smelting to reclaim the copper and silver values. It should, however, not be so smelted until proper dust catching equipment has been put on the reverberatory stack. Otherwise, the arsenic and lead would only be caught from the roaster stack to be turned loose again in reverberatory smoke.

This installation will catch about 18 tons of dust daily, assaying 4.5% copper and 10.5 oz. silver, from which the following annual return may be expected:

Copper	81 lbs.	at 10¢	$ 8.10	per ton
Silver	9.5 oz.	at 50¢	4.75	"
			$12.85	"
	Less smelting		2.35	"
			$10.50	"
	Per year (6480 tons)		$68000.00	
	Less annual operating expenses		30000.00	
			$38000.00	

Reverberatory and Copper Blast Furnace: Tests show that two reverberatories produce about 420,000 cubic feet of smoke per minute and that two reverberatories plus a copper blast furnace about 650,000 cubic feet. I am of the opinion that after properly conditioning with water 80% of the solids may be taken from this smoke at an average treater velocity of 9-1/2 to 10 feet per second through an effective electrode length of 64 feet. Such an installation would cost approximately as follows:

Units - 9 at $60,000.00		$540,000.00
Conditioning Chamber		150,000.00
Fans		80,000.00
Flues		100,000.00
		$870,000.00
	Contingencies	87,000.00
	Total	$957,000.00

On the other hand, a baghouse to treat 650,000 cubic feet, based on data in baghouse work at Tooele, would require 6500 bags (30 ft. X 18 in. dia.) and would cost not more than $877,500 determined as follows:

1000 bag baghouse cost in 1914	$ 45,000.00 (#)
Add 50% for 1928 prices	22,500.00
Present cost	$ 67,500.00
Multiplying by 6-1/2 for 6500 bags	438,750.00
Double for cost in Perú	877,500.00

(#) This figure includes flues, fans and all equipment.

The maximum per 24 hours in dust and fume emitted from the reverberatory stack is 46.5 tons (93000 pounds), an equivalent of about 3880 pounds per hour, or with 6500 bags 0.6 pounds fume per bag per hour.

By continuous shaking and having each shake consist of three inflations and deflations, it has been found recently at Tooele that

2000 cubic feet gas per bag per minute could be filtered with a dust catch of 3-1/2 to 4 pounds per hour. On this basis of gas volume the amount of filtering area required in the above estimate would be cut in two and the cost, therefore, reduced to about $440,000.00.

Preliminary tests show a dust acidity of 5.4 (in terms of excess SO_3 when two reverberatories and one blast furnace are operating.

Desired protective alkalinity	5.5% (#)
Acidity	5.4%
Protective alkalinity to be furnished	10.9%

CaO required = $\frac{10.9}{1.43}$ = 7.1% or 9% in terms of hydrated lime.

(#) For protective alkalinity determinations and instructions see Appendix I.

When the fume emitted is a maximum, there would be needed 9% of 46.5 tons = 4.2 tons daily. As an average, there would be needed only 2.7 tons as 30 tons is the daily average of the dust emitted.

In the light of the above I would strongly urge the transferring of the experimental baghouse erected on the converter gases to the reverberatory gases and operate it for 8 or 10 months, determining the volume of smoke that may be put through and the amount of lime required for necessary protective alkalinity. If undue deterioration of bags is going to occur it should be evident with a run of this length of time.

If a baghouse is finally decided upon the following points must be remembered:

(1) Temperatures of gases entering should range from 190° to 220° F. (90° to 110° C.) The flues leading to the baghouse must be so designed as to accomplish this, which should not be difficult as the stack temperatures range from 100° to 150° C. at present;

(2) The roof must be designed in such a manner as to afford practically perfect heat insulation as any condensation means drip and this condensed water will eat holes in the bags. In Appendix II, I am showing a detail of roof design that has proven very satisfactory;

(3) A screw conveyor in each pit for taking out the fume will work all right provided it be run often, thus not allowing fume to accumulate.

Likewise, it would be a good plan to dismantle the experimental Cottrell treater at the roaster plant as soon as the data required there is obtained and remove it to the reverberatory flue in order to determine what size treater would be needed to handle this smoke properly by Cottrelling. While I think that a baghouse will be finally determined upon here, nevertheless, it would be well to have the treater data all at hand in case the pilot baghouse should prove that baghousing was not feasible.

My experience has been that the operating costs of Cottrell treaters and baghouses are about the same when the cost of lime for the latter is not considered. In other words, baghouse operation will cost more than Cottrell by the cost of the lime needed to be added. The stack clearance, of course, with the baghouse is perfect, which is never the case with a treater.

It may be that a better location for a baghouse or Cottrell treater may be picked by your engineers than the following suggestions:

To me it seems that either could be located in the space generally located up the river from the power house and toward the river between the transformer station and the administration building. The smoke would be discharged up a new stack or through a flue parallelling the river side of the power house and then back behind the power house into the present stack, depending upon which is cheaper.

The above concerns the treatment of smoke from the copper blast furnace as well as the two reverberatories with a total of some 650,000 cubic feet of smoke per minute. While nothing definite can be drawn from the following table due to the great fluctuations in dust caught, nevertheless, it is significant in pointing out that the dust carried in copper blast furnace smoke after passing through the dust chamber may not be a very great item:

Test No.	Dust - tons per day up stack	Remarks
46	46.3	2 reverberatories - no blast furnace
48-3	35.1	"
51	22.8	"
Average	34.7	
48-1	46.4	2 reverberatories - 1 blast furnace
48-2	31.5	1 " 1 "
53-A	18.3	2 " 1 "
Average	32.4	

To pass the smoke from the blast furnace dust chamber is a hard problem, and will entail considerable expense - out of proportion in fact to the comparatively small percentage of the time that this furnace is operating. This smoke will also require slightly more than half again as much treater or baghouse as would be needed for the reverberatories alone. If a baghouse is finally built, while the matter of cooling the gases is not a serious one, nevertheless, it can be practically eliminated if the copper blast furnace smoke is not turned into it, and, furthermore, this smoke furnishes most of the acid necessitating the use of lime.

This matter is not brought to your attention in the way of a recommendation, but merely as a point for your consideration.

There will be no money return from fume caught from copper furnace smoke under existing metal prices. The average analysis is 14.5% lead, 0.3% Cu and 3 oz. Ag, the recoverable value of which is:

Pb - 252# at 2.3¢	$5.80
Ag - 2.7 oz. at 50¢	1.35
Cu - 4 lbs. at 10¢	.40
	$7.55

It would not pay to try to treat a heavy arsenical material of this kind for $7.55.

As to its disposal it could be pugged with water and sent out to the dump with the slag where it would be buried and never be a source of trouble. It would be irretrievably lost by such a method, but it is difficult to see where large stocks of it could be built up for a possible treatment at some future time.

<u>Sintering Plant and Lead Blast Furnace</u>: In my letter to Mr. Kingsmill under date of March 20th, I made a recommendation "that a flue be built from where the present sintering plant flue enters the converter flue over above the converter building and lead blast furnace to connect into the copper blast furnace dust chamber flue," etc. and pointed out that such a flue could be used later as a permanent connection for bringing the lead blast furnace smoke back to the sintering plant flue and thence into a separate Cottrell treater for sintering plant and lead blast furnace smoke. Since then Mr. Bendel has estimated the cost of such a flue at £23,000 sterling, a figure out of all proportion to the value of the results to be accomplished.

At the present time, lead blast furnace smoke is being discharged through the copper blast furnace dust chamber and into the reverberatory stack. This furnace is producing about three tons per day of fume that is now assaying 20 to 25% Pb, 4 ozs. Ag, 15% As, and 4.3% Sb. Most of this is now being caught in the dust chamber and of this dust only a small portion is going up the stack. When the copper blast furnace starts more of it will go out the stack due to the increase of gas velocity in the dust chamber. When a second lead furnace is placed in operation there will be about six tons of fume per day and probably a fair proportion will be deposited in the chamber if there be no copper blast furnace operating - just how much it will be hard to say. The best way to catch this smoke (low temperature and non-acid) is undoubtedly by means of a baghouse, located somewhere near the furnaces. For two furnaces, 800 standard bags (30 ft. X 18 in. dia.) should meet requirements - 400 per furnace. The cost of an 800 bag baghouse would be somewhere between $100,000. and $125,000. including fan, but exclusive of flue connections.

Mr. Spilsbury tells me that it looks as though it would require seven sintering machines to serve one lead furnace instead of six. As practically the same amount of smoke is evolved from a lead blast furnace as from a Dwight-Lloyd machine, my recommendation for handling this smoke remains as per my letter to Mr. Kingsmill of March 20th, and is as follows:

At present a baghouse would efficiently handle sintering plant smoke. However, it would prevent ever putting into the sintering plant charge ores of high pyritic content as with the elemental sulphur produced therefrom there is always the danger of fire burning up all the bags.

For sintering plant smoke I recommend a conditioning chamber equivalent to about one-half of the capacity and similar in design to that now in existence, one fan similar to those installed on converter treater, and three units of the same design as the converter treater, except that each unit consist of three instead of four machines, giving a total effective electrode length of 48 feet instead of 64 feet, and, further, that the modifications in design given under the heading: "Converter Smoke" also apply here. This treater is to discharge into the sinter plant stack.

I would expect on an installation of this kind a treater recovery of 80% at 7 feet per second. However, about 30% of the dust given off of the sintering machines will be going in the flue and conditioning chamber ahead of them, thus bringing the total recovery of the system up to 85% or 86%.

The above is on a basis of seven sintering machines. We may say in round numbers that each sintering machine will produce 20,000 to 25,000 cubic feet of smoke per minute. The estimated cost of such a treater is roughly $242,500.00 given in detail as follows:

Estimated Cost

3 units at $45,000.00	$135,000.00
Fan	28,000.00
Conditioning Chamber	50,000.00
Flues	7,500.00
	$220,500.00
Contingencies	22,000.00
	$242,500.00

I cannot tell just what money return on this will be as we have not had aspiration tests at the present time on the flues. However, I would assume the dust would be about the same value as that caught in the converters and that you would have about 4 to 5 tons a day of it. Assuming the net value of the dust to be $20. per ton we have a return of approximately $90. per day, or $30,000. per year, which would pay for the installation in approximately eight years. (#)

The reason for recommending catching sintering plant and lead furnace fumes separately from converter fumes and dust is:

There will be a concentration of arsenic in the dust from the sintering plant and blast furnace smoke, coming from the original charge - now about one per cent. As this dust is retreated for the recovery of values, the arsenic content will accumulate in it on account of insufficient means of escape from the system. Finally, there will be so much on the charge as to affect seriously lead furnace operations. If these smokes be kept separate from the converter smoke, their arsenic content will soon build up to a point where a major portion of it can be eliminated by means of a small arsenic plant. If not separated, the dilution caused by the converter treater dust will prevent its elimination, but the bad effects on the lead furnace will remain. In other words, a separate treatment for lead smoke affords an outlet for arsenic from the lead smelting system.

The sintering plant and lead blast furnace fume and dust will be retreated through the lead plant until such time that the arsenic content of each has built up to a stage that it is interfering too much with lead furnace operations. When this point is reached it will be necessary in order to recover the values contained to erect an arsenic roaster for its elimination. If the arsenic market is sufficiently high (a doubtful supposition) it may be caught in kitchens for recovery. If not, this roaster could discharge its smoke into the baghouse or treater erected for the reverberatory furnaces.

(#) This statement has been revised since my letter of March 20th, on account of the fact that the lead blast furnace smoke is not going to be caught in this treater.

APPENDIX I

DETERMINATION REQUIRED FOR FIGURING ALKALINITY OF BAGHOUSE FUMES

TOTAL ZINC - Made in the usual manner. Convert to ZnO.

SOLUBLE ZINC - Made as follows: To 1/2 gram sample in #2 beaker add 150 cc of pure distilled water. Boil 5 minutes and filter through #0 11 cm munktell paper. Add 5 cc NH_4OH, 5 grams NH_4CL (pure) and 1/2 gram $NH_4C_2H_2O_4$ to filtrate and boil 5 minutes. Filter and titrate the $Ca(C_2H_2O_4)_2$ with $K_2Mn_2O_8$.

SOLUBLE SULPHUR - Made as follows: To 1/2 gram sample in #2 beaker add 150 cc pure distilled water. Boil 5 minutes and filter through #0 11 cm filter paper. Add to filtrate 5 cc HCl, 5 grams NH_4Cl and 5 cc of a 10% solution of $BaCl_2$. Boil 5 minutes, allow to settle and filter. Burn and weigh as $BaSO_4$.

TYPICAL ANALYSIS OF FUME & CALCULATION OF PROTECTIVE ALKALINITY

CaO = 3.5% ZnO = 2.4% S = 0.5%

This CaO and Sulphur are water soluble determinations while ZnO is total.

56 parts CaO combines with 80 parts SO_3 to form $CaSO_4$. $\frac{80}{56} = 1.43$

81 parts ZnO combines with 80 parts SO_3 to form $ZnSO_4$. $\frac{80}{81} = 1.00$

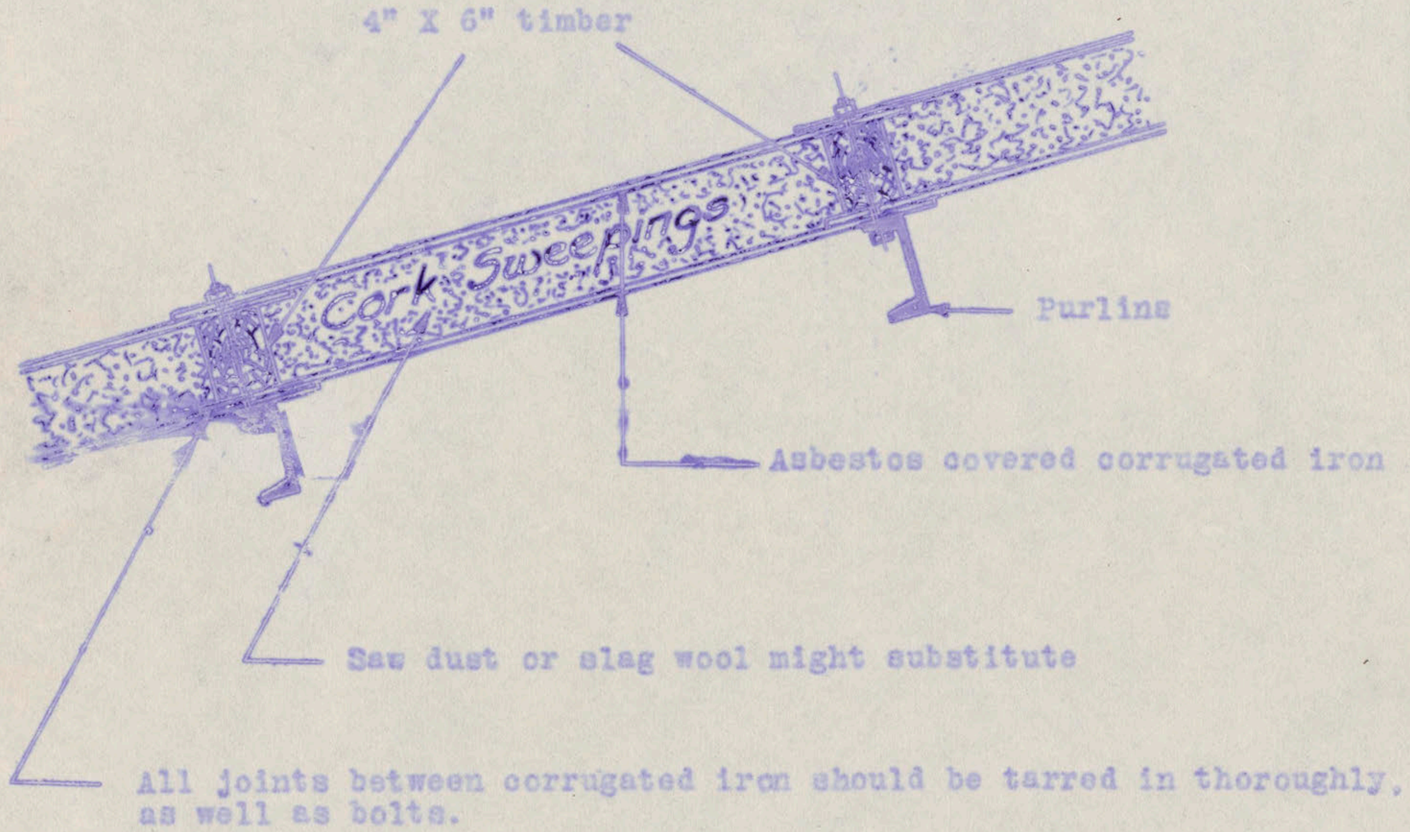
∴ Lime found or 3.5% X 1.43 = 5.0% = SO_3 to combine with Lime.

ZnO found or 2.4% X 1.00 = 2.4% = SO_3 to combine with ZnO.

Total	7.4%	SO_3
Sulphur found 0.5% X 2.5 =	1.25%	SO_3 present
Difference	6.15%	Excess Alkalinity

This figure is also termed "Protective Alkalinity."

APPENDIX II



CROSS-SECTION OF BAGHOUSE ROOF
SHOWING SUGGESTED METHOD OF HEAT INSULATION

-- oOo --

Note: Nailing strips of wood placed inside will in time char, thus being liable to fall down inside.

A-120.

51 Maiden Lane.

New York, N. Y., Aug. 10, 1928.

Mr. C. V. Drew,

Vice Pres., Cerro de Pasco Copper Corp.,

44 Wall St., New York, N. Y.

Dear Mr. Drew:

SMOKE - ROASTER COTTRELL.

I have read carefully the photostatic copy of the Kingsmill letter of July 15th with enclosures, and I see no reason to dissent from the conclusions drawn therein from the excellent experimental work done.

Yours very truly,

Adx/B.

L. A.

B.

CONTENTS NOTED
AUG 20 1928
LAWRENCE ADDICKS

FIRST CARBON
WITH ORIGINAL
MAILED S/S EBRO
18

July 15, 1928

Smoke - Roaster Cottrell

CERRO DE PASCO COPPER CORP. NEW YORK RECEIVED JUL 31

Copy to Mr. J. H.? Lyco also to adx

Cerro de Pasco Copper Corporation,
44 Wall Street,
New York City.

Dear Sirs:

I quote your cablegram of 11th July as follows:

"To comply with recommendations made by Young, Hamilton, Spilsbury, suggest designs for roaster Cottrell be made as soon as possible and that a dust chamber be included."

In connection with this matter I beg to enclose herewith for your information copy of Mr. Colley's letter to me of 13th July, together with reports mentioned therein giving summary of the operation of the experimental Cottrell to date.

On Page 2 of Mr. Colley's letter you will note that he states that a small dust chamber has been built ahead of the experimental roaster Cottrell. This dust chamber is now in commission starting on the 14th July and so far is giving very satisfactory results. This dust chamber will be operated for the next ten days, by which time it is thought that all information necessary to proceed with the design of the combination dust chamber and Cottrell will be available.

The report mentioned in the final paragraph of Mr. Colley's letter will be sent when completed.

Yours truly,
Original signed by
Harold Kingsmill.

~~General Manager.~~

Oroya, Peru,
June 27, 1928.

Mr. B. T. Colley,
Metallurgical Engineer,
O r o y a.

Dear Sir: Experimental Pilot Roaster Cottrell

The Experimental Pilot Cottrell situated at the base of the roaster stack is of the straight line plate type. The treater is built of common brick and has a length of 60 ft., width 8-1/2 ft and height to top of the operating floor 12-3/4 ft. (For general layout see attached blue print #5289)

The treater consists essentially of 4 banks of No. 24 B.W.G. corrugated steel sheets, 6 ft. high, 8-1/2 ft. long, set at 6" centre to centre, these forming the collecting electrode. The discharge electrode consists of 3/8" square twisted iron rods.

Total effective plate area 2,050 square feet
Total effective hot electrode 6,720 lineal feet

Underneath each bank of plates are two dust bins or hoppers, divided by a baffle wall. Ahead of No. 1 bank of plates is a dust settling chamber 6 ft. long and of the same height and width as the treater, this space also gives the gases an opportunity to spread out before entering the treater.

A No. 9 Sirocco fan direct connected to a 50 H.P. motor withdraws the smoke from the main roaster flue through a 36" diameter pipe to the treater. The smoke after passing the treater is discharged into a wooden stack on top of the fan house which has an area at the sampling station of 9.76 sq. ft.

The voltage for the treater was taken from the No. 2 rectifier located in the power house, and carried to the treater on one of the overhead 50,000 volt high tension lines which previously had been used in connection with the roaster tube type Cottrell installation.

Operation of the Pilot Cottrell started on April 13th and continued until June 14th some 11 tests having been made during this period.

The purpose of these tests was to gather the necessary data for the economical and efficient treatment of the roaster smoke, and at the same time to determine such factors as:

1 Velocity
2 Temperature
3 What advantage can be taken of selective precipitation

4 The length of effective electrode necessary for an efficient clearance.
5 The necessity or not of water conditioning
6 Electrical conditions, i.e., power input, kilovolt and milliampere readings on the high tension side.
7 Mechanical operations, i.e., frequency of rapping the hot and cold electrodes.

During the period April 13th to May 2nd (Tests Nos. 1-4) several operating troubles were encountered and remedied, these being:

1 Treater leakage - Reduced by tar painting the brickwork and sealing up all joints.

2 Smoke leakage through the portholes round the hot electrodes: Reduced by the installation of a 2" ring gap round the hot electrodes.

3 Insulator leakage: Replacing the pine insulators with maple, later it was found necessary to use porcelain.

The data for this period should not be used for calculations requiring temperatures and volumes.

The Pilot Cottrell worked well electrically under most conditions. Different kinds of deposits were obtained, wet and dry, and in some cases wet mud and acid dripped from the plates. Throughout the tests very little trouble was experienced in making the installation work on this type of smoke.

Following Tests Nos. 1 - 4 were Tests Nos. 5 - 11, and for the purpose of tabulating the results of these, I shall conveniently divide them into three divisions, namely:

1 Tests Nos. 5 & 6 - With power on all 4 treaters.

2 Tests Nos. 7 & 8 - Without power on the treaters.

3 Tests Nos. 9, 10 & 11 - Without power on treaters 1 and 2 and with power on treaters 3 and 4.

TABLE I

	With power on all 4 treaters		Without power on the treaters		Without power on treaters 1 & 2, with power on treaters 3 & 4.		
Test No.	5	6	7	8	9	10	11
Length of test - hours	114-1/3	119	74-1/2	71	102-2/3	96-1/3	106-1/3
Dust:							
Lost from sampling stack - S. Tons	0.037	0.331	0.795	0.493	0.218	0.187	0.227
Recovered from treater - S. Tons	12.118	6.696	4.092	2.749	6.989	6.078	7.327
Total to treater - S. Tons	12.155	7.027	4.887	3.242	7.207	6.265	7.554
Recovery %	99 +	95.5	83.7	84.8	97.0	96.8	97.0
Dust recovered from treaters - Lbs.							
Hopper No. 1 Mechanical dust	1,194	549	522	451	783	681	639
2 & 3 1st treater	12,585	7,033	2,531	1,917	3,668	3,700	3,241
4 & 5 2nd treater	8,124	3,840	2,217	1,444	2,555	2,134	2,563
6 & 7 3rd treater	1,940	1,435	1,914	1,085	5,522	4,086	5,162
8 & 9 4th treater	393	535	1,001	601	1,451	1,555	1,939
Total	24,236	13,392	8,185	5,498	13,979	12,156	14,655
Dust in grams per cu. ft. of gas	.076	.041	.049	.0489	.054	.049	.052
Analysis of dust from sampling stack:							
Cu	-	-	1.20	1.03	-	-	-
As	8.8	7.5	23.5	22.2	14.4	6.0	12.6
Temperature: °C.							
Treater inlet	129°	125°	128°	126°	122°	103°	131°
Treater outlet	103°	102°	113°	104°	108°	100°	101°
Treater average	116°	113°	120°	115°	115°	101°	116°
Volume: Cu. ft per minute in treater at average temperature	20,500	21,000	19,750	13,700	19,250	19,750	20,000
Velocity: Ft. per second in treater at average temperature	9.0	9.0	8.9	6.6	8.4	8.1	14.6
Power: Average per 24 hours:							
Amperes 240 V. side	47	44	-	-	37	37	30
Kilovolts	44	43	-	-	43	38	49
Milliamperes	145	145	-	-	123	136	106

Tests Nos. 5 & 6 - Power on treaters 1, 2, 3 and 4.

The best visual clearance, apart from the recovery shown, were tests Nos. 5 and 6, with power on all 4 treaters and a velocity of 9 ft. per second in the treater.

The dust recovered from Treaters Nos. 1 and 2 indicates the ease with which this type of smoke can be Cottrelled. Test No. 6 practically duplicates the same conditions as Test No. 5 only with this difference, Test No. 5 showed a much larger amount of dust per cubic foot of gas treated. This can be accounted for by the fact that previous to Test No. 5 the smoke had been withdrawn from the main flue at a velocity of only 25 ft. per second, whereas for Test No. 5 the velocity was increased to 50 ft. per second. This resulted in the solids, which had previously settled out from the smoke in the flue, being drawn into the treater by the increased suction for this test.

The dust assays on Table No. 3 show for Tests Nos. 5 and 6 the advantage which can be taken of selective separation.

The question now arises: What amount of mechanical dust does this smoke carry? How much will settle out, and at what velocity?

Tests Nos. 7 & 8 - No power on the treaters.

Accordingly, the treater was used for Tests Nos. 7 and 8 as a settling chamber, the plates and rods being rapped every hour, otherwise the dust would build up and reduce the velocity. Test No. 7 was run at about the same velocity as Tests 5 and 6, namely 9 ft, resulting in a recovery of 83.7%, and Test No. 8 at a velocity of 6.6 ft. per second showed only about 1% better recovery for the lower velocity.

This would indicate that advantage could be taken of this large amount of mechanical dust carried by the smoke, namely, the installation of a dust settling chamber, where the temperature can be maintained as high as possible, with a velocity of 8 ft. per second. I would suggest here, that a Roesing system of suspended wires should be installed to facilitate the separation of this mechanical dust. An installation of this type would result in a recovery of 80% of the solids high in copper and silver, and in a condition to be easily handled as calcines in the reverberatories. This dust would carry about the following analysis:

Cu	Ag	Pb	As
5.0%	7 - 8 ozs.	2 - 3%	8%

The higher the temperature can be maintained the lower will be the lead and arsenic in this product.

Tests Nos. 9, 10 & 11 - No power on Treaters Nos. 1 and 2, power on Treaters Nos. 3 and 4.

This division takes in Tests Nos. 9, 10 and 11, and makes the pilot plant into a combination settler and Cottrell, using Treaters Nos. 1 and 2 without power as a settler, and Treaters Nos. 3 and 4 as a Cottrell.

This combination was the outcome of the results indicated by Tests Nos. 5, 6, 7 and 8, and accordingly it was followed out with very encouraging results. While the settling capacity was limited to a distance of some 31 feet, at a velocity of 8 ft. per second, the recoveries resulting from this combination of settler and treater were 97%. While Test No. 11 with a velocity of 14.6 ft. per second gave 97% recovery, 7% of the dust recovered was from the fan housing, and the visual clearance was not good, indicating as would be expected, that this velocity was too high for the combination settler-treater.

The dust recovered from the charged sections of the treater indicates that the smoke still carries some very finely divided dust, and that the first bank of charged treater catches 75% of the solids and the second 25%. The analysis of the dust caught by the first charged treater indicates that this should be a hot Cottrell, the higher the temperature the lower will be the lead and arsenic as was pointed out for settling chamber conditions, under the heading of Tests Nos. 7 and 8 "No power on treaters". This hot Cottrell would give a product easy to handle, with about the following analysis:

Cu	Ag	Pb	As
2.5%	4 ozs.	4%	17%

The gases now cleaned so far as the economically recoverable copper and silver, still carry a small amount of lead 4%, arsenic 24%, and are highly charged with sulphuric acid. This can be cleaned successfully in a cold Cottrell at a temperature of 85° to 90° C. for good visual clearance. The resulting product being a very corrosive wet black mass, having the following analysis:

Cu	Ag	Pb	As
.5%	1 - 2 ozs.	4 - 5%	26 - 28%

Table No. 2 shows complete operating data for each test.

Table No. 3 gives the assays of the dust precipitated for copper, silver, lead and arsenic for each test, according to the hoppers under their respective treaters.

Other Data:

Throughout this test there were 15.6 roasters operating.
Plate area, Tests Nos. 1 - 10 = 48 sq. ft.
Ratio stack area to plate area 1 - 5.
Ratio stack area to plate area (Test No. 11) = 1 - 3.

Total dust recovered from treaters during test	= 54.974	S.Tons.
Total dust lost from stack	= 2.358	S.Tons
Total feed to treater	= 57.332	S.Tons.

Duration of tests 913 hours or 38 days.
or a daily recovery of 1.5 S. Tons.

Average volume of smoke treated 19,050 cu. ft. per minute at treater temperature of 113° C.

Summary of Tests

The roaster smoke can be very efficiently cleaned without conditioning, with economical selection of the copper and silver at a velocity of 8 ft. per second and with a low power input. I wish to emphasize that these tests on roaster smoke were on the treatment of gases particularly favorable to the process on account of their high acid content and also because of the large amount of mechanical dust carried, that the process seems to lend itself more economically to a settling treatment followed by a hot Cottrell. Following this, for efficient clearance and selective precipitation, a cold Cottrell in series, with a corresponding temperature drop. The results of the tests carried on from April 13th to June 14th, were:

1 Proof that 80% of the mechanical solids can be recovered in a settling chamber, at a velocity of 8 ft. per second, and at a temperature of not less than 115° C.

2 That by treatment of the gases after settling at different temperatures, by two banks of treaters in series, and with the necessary drop in temperature between treaters, selective precipitation is possible, and can be successfully operated, provided the correct temperatures are maintained.
For example:
Collecting 75% of the remaining solids after settling, at a temperature as near to that of the settling chamber as possible, at a velocity of 8 ft. per second, and an effective electrode length of 10 ft., then by further cooling the gases to 85° to 90° C. and cold Cottrelling for the recovery of arsenic and sulphuric acid.

Recommendations:

From experience obtained it is evident that conservation of the heat in the smoke is of vital importance. Starting with a temperature of only 190° C. in the main roaster flue and requiring a temperature of not less than 115° C. for the hot Cottrell, means that insulation and exclusion of air leakage is absolutely necessary for successful operation. I would suggest:

First. The down comer from the present roaster flue to the proposed settling chamber be of steel, and should be insulated.

Second. For the settling chamber. Hard burned common brick. Tar painted inside and out, and the chamber be reinforced with bands to prevent movement caused by temperature changes.

Third. The hot Cottrell treaters should be built of acid resisting brick, also tar painted to prevent air leakage. There may be a possibility of a damp or even a wet condition at this point should the temperature of the settling chamber fall for any reason. The same applies to the cold Cottrell treaters.

Fourth. In the construction of the treaters, the main supporting members should be protected from contact with the dust as much as possible. Porcelain insulators should only be used, also a 2" Ring-Gap around the hot electrodes in place of portholes in the sheet iron division walls of the discharge electrode suspension housing.

Yours very truly,

W. E. King.

In charge Experimental Roaster Cottrell.

- Smoke Investigation -

TABLE II

Test number	1	2	3	4	5	6
Test started	Apr. 13	Apr. 14	Apr. 21	Apr. 27	May 2	May 12
Duration of test - hours	17	32-1/3	[illegible]-2/3	87-3/4	114-1/3	119
Dust: Lost from sampling stack - S. Tons	-	0.021	0.046	0.003	0.037	0.331
Recovered from treater - S. Tons	1.236	1.905	3.024	2.760	12.118	6.696
Total to treater - S. Tons	-	1.926	3.070	2.763	12.155	7.027
Recovery, %		99 +	98 +	99 +	99 +	95.5
Per cu.ft. of gas at inlet, in grams	.106	.082	.057	.033	.076	.041
Per cu.ft. of gas at outlet, in grams	.00004	.0005	.0006	.00003	.0002	.0017
Distribution in hoppers - Lbs.						
Hopper No. 1 Mechanical dust	162	221	329	340	1,194	549
2 1st section of treater	1,080	1,688	2,367	2,041	6,928	3,984
3 " " " "	577	993	1,444	1,407	5,657	3,049
4 2nd section of treater	311	527	720	719	5,366	2,364
5 " " " "	146	230	483	525	2,758	1,476
6 3rd section of treater	90	77	254	218	1,165	734
7 " " " "	54	34	245	128	775	701
8 4th section of treater	33	32	116	95	283	364
9 " " " "	20	9	90	47	110	171
Cleanings from fan house	-		-	-		-
Total, Lbs.	2,473	3,811	6,048	5,520	24,236	13,392
Temperature: °C.						
Main roaster flue to stack	193°	190°	-	-	-	-
Inlet pipe to treater	133°	138°	129°	126°	135°	131°
Treater inlet	128°	133°	123°	114°	129°	125°
Treater outlet	87°	85°	83°	75°	103°	102°
Treater average	110°	109°	103°	95°	116°	113°
In sampling stack	76°	75°	66°	64°	88°	88°
Volumes: Cu. ft. per minute:						
Inlet pipe to treater	8,520	10,920	12,780	14,280	21,180	21,720
Outlet in sampling stack	18,900	19,140	18,240	18,720	24,480	24,780
Air dilution, %	55	43	30	24	13	12
Velocity: Ft. per second:						
Inlet pipe to treater	20.1	25.8	30.2	33.7	50.0	51.2
Outlet in sampling stack	32.3	32.7	31.1	32.0	41.8	42.3
In treater at average treater temperature	7.1	7.2	6.9	7.0	9.0	9.0
Power: Average per 24 hours:						
Amperes 240 V. side transformer	35	30	26	37	47	44
Kilovolts on treater side	37	48	47	42	44	43
Milliamps	100	95	76	119	145	145

TABLE II (Cont'd)

Test number	7	8	9	10	11
Test started	May 19	May 24	May 28	June 3	June 14
Duration of test - hours	74-1/2	71	102-2/3	96-1/3	106-1/3
Dust: Lost from sampling stack - S. Tons	0.795	0.493	0.218	0.187	0.227
Recovered from treater - S. Tons	4.092	2.749	6.989	6.078	7.327
Total to treater - S. Tons	4.887	3.242	7.207	6.265	7.554
Recovery, %	83.7	84.8	97.0	96.8	97
Per cu. ft. of gas at inlet, in grams	.049	.0489	.054	.049	.052
Per cu. ft. of gas at outlet, in grams	.007	.0059	.0014	.0013	.0014
Distribution in hoppers - Lbs.					
Hopper No. 1 Mechanical dust	522	451	783	681	639
2 1st section of treater	1,286	1,068	1,955	2,091	1,684
3 " " " "	1,245	849	1,713	1,609	1,557
4 2nd section of treater	1,115	805	1,460	937	1,471
5 " " " "	1,102	639	1,095	1,197	1,092
6 3rd section of treater	1,108	651	3,414	2,210	2,930
7 " " " "	806	434	2,108	1,876	2,232
8 4th section of treater	681	396	1,060	1,106	1,398
9 " " " "	320	205	391	449	541
Cleanings from fan house	-	-	-	-	1,111
Total, Lbs.	8,185	5,498	13,979	12,156	14,655
Temperature: °C.					
Main roaster flue to stack	-	-	-	-	-
Inlet pipe to treater	133°	132°	127°	108°	137°
Treater inlet	128°	126°	122°	103°	131°
Treater outlet	113°	104°	108°	100°	101°
Treater average	120°	115°	115°	101°	116°
In sampling stack	97°	84°	88°	86°	78°
Volumes: Cu. ft. per minute:					
Inlet pipe to treater	20,160	14,100	19,620	19,920	20,760
Outlet in sampling stack	24,480	17,760	22,920	22,680	23,040
Air dilution, %	18	21	14	12	10
Velocity: Ft. per second:					
Inlet pipe to treater	47.5	33.2	46.3	47.0	49.0
Outlet in sampling stack	41.8	30.3	39.2	38.7	39.4
In treater at average treater temperature	8.9	6.6	8.4	8.1	14.6
Power: Average per 24 hours:					
Amperes 240 V. side transformer	-	-	37	37	30
Kilovolts on treater side	-	-	43	38	49
Milliamps		-	123	136	106

TABLE III

DUST ASSAYS

Hopper No.		Test No. 1				Test No. 2				Test No. 3			
		Cu	Ag	Pb	As	Cu	Ag	Pb	As	Cu	Ag	Pb	As
1	Mechanical dust	6.54	9.6	2.8	-	6.89	8.4	3.7	7.6	6.36	11.2	2.8	-
2	1st section of treater	5.22	7.3	3.4	-	5.87	7.6	3.8	11.3	5.56	9.7	4.0	-
3	" " " "	4.47	6.4	3.7	-	4.57	6.6	4.3	13.2	4.28	7.8	3.8	-
4	2nd section of treater	4.82	6.6	3.5	-	3.55	4.9	4.8	15.7	3.60	7.2	4.2	-
5	" " " "	4.31	6.1	3.5	-	1.22	3.8	6.6	20.4	1.80	4.9	5.2	-
6	3rd section of treater	4.24	6.0	3.4	-	1.58	2.8	5.9	18.3	1.36	3.8	4.9	-
7	" " " "	3.53	5.5	3.3	-	.75	1.7	7.7	20.0	.56	2.1	5.3	-
8	4th section of treater	3.29	5.2	3.6	-	.90	1.7	6.4	19.9	.44	1.7	4.6	-
9	" " " "	3.02	4.9	3.9	-	1.65	2.8	4.3	17.5	.28	1.7	4.6	-

Power on all four sections of treaters.

Hopper No.		Test No. 4				Test No. 5				Test No. 6			
		Cu	Ag	Pb	As	Cu	Ag	Pb	As	Cu	Ag	Pb	As
1	Mechanical dust	5.64	7.6	2.9	-	6.68	8.2	2.9	9.2	5.51	8.3	2.3	10.7
2	1st section of treater	3.92	6.8	3.2	-	5.68	7.7	3.3	10.6	4.39	7.4	3.2	13.0
3	" " " "	3.56	5.1	3.3	-	5.04	7.3	3.7	12.5	3.60	6.2	2.8	14.0
4	2nd section of treater	3.32	2.1	3.5	-	4.80	5.8	3.8	14.7	3.25	5.1	3.1	16.2
5	" " " "	1.28	2.0	4.5	-	3.08	4.4	4.0	19.2	1.58	3.2	4.0	23.1
6	3rd section of treater	.44	1.4	3.8	-	2.36	4.3	4.2	22.2	1.03	2.9	3.4	22.4
7	" " " "	.16	Tr	4.8	-	.32	2.4	6.0	26.7	.19	1.0	4.1	23.3
8	4th section of treater	.08	Tr	4.0	-	.12	1.5	6.9	28.2	.08	1.0	4.4	27.9
9	" " " "	.04	Tr	2.7	-	.08	1.3	7.6	27.4	.04	.9	4.9	23.9

Power on all four sections of treaters.

TABLE III (Cont'd)

DUST ASSAYS

Hopper No.		Test No. 7 Cu	Ag	Pb	As	Test No. 8 Cu	Ag	Pb	As	Test No. 9 Cu	Ag	Pb	As
1	Mechanical dust	5.44	7.5	2.6	8.4	6.78	8.5	2.6	5.3	6.79	10.3	2.4	7.4
2	1st section of treater	5.83	8.0	2.8	7.5	7.09	8.4	2.0	9.3	6.86	11.8	2.5	8.4
3	" " " "	6.54	8.0	2.5	7.0	7.05	9.0	2.3	9.6	6.82	11.9	2.3	8.4
4	2nd section of treater	5.40	8.0	2.7	10.1	6.62	8.6	2.3	9.8	6.35	11.3	2.7	9.1
5	" " " "	4.72	6.5	2.7	10.6	5.68	7.5	2.5	10.5	6.16	9.5	2.3	10.9
6	3rd section of treater	5.48	7.1	2.6	11.8	5.49	7.9	2.5	12.6	4.56	7.0	3.2	12.5
7	" " " "	5.04	5.7	2.8	9.9	4.82	7.4	2.5	14.2	1.09	3.9	4.3	21.6
8	4th section of treater	5.04	5.3	2.7	12.4	4.94	7.4	2.3	13.8	1.01	2.8	5.3	28.4
9	" " " "	4.81	5.2	2.4	8.6	3.29	4.7	2.3	17.6	.59	2.6	4.7	26.8

No power on treaters for Tests Nos. 7 and 8.
Power only on sections 3 and 4 for Test No. 9.

Hopper No.		Test No. 10 Cu	Ag	Pb	As	Test No. 11 Cu	Ag	Pb	As
1	Mechanical dust	6.76	9.8	2.9	8.0	7.52	10.5	2.9	2.7
2	1st section of treater	6.52	10.6	3.1	7.7	7.21	11.1	2.8	4.3
3	" " " "	6.56	11.1	2.7	8.7	7.33	10.4	2.7	5.2
4	2nd section of treater	6.04	10.4	3.0	8.6	6.94	10.2	2.9	8.1
5	" " " "	5.76	7.0	3.0	9.8	6.71	10.9	2.8	8.4
6	3rd section of treater	4.00	4.6	3.5	13.6	5.38	10.6	3.1	8.0
7	" " " "	1.16	3.0	4.6	21.0	3.43	10.6	3.5	14.2
8	4th section of treater	.64	1.8	5.1	25.1	1.99	8.0	4.9	19.2
9	" " " "	.16	Tr	4.6	24.0	1.01	5.5	4.2	20.7
	Fan house clean-up					1.33	3.1	3.5	20.4

Power only on sections 3 and 4.

Oroya, Perú,
July 13, 1928.

Mr. Harold Kingsmill,
General Manager,
La Oroya.

Dear Sir:

Roaster Experimental Cottrell

Attached please find a report on all operations of the Roaster Experimental Cottrell from the start up to date.

The conclusions which are to be drawn from these experiments may be summarized as follows:

First: Owing to the presence of considerable quantities of sulphuric acid, which is an excellent conditioner, the deposition of solids from the roaster gases is rendered easy.

Second: Due to the presence of this acid, no water conditioning is necessary.

Third: Because of the excellent conditioning due to the presence of acid, high recoveries of the solids well over 90% are easy of attainment.

Fourth: It has been proved (See tests 7 & 8) that a good serviceable separation of the valuable metals from the arsenic can be made by using a dust chamber ahead of the Cottrells.

Though all of the points proved are of importance and of gratifying outcome, by far the most important is the fourth, because it appears that most of the values may be collected in a dust chamber while the more volatile arsenic may be passed on to the Cottrell plant where it is deposited as a more or less valueless fume.

If this scheme can be successfully worked out, it will do away with all of the retreatment of arsenic and it's segregation by means of kitchens, baghouses, etc. The arsenic fume would simply be removed from the hoppers of the Cottrell plant and dumped as waste.

To test this scheme more adequately, there is now being built a small dust chamber ahead of the Experimental Roaster Cottrell. With this it is proposed to determine with accuracy the feasibility of this possible process. The location of this dust chamber is shown on the attached blueprint #5289.

The results from this experiment will form the subject matter of another and final report with definite recommendations.

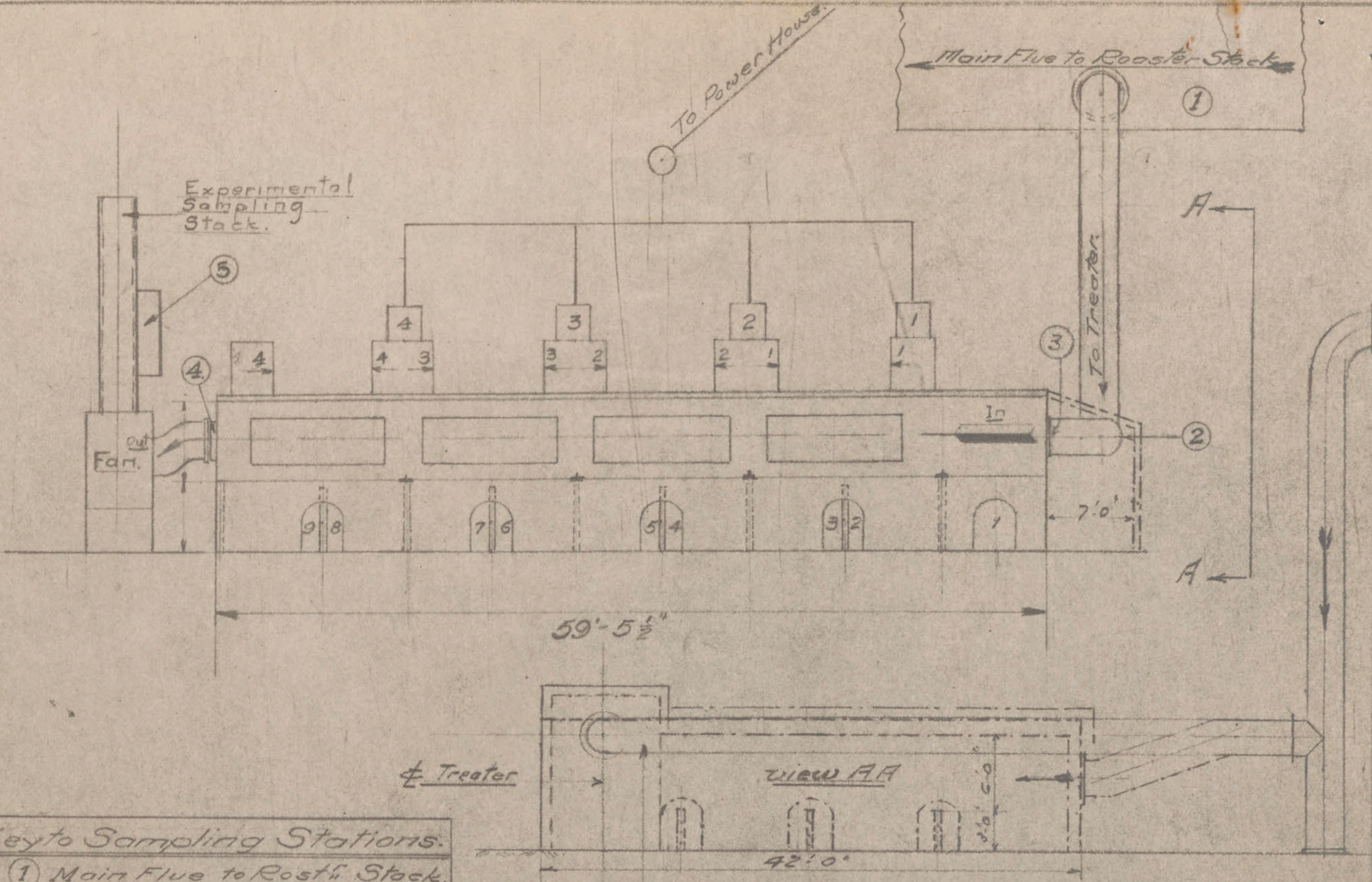
Yours very truly

B. T. Colley

B T Colley

BTC:RR
Encl.

cc W.W.F.
W.E.K.



Key to Sampling Stations.	
Nº (1)	Main Flue to Rost'g Stack.
" (2)	Inlet Pipe to Treater.
" (3)	Treater Intake.
" (4)	" Outlet.
" (5)	Sampling Station on Stack

CERRO DE PASCO COPPER CORP.
OROYA - PERU.

Roaster Plant.

Experimental Cottrell.

DWG BY: M. Palacios R.
SCALE
TRACED:
DATE: 4-30-1928.
CHECKED:
APPROVED:

Nº 5289.