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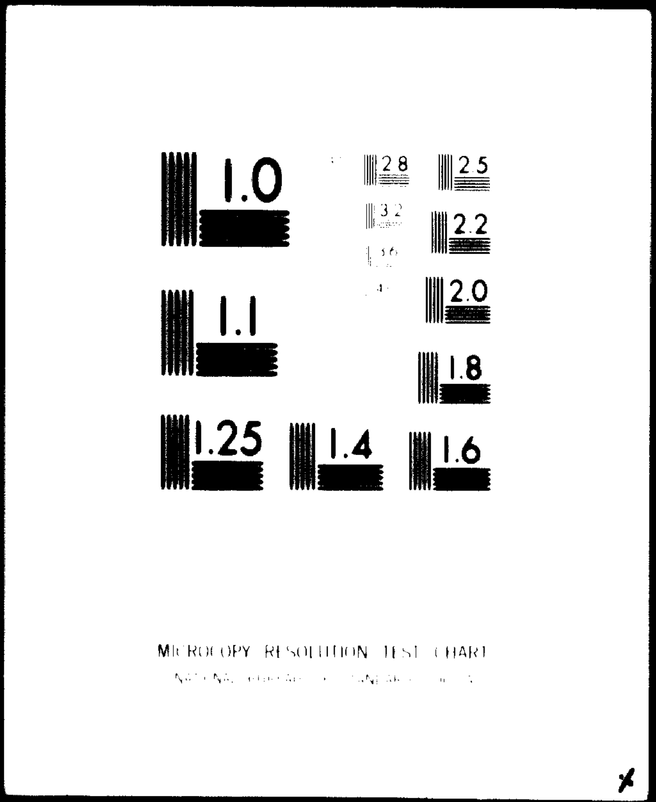
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SURVEYER, NENNIGER & CHÊNEVERT INC.

CONSULTANTS MONTRÉAL

REPORT ON
EXPERIMENTAL PRODUCTION PLANT
FOR ASBESTOS PROCESSING
COCHABAMBA, BOLIVIA, UNDP/SF
SYMBOL: BOL-20
PHASE I
EVALUATION OF ASBESTOS MINERAL ORE
SNC CONTRACT NO 2974

Prepared for:

The United Nations Industrial
Development Organization
UNIDO
AUSTRIA.

Prepared by:

The Mining & Metallurgy Department
Surveyer, Nenniger & Chênevert Inc.
MONTREAL
CANADA.

Distribution: August 5, 1970

UNIDO (Six copies in English)

UNIDO (Six copies in Spanish)

SNC Inc. (Four copies in English)

SNC Inc. (Four copies in Spanish)

SURVEYER, NENNIGER & CHÊNEVERT INC.
CONSULTANTS
OWNED AND OPERATED BY ENGINEERS

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1550 DE MAISONNEUVE BLVD WEST
MONTREAL 107, CANADA

August 5, 1970

Our ref. 2974

Mr. D.C. Newton,
Chief, Procurement Operations Unit,
UNIDO,
P.O. Box 707,
A-1011 Vienna,
AUSTRIA.

re: Experimental Production Plant for
Asbestos Processing - Contract 70/15

Dear Mr. Newton:

Please find attached our final report of Phase I of the project "Experimental Production Plant for Asbestos Processing, Cochabamba, Bolivia, UNDP/SF Symbol: BOL-20", Contract No. 70/15.

Our conclusions indicate that the Bolivian fibre can be successfully cleaned and processed. However, it is weaker than competitive South African fibre and may therefore have to be sold at a discount on the world market. This does not exclude the possibility of using it economically for asbestos cement production, especially in Bolivia. Based on the recoveries obtained from the different samples, 3000 - 4000 tons of concentrate from the Filadelfia mine would produce 1500 tons of fibre. To obtain 1500 tons of fibre from the San Francisco and Tres Amigos mines would require from 5000 - 8000 tons of concentrate respectively. The grades obtained were somewhat lower than expected. The fibre was predominantly grade D. Target production figures and in-put are shown in section 9 of our report.

The information in our possession on the work done to date does not indicate whether sufficient reserves are available to produce 1500 tons of fibre per year in the experimental plant and, even much less, the 10,000 tons per year projected for the future. Before proceeding with final feasibility, design and construction, we therefore recommend that the deposits be explored further, both geologically and for economics of mining. We suggest that a minimum of ten year ore reserves be proven to make sure that Bolivia does not find itself in the unfortunate position of owning an inoperative plant.

.../2

Attached to this report you will find a proposal by Watts, Griffis & McOuat Ltd. to carry out this investigation. The investigation may not necessarily have to be as extensive, but we recommend that you retain a competent consulting firm for this purpose before proceeding with Phase II of the present study. We are prepared to accept a delay and remain with our original quoted price plus reasonable escalation charges based on acceptable indices.

We also recommend the adoption of our proposal outlined in Item 11.2 (v. c) of Progress Report No. 2 to substitute South African fibre with Bolivian fibre and test same for the contemplated Bolivian asbestos cement plant. The cost for this testing was estimated at $750. U.S.

Thank you for entrusting us with this interesting and important assignment. We hope we have satisfied your requirements for the first phase and are at your disposal for further discussions.

Yours very truly,

SURVEYER, NENNIGER & CHENEVERT INC.

J. Hahn
Vice President - Development.

/fp

CONTENTS

SUMMARY

A trip to the crocidolite asbestos deposits of the Alto Chapare region of Bolivia was made and a sample of approximately two tons of concentrated fibre-bearing material was collected from several mines in that region. The sample was representative of the surface exposures of the asbestos ore, but may not be representative of the material to be found at depth.

The samples were processed through the pilot plant of the Quebec Department of Natural Resources and the asbestos fibre extracted. Quebec Standard Tests, Magnetic Rating, Surface Area, McNett Rating, freeness and strength unit tests were carried out. The fibre can be processed by normal milling operations, but is weaker than the South African Blue Fibre.

Provided raw material is available, 1500 tons per year of predominantly grade D fibre can be produced from the Filadelfia and San Francisco Mines.

1. INTRODUCTION

On March 5th, 1970, the United Nations Industrial Development Organization awarded a contract to Surveyer, Nenniger & Chenevert Inc. "for testing of asbestos samples, preparation of a feasibility study, selection of a manufacturing process, supply of equipment, spares and designs and provision of services for the erection and commissioning of an experimental production plant for asbestos processing".

This report covers Phase I of the project, namely, the Evaluation of Asbestos Mineral Ore of the Alto Chapare Region in Bolivia.

Surveyer, Nenniger & Chenevert Inc. retained the services of Watts, Griffis and McOuat Limited, consulting geologists, to supervise the gathering of a representative sample of the asbestos ore.

The sample was shipped and the asbestos fibre was extracted and tested at the Pilot Plant of the Quebec Department of Natural Resources.

The testing was supervised, data tabulated and analyzed by Surveyer, Nenniger & Chenevert Inc. in Montreal. Mr. Phil Wiser, world renowned asbestos consultant, assisted Surveyer, Nenniger & Chenevert Inc. in the supervision and evaluation of tests.

2. ACCESS AND LOCATION

In the Alto Chapare region of Bolivia, about one hundred kilometres northeast of Cochabamba is a zone which has long been known for its surface showings of crocidolite asbestos.

Access to this area has been extremely difficult in the past and the current route to the properties is an experience for any traveller. The road from Cochabamba climbs to somewhere between 4,500 and 4,800 metres in the Andes before descending very rapidly to the dense tropical jungles of eastern Bolivia. The drop of 4,000 metres is accomplished in a very short horizontal distance via a narrow road cut into the steep mountain sides. This road is open to one way traffic only and has a specific direction for each day of the week.

Once in the Alto Chapare region access to the individual properties is via foot, mule or in one case by an aerial tramway, on which one pulls oneself for about sixty metres along a cable suspended over a swift mountain river some twenty metres below.

The transport of materials and equipment to the mines as well as the ore from the mines, has probably been the single, most important reason for the lack of development of the deposits. This situation will be improved by the end of this year when it is expected that a new all-weather road through to Villa Tunari will be completed. A substantial portion of the road has been asphalted and it is expected that the remainder of the asphalting will be done by the end of next year.

This road will pass within two hundred metres of the Filadelfia mine and within two to four kilometres of the other mines being considered for exploitation.

The Alto Chapare region receives the greatest amount of rainfall of any region in Bolivia with an annual average of approximately 4,000 millimetres. Most of this falls during the period from December to March inclusive. At this time of the year, it is almost impossible to carry on normal mining operations.

Dense growth covers most of the region except for those steep slopes where erosion has occurred due to the slide of water saturated material.

3. MINING CONCESSIONS

All mining is done on concessions which have been awarded by the government. The exact boundaries of these concessions are not known (see Sketch No. 1). The concessions are merely defined as being a number of hectares in a certain region and the annual nominal lease payments are based on that number. It is probable that boundary disputes will arise in the event that any significant discoveries are made or if the economic outlook for the known deposits improves considerably.

The concessions are generally owned by persons resident in Cochabamba who assign associates to supervise the mining operations during the intermittent periods when the mines operate. Workers for the mines are almost entirely Quechua Indians from Cochabamba.

The main concessions visited were:

3.1 Filadelfia

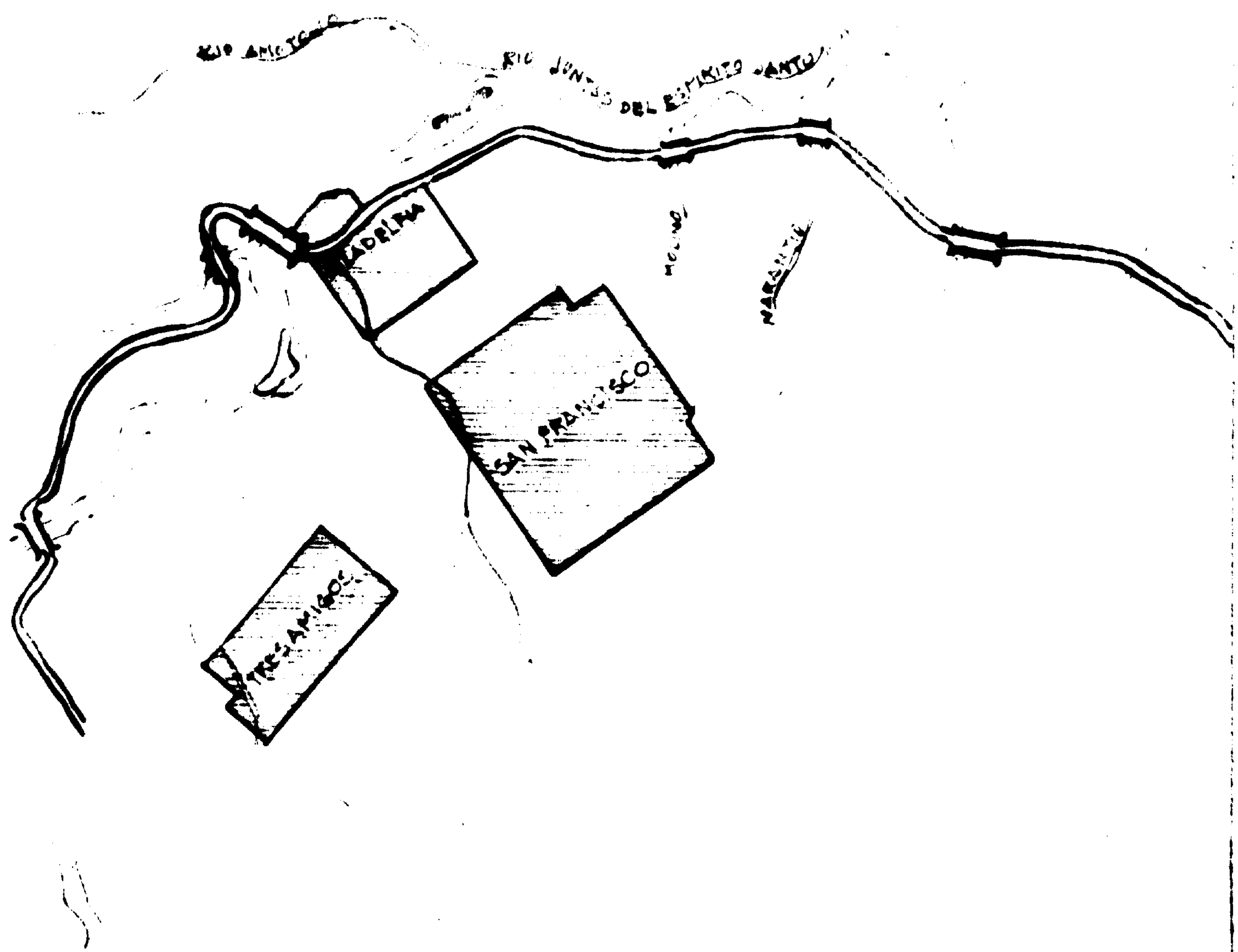
This property is the most accessible and has probably been responsible for the largest proportion of past asbestos fibre production. It still looks as the most promising prospect for future production. It is presently inactive and considerable work had to be done to recover a sample.

The Filadelfia mine was formerly owned fifty percent by Mrs. Wormald and fifty percent by Mr. Llubetic, both of Cochabamba. Mrs. Wormald has become involved in some lawsuits over alleged misrepresentation of mineral properties and has left Bolivia. Her portion of the Filadelfia mine has been taken over by Mr. Vila Plano of Cochabamba. The person who appears to have had the greatest actual contact with the property while it was in production is Mr. Reinicke. He was present during the sampling.

The Filadelfia has been mined entirely by surface methods. The dimensions of the excavation are sixty metres in length, thirty metres in width and ten metres in depth.

Several scattered veins were observed around the pit. The only fibre actually being produced at the present time is through the hand picking of fibre stringers by two women in the overburden along the west wall. It is claimed that there are veins of long fibre in the pit floor which are now covered with soil and waste from veins which were easier to get at in the walls of the excavation. There is possibly some justification for believing this claim as several rocks were accumulated in one area which contained good fibre but which would have required crushing to liberate.

ALTO CHAPARE REGION
MINING CONCESSIONS
SKETCH No 1



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3.1 Filadelfia (cont'd)

The types of fibre included cross fibre, slip fibre and mass fibre with the latter being most predominant. A good percentage of the fibre contained in the hard rock which could not be hand cobbed without drilling, blasting, and crushing was cross fibre and thus this type may increase with depth.

From what could be observed, it would appear that the Filadelfia mine offers the best possibilities of any of the properties visited for fibre in the quantities required.

3.2 San Francisco

The San Francisco mine is located some two to three kilometres from the main road and one stream, the Crystal Mayu, must be crossed. The topography in the area is very rugged.

The owner of this concession is Oscar Tejada of Cochabamba, while his brother, Lucio, is resident on the property during working periods.

Several locations on the property are being worked. Three of those visited are mined by underground adits driven normal to the bedding planes and intersecting small veins at random intervals. Two other locations were surface showings.

Almost all fibre was of the mass variety. In all of the underground workings, extremely wet conditions prevailed and the fibre was saturated. Some isolated pockets of long fibre would be encountered, but the bulk of the fibre was less than twelve millimetres. A fibre content of between three to five percent was visible in most workings.

Ventilation in the adits was poor and working conditions very difficult. Lighting was provided by carbide lamps. Hand drilling of short holes, followed by blasting, would allow an advance of up to a metre. Tools used were picks and bars. A minimum of scaling and timbering was done and loose rock was evident everywhere.

The ore reserves calculated by GEOBOL, (Servicio Geologico de Bolivia) during their geological survey in 1967, suggested that the greatest tonnage of reserves was located on the San Francisco property.

3.2 San Francisco (cont'd)

If this is in fact the case and it is desired to supply a substantial portion of the fibre requirements for the experimental plant from this deposit, then considerable thought and money is going to have to be allocated to prepare access, defining of ore blocks and methods of mining.

3.3 Tres Amigos

Located on a sizeable stream, the Minas Mayu, about four kilometres from the main road, the Tres Amigos concession also presents some very difficult access problems. The topography in the area is very rugged. Access to the property includes the use of an aerial cableway suspended across the Minas Mayu.

The property is owned and operated by Alphonso Tejada who was present during the visit to the property.

Five working places were visited. One or two men were hand cobbing fibre at three locations. The fibre is generally all of the mass variety and short. Only one vein containing fibre greater than twenty-five millimetres was observed and it was located in a steep face. With the present equipment, it would not be possible to recover this fibre.

All of the workings at Tres Amigos were surface showings and the fibre was being recovered from unconsolidated material. A notable characteristic of the fibre exposures at Tres Amigos is that all will require substantial amounts of overburden to be removed if fibre production is to be increased.

With the combination of access difficulties, short fibre and extensive overburden, the economic attractiveness of the Tres Amigos deposits would appear to be rather limited pending further exploration and development.

3.4 Rosa and Corpus Christi

Both of these concessions are owned by Mr. Reiniche of Cochabamba.

The only exposure on the Rosa property is where the new road under construction has cut through overburden revealing veins of blue material which is largely clay but does contain some traces of fibre. The concession is, therefore, only an interesting prospect at the moment.

3.4 Ross and Corpus Christi (cont'd)

The Corpus Christi property has two short adits which have been following small stringers of poor quality fibre. The concession looks to be of limited economic interest and it was recommended that operations cease.

4. GEOLOGY

Geological mapping of the general region has been carried out by GEOBOL (Servicio Geologico de Bolivia) and further detailed work done on the Filadelfia and San Francisco properties. However, no drilling has ever been done anywhere in the region.

None of the geologic reports published have examined the economic attractiveness of the asbestos deposits and it is in this area that much additional work needs to be done.

The crocidolite is generally found in a series of quartzites and iron-bearing sandstones. Overlying these rocks is a black, argillaceous shale followed by a dolomite. The thickness of the quartzites and sandstones varies and in one adit on the San Francisco concession, they were exposed for sixty metres.

The structural geology of the area is extremely complex. Numerous folds were observed as well as extensive faulting. The dense growth and overburden make it difficult to do any detailed interpretation of the area.

Other minerals were noted in the area. Extensive deposits of magnesite exist which are reported to be of good grade. In one adit on the San Francisco property pyrite crystals were intermixed with the crocidolite. On the Tres Amigos property, isolated rocks of specular hematite were observed in several locations. A substantial vein is reported to exist. Malachite was also visible in samples taken from one crocidolite location.

The fibre veins are very irregular in their number and orientation. In some locations they are conformable with the bedding planes and in others at right angles to the beds. Frequently the orientation is neither one nor the other.

All of the fibre observed was very loosely bonded and no difficulties should be encountered in opening this fibre. An exception to this may occur at depth in the Filadelfia property. Several large rocks left over from previous mining, show a fibre that is much more regularly oriented and bonded tighter. The host rock for this fibre is of a colour and appearance similar to crocidolite and presumably is a closely related member of the amphibole family such as riebeckite.

5. MINING METHODS

Mining to date has been entirely by primitive methods. Labour is in plentiful supply and inexpensive. The only tools are picks and shovels. Dynamite is purchased and used where ground conditions require it.

Mining usually originates at a surface exposure of fibre and follows that vein until the overburden becomes too great or, in the case of adits, the distance from fresh air is too great.

It is certain that before any increased production of fibre can be contemplated, it is going to be necessary to formulate definite mining plans which are supported by adequate equipment and facilities. The personnel who are to operate the mines will also require supervision and training during any changeover period.

Transportation of fibre from the mines is presently by mules. To get the fibre to a point where it can be loaded onto mules usually requires that the workers transport it on their backs for several hundred metres over some very difficult terrain.

At present, production from the San Francisco and Tres Amigos properties is about five to ten tons per month. To achieve the required production of 1,500 tons of fibre per year over an eight-month period (due to rainy season), or roughly 200 days, will require 7.5 tons of fibre or 25 tons of concentrate per day. This is absolutely impossible under present conditions.

If one assumes that the recoverable fibre content of the rock is four percent, then this would mean a daily mining rate of two hundred tons of ore plus much greater quantities of overburden at most locations. Again, this is just not physically possible at present.

6. SAMPLING

The objective of the visit to the Alto Chapare was to obtain a five ton sample representative of the asbestos ore that would be processed in the proposed plant.

It was not possible to gather five tons for two reasons:

1. There was not sufficient exposed fibre-bearing ore.

2. The fibre which was exposed was not considered to be completely typical of that which would likely be found at depth.

Samples of approximately two tons were taken. These were felt to be representative of the material which would be mined in the first year of production. Beyond this period, it is impossible to confirm the continuity of this fibre to depth. To confirm the continuity of fibres and obtain representative samples for future years would require extensive and concentrated testing which was beyond our scope of work.

Some of the samples were pre-concentrated, that is, they had been hand cobbed and probably contained up to fifty percent fibre.

Most samples were placed in jute bags and then in steel drums. A rock pile that was situated near the Filadelfia mine was loaded directly into the drums. This material could not have the fibre released without crushing.

Water content of the loose fibre was very high and drying would have to be carried out before processing.

The final lot of steel drums arrived in Cochabamba on April 17, and the complete sample was due to be air freighted to the Department of Natural Resources in Quebec City. They arrived on April 28.

The samples collected were:

6. SAMPLING (cont'd)

6.1 Filadelfia Mine

Location	Number of Deposit	Quantity
East side of pit	P1, P2	2 bags
East side of pit - short fibre zone	P3, P4, P5, P6	4 bags
West wall - hand cobbed from overburden	P7, P8	2 bags
Fibre stockpile	P9	1 bag
Current workings east side	P10, P11	2 bags
Bulk sample of large rocks		2-1/2 drums

6.2 San Francisco Mine

Location	Number of Deposit	Quantity
Adit currently working	1	2 bags
Adit previously worked	1	2 bags
Surface working face	4	4 bags
Surface fibre stockpile	4	2 bags
Very old adit with pyrite in veins - channel sample	7	1 bag
stockpile at portal	7	1 bag
Sal si Puedas - near river bank		2 bags

6.3 Tres Amigos Mine

Location	Number of Deposit	Quantity
Main workings	A1	1 bag
	A2	2 bags
	A3	2 bags
Fault zone with long fibre	B	1/2 bag
Zone with hematite showing	C	1/2 bag
Steep erosion scar above camp	D1	1 bag
- stockpile	D2	1 bag
- stockpile	D3	1 bag

7. PILOT PLANT

7.1 Sample preparation

When received, the samples were visually examined and grouped as follows:

Sample No. 1 - Long crude fibre to be cleaned by hand to produce Bolivian Grade A.

Sample No. 2 - Large pieces of rock to be processed through the Pilot Plant to produce Bolivian Grade B,C, and D.

Sample No. 3, 4 and 5 - Fine, earthy looking material from the Filadelfia, San Francisco and Tres Amigos mines to be milled separately to produce Bolivian grade B, C, and D.

The five samples were then weighed, dried and weighed again. The results were:

Sample No.	Origin	Dry Weight Kilograms	Humidity %
1	Crude Fibre (not identified)	67	(not measured)
2	Filadelfia Mine (Rock Sample)	642	9.0
3	Filadelfia Mine (Fine Ore)	330	29.0
4	San Francisco Mine (Fine Ore)	586	16.4
5	Tres Amigos Mine (Fine Ore)	328	27.6

7.2 Milling

7.2.1 Sample No. 1

A few kilograms of the crude fibres, sample No. 1, were cleaned by hand. They were not difficult to clean, using a hammer and small quantity of air, under pressure, vacuum or both. No milling was attempted since it would have destroyed the fibres.

7.2.2 Sample No. 2

The rock samples required more than normal milling operations. These numerous milling operations were made to gather as much information as possible for future design of a plant.

7. PILOT PLANT (cont'd)

7.2.2 Sample No. 2 (cont'd)

The ore was crushed in the jaw crusher. The earth adhering to the rock was freed and lifted on Screen F-1. This lifted product F-1 had no commercial value, as such. The earth would have had to be removed by hand before processing the fibre in the fibre circuit. Therefore, Lift F-1 was not included in our evaluation. The fibre was then processed as per the flowsheet included as Appendix 1.

Ten fibre lifts were made. They contained 38.62% of the 642 kilograms processed by weight, as follows:

Dry Weight Processed - 642 Kilograms

Lift No.	F-1	F-2	F-3	F-4	F-5	F-6
Fibre Yield	0.496	4.603	0.549	0.106	1.558	3.187

Lift No.	F-7	F-8	F-9	F-11	Total
Fibre Yield	3.399	3.187	20.963	0.567	38.615%

Products	Distribution in %
Plus 6 mm	9.91
Minus 6 mm - Plus 35 mesh	35.13
Minus 35 mesh	11.72
Filter dust	4.62
Fibre	38.62
Total	100.00

7. PILOT PLANT (cont'd)

7.2.3 Sample No. 3

Following crushing, the fine ore sample from Filadelfia Mine was screened on a 35 mesh to remove earth dust and then passed on a 6.35 mm. opening screen. This first lift, S-2, contained much earth, had no commercial value, and would have had to be cleaned by hand before processing in the fibre circuit. Therefore, this lift was not included in our evaluation. The other products were then processed as per Flowsheet No. 2 included in Appendix 1. Five lifts were made. They contained 48.14% of the 330 kilograms processed by weight, as follows:

Dry Weight Processed - 330 Kilograms

Lift No.	S-2	F-2	F-3	F-4	F-5	Total
Fibre Yield	1.376	6.602	1.513	11.004	27.648	48.143%

Products	Distribution in %
Plus 6 mm.	5.23
Minus 6 mm. - Plus 35 mesh	10.14
Minus 35 mesh	29.61
Filter Dust	6.88
Fibre	48.14
Total	100.00

7.2.4 Sampling No. 4

Following crushing, the fine ore sample from San Francisco Mine was screened on a 35 mesh to remove earth dust and then passed on a 6.35 mm. opening screen. This first lift, S-2, contained much earth, had no commercial value, and would have had to be cleaned by hand before processing in the fibre circuit. This lift was not included in our evaluation. The other products were processed as per Flowsheet No. 3 included in Appendix 1. Five lifts were made. They contained 27.83% of the 586 kilograms processed by weight, as follows:

7. **PILOT PLANT** (cont'd)

Sample No. 4 (cont'd)

Dry Weight Processed - 586 Kilograms

Lift No.	S-2	F-2	F-3	F-4	F-5	Total
Fibre Yield	0.620	1.783	9.070	15.194	1.162	27.829%

Products	Distribution in %
Plus 6 mm.	6.67
Minus 6 mm. - Plus 35 mesh	26.74
Minus 35 mesh	33.80
Filter Dust	4.96
Fibre	27.83
Total	100.00

7.2.5 Sample No. 5

The fine ore sample from Tres Amigos Mine was processed as per Flowsheet No. 4 included in Appendix 1. Four lifts were made. They contained 18.86% of the 328 kilograms processed by weight, as follows:

Dry Weight Processed - 328 Kilograms

Lift No.	D-1	F-2	D-2	D-4	Total
Fibre Yield	2.219	0.278	14.147	2.219	18.863%

Products	Distribution in %
Plus 6 mm.	1.11
Minus 6 mm. - Plus 35 mesh	22.37
Minus 35 mesh	43.79
Filter Dust	13.87
Fibre	18.86
Total	100.00

7. <u>PILOT PLANT</u> (cont'd)

7.2.6 Pilot Plant Comments

During the milling of the four (4) ore samples, it was observed that the rock was very hard to crush, while the fibre was weak and held firmly to the rock. Furthermore, a lot of earth adhered to the ore received. Even if these propertiss and conditions are not ideal for mechanical treatment, clean asbestos fibre can be produced from Bolivian ors by ordinary milling operations.

8. FIBRE TESTING

8.1 At the Pilot Plant Laboratory

8.1.1 Tests Made

All lifts from samples No. 2, 3, 4 and 5 were tested for Quebec Standard Tests, McNett, Surface Area and Magnetic Rating. Procedures used are described in Appendix No. 3.

8.1.2 Test Results

The laboratory test results will be found in Appendix No. 2.

8.1.3 The fibre yield for each grade in percent of tonnage processed was: (Total excludes Lifts F-1 and S-2)

Sample No.	Location	Grade A & B	Grade C	Grade D	Total
2	Filadelfia Mine (Rock Sample)	4.23	11.02	22.87	38.12%
3	Filadelfia Mine (Fine Ore)	2.90	18.38	25.49	46.77%
4	San Francisco Mine (Fine Ore)	0.22	4.63	23.36	28.21%
5	Tres Amigo Mine (Fine Ore)	0.49	2.58	15.79	18.86%

This same data expressed in percent of total fibre recovered:

Sample No.	Location	Grade A & B	Grade C	Grade D	Total
2	Filadelfia Mine (Rock Sample)	11.1	28.9	60.0	100.0%
3	Filadelfia Mine (Fine Ore)	6.2	39.3	54.5	100.0%
4	San Francisco Mine (Fine Ore)	0.8	16.4	82.8	100.0%
5	Tres Amigo Mine (Fine Ore)	2.6	13.7	83.7	100.0%

8. FIBRE TESTING (cont'd)

8.1 At the Pilot Plant Laboratory (cont'd)

8.1.4 Test Result Analysis

These tests can be summarized as follows:

Grade A

The long crude fibre, Sample No. 1, weighed 67 kilograms or less than 3.5% of the total dry weight processed. The other samples yielded almost no additional Grade A fibre. The recovered fibre of Grade A in the samples processed was then less than the 12% asbestos fibre content required.

Grade B

Samples Nos. 2, 3, 4 and 5 yielded 0.8 to 11.1% of Grade B fibres. These percentages fall short of the 40% required.

Grade C

Sample No. 3 yielded 39.3% of Grade C fibre and Sample No. 2, 28.9%. Samples Nos. 4 and 5 failed to yield close to the 30% required.

Grade D

Samples yielded 54.5 to 83.7% of fibres. Only 18% was required.

The tests did show that the fibre contained in the samples gathered was much shorter than expected. The fibre was predominantly a Grade D, while a Grade BC had been expected.

The fibres extracted are very different from sample to sample. To have a uniform end product in the experimental plant, the ore from the different mines will have to be properly mixed, before being processed, to achieve the desired end products.

8. FIBRE TESTING (cont'd)

8.1 At the Pilot Plant Laboratory (cont'd)

8.1.5 Additional Tests Suggested

Preliminary manual tests indicate that the Cochabamba fibres spin better than the South African fibres. However, it is doubtful whether the Cochabamba fibres, due to their lower strength, can be successfully processed through industrial asbestos spinning machines. We could not locate an independant laboratory able to conduct such test. Fibre will have to be submitted to a processing plant for evaluation.

8.1.6 Colour

Since it was found impossible to obtain a reliable colour test through the standard procedure of the Quebec Manufacturer's Association, we have visually compared the Bolivian fibre with standard South African Blue. Our conclusions are that the Bolivian fibre compares well. Its colour would be more acceptable for the manufacture of asbestos paper. Colour is not important for asbestos cement products. The lightest fibre comes from the San Francisco deposits and the darkest from Filadelfia.

8.2 Operating Plant

8.2.1 Freeness

All freeness tests were made in the laboratory of one of the Quebec Asbestos producers. The results will be found in Appendix No. 2. They indicate that the filterability of the fibre is fair.

8.2.2 Strength Unit Tests

Strength unit tests were made in the laboratory of one of the Quebec Asbestos producers. The results are:

Test No. 1:	62.8	strength units
Test No. 2:	61.7	" "
Test No. 3:	58.1	" "

South African:	+ 85	(average expected result)
Canadian :	+ 100	" " "

These results indicate that the fibre is low in strength when compared to the South African blue fibre.

9. QUANTITATIVE STUDY

Using the fibre yield distribution, a quantitative study was made to define the tonnage of concentrate required to produce 1,500 tons of fibre per year. The following table also indicates the tonnage of each grade of fibre expected to be produced:

Mines	Tonnage of Concentrate Required	Gr. A & B	Fibre Yield C	Fibre Yield D	TOTAL
Filadelfia (rock sample)	3,935	166.5	433.6	899.9	1,500
Filadelfia (fine ore)	3,207	93.1	589.4	817.5	1,500
San Francisco	5,317	11.7	246.2	1242.1	1,500
Tres Amigos	7,953	39.0	205.2	1255.8	1,500

This indicates that it would be possible to produce 1,500 metric tons of asbestos fibres from less than 7,000 tons of concentrate from the Filadelfia and San Francisco Mines.

10. RECOMMENDATIONS

10.1 Approximately 30,000 tons of ore will have to be mined yearly to supply the experimental plant with 2500 to 7000 tons of concentrate per year.

We recommend that geological explorations be made and a mining program prepared to establish the ore reserves and the feasibility of bringing the mines into production.

10.2 Fibre distribution, properties and yield differ from one mine to the other. A lower tonnage of concentrate would be required to produce 1500 tons of fibre from fine ore or rock from the Filadelfia mine than from the other two. Fibre recovered is longer and a better yield is obtained. This deposit is also more accessible than any of the other deposits. We recommend that the experimental plant be designed to treat only ore from that mine if sufficient reserves can be established.

The design of the pilot plant could include sufficient flexibility to permit modifications at a later date. The cost to bring this property into production would probably be less than any of the others.

10.3 Based on laboratory results obtained, we recommend additional testing to investigate the suitability of the fibre for admixtures in asbestos cement products in Bolivia. If found suitable there, it could possibly be used in other countries for the same purpose.

11. CONCLUSIONS

The objective of the program is to establish in Cochabamba an experimental production plant, capable of processing 1500 tons per year of crocidolite asbestos from the Alto Chapare region. It is anticipated that this plant will provide the necessary experience and data required to construct a 10,000 ton per year processing plant.

11.1 Production

The tests indicated that Bolivian asbestos concentrate can be cleaned and processed by normal asbestos milling practice. It is possible to produce 1500 tons of fibre from 3000 - 4000 tons of Filadelfia and 5000 - 6000 tons of San Francisco concentrates. The fibre produced falls short of the anticipated grade distribution as follows:

GRADE	TEST RESULTS	UNIDO ANTICIPATED RESULTS
A	0.8 to 11.1%	+ 12%
B		+ 40%
C	13.7 to 39.3%	+ 30%
D	54.5 to 83.7	+ 18%

Indicated input and output of products considered obtainable are shown on page 22 of this report.

11.2 Properties

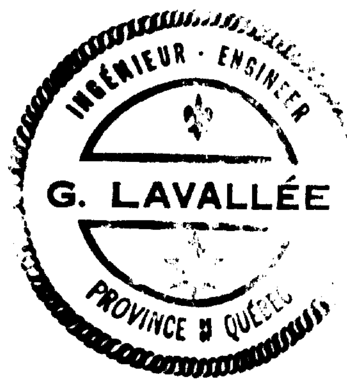
The test results also indicated a fair filterability index however a lower strength than South African blue (58.1 to 62.8 compared to + 85). Although the fiber may spin better than South African blue, its lower strength may prevent its use for industrial spinning.

Respectfully Submitted,

SURVEYER, NENNIGER & CHENEVERT INC.

G. Lavallée, P.Eng.
Manager
Mining & Metallurgy

GL/fp



CONTRIBUTORS:

Report prepared by C. Blais, P.Eng.

Report prepared (Geology only) by G. Farquharson

Report checked by J. Lemberg, P.Eng.

Report approved by J. Mahn, Project Executive

Report reviewed by P. Wiser, Asbestos Consultant.

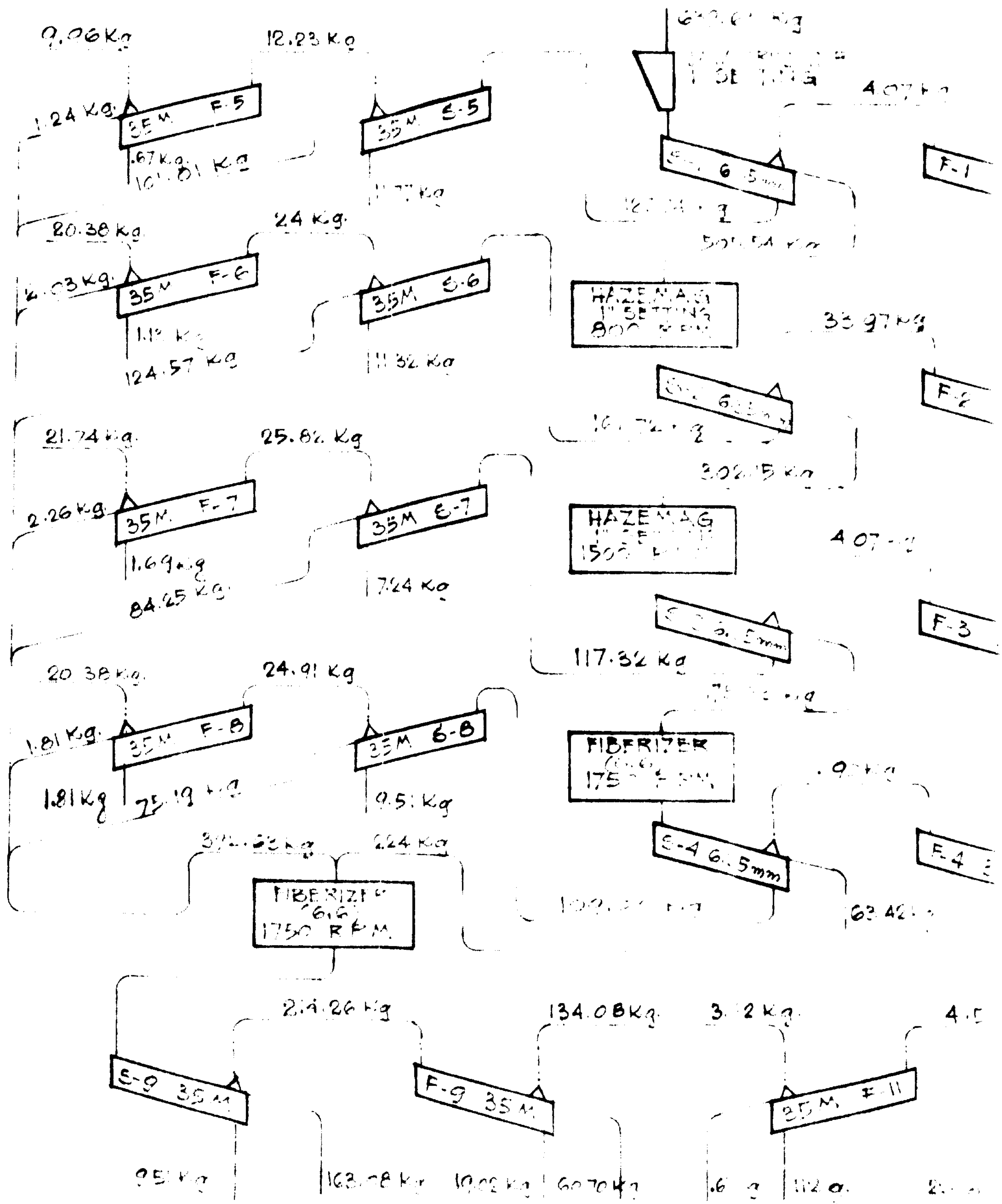
APPENDIX 1

FLOWSHEETS

APPENDIX I

FLOWSHEET No1

FILADELFIA MINE (ROCK



SECTION 1

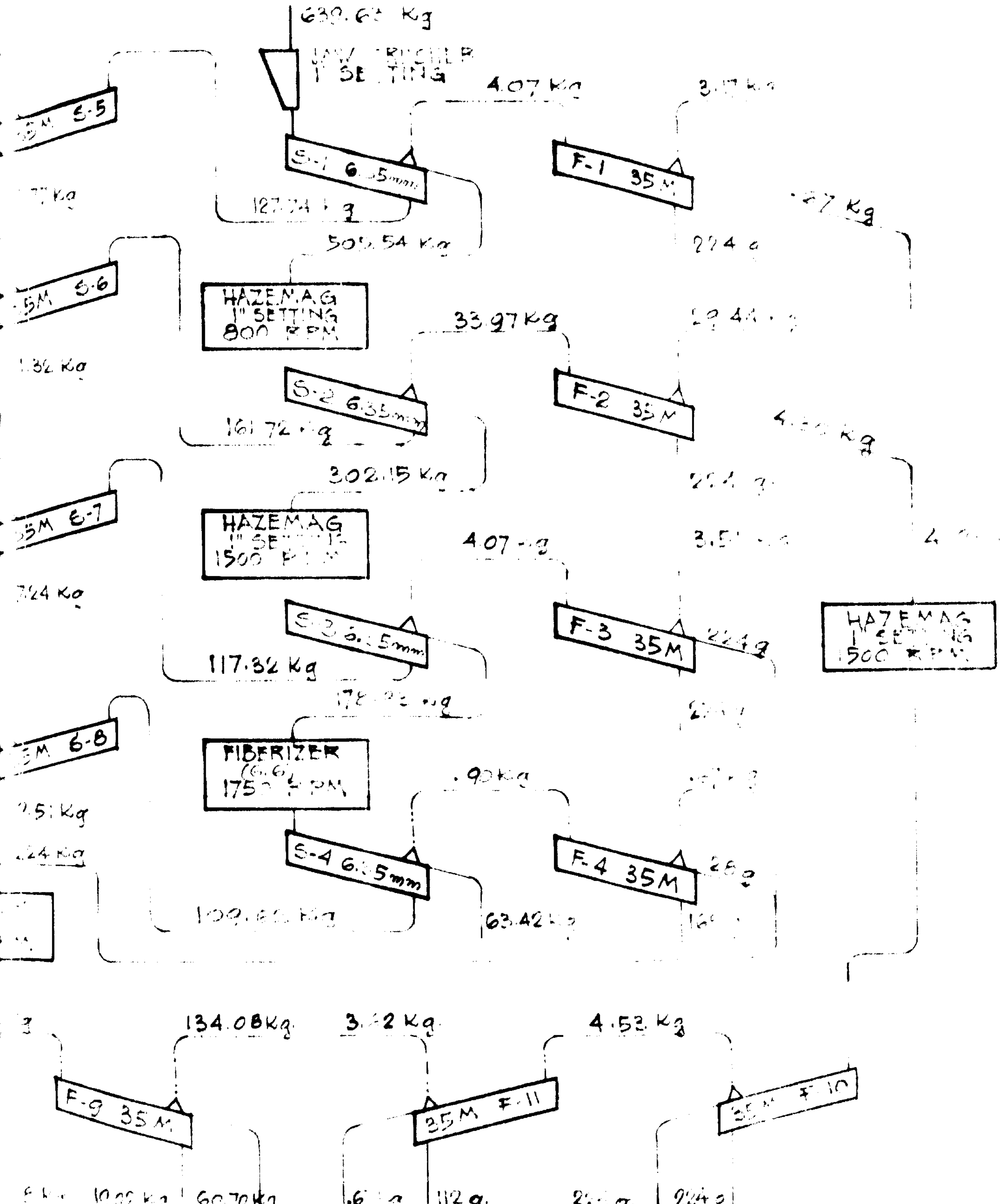
DESIGNED:
C. BLAIS

DRAWN:

APPENDIX I

FLOWSHEET No1

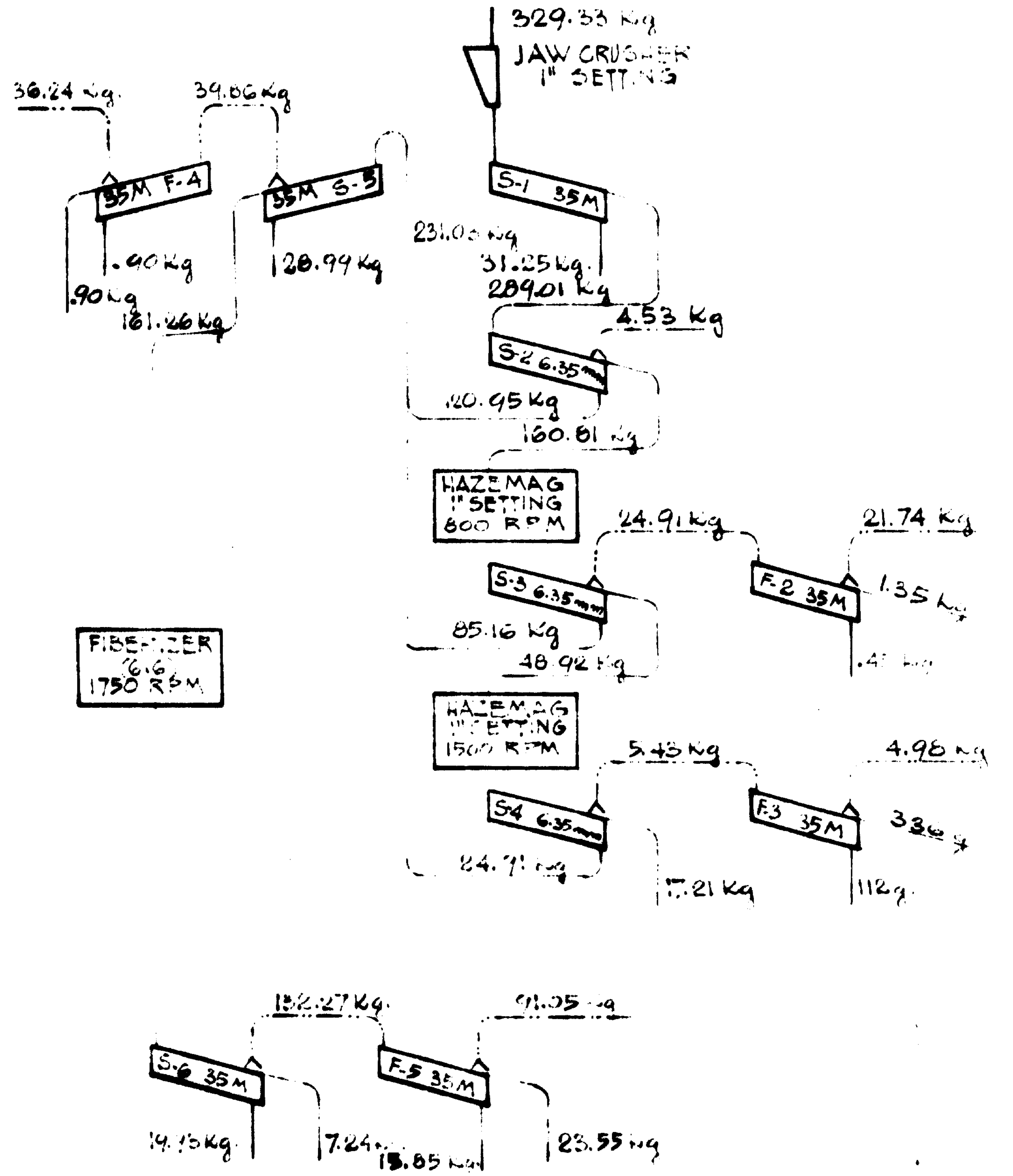
ADELFIA MINE (ROCK SAMPLE)



SECTION 2

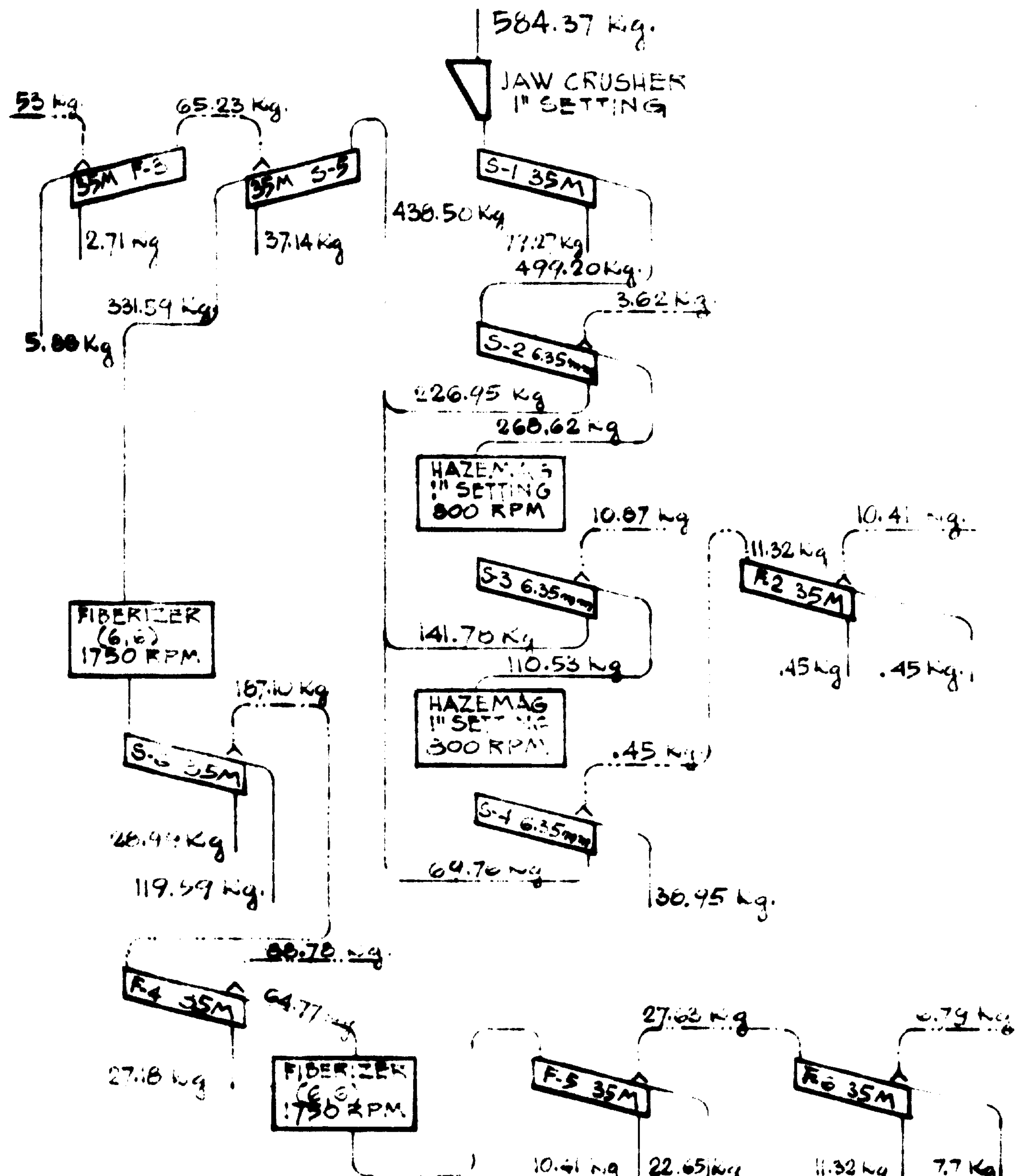
DESIGNED:	DRAWN:	CHECKED:
C. BLAIS	V. V. BENEDIK.	J. LEMBERG

APPENDIX I
FLOWSHEET No 2
FILADELFIA MINE (FINE ORE)



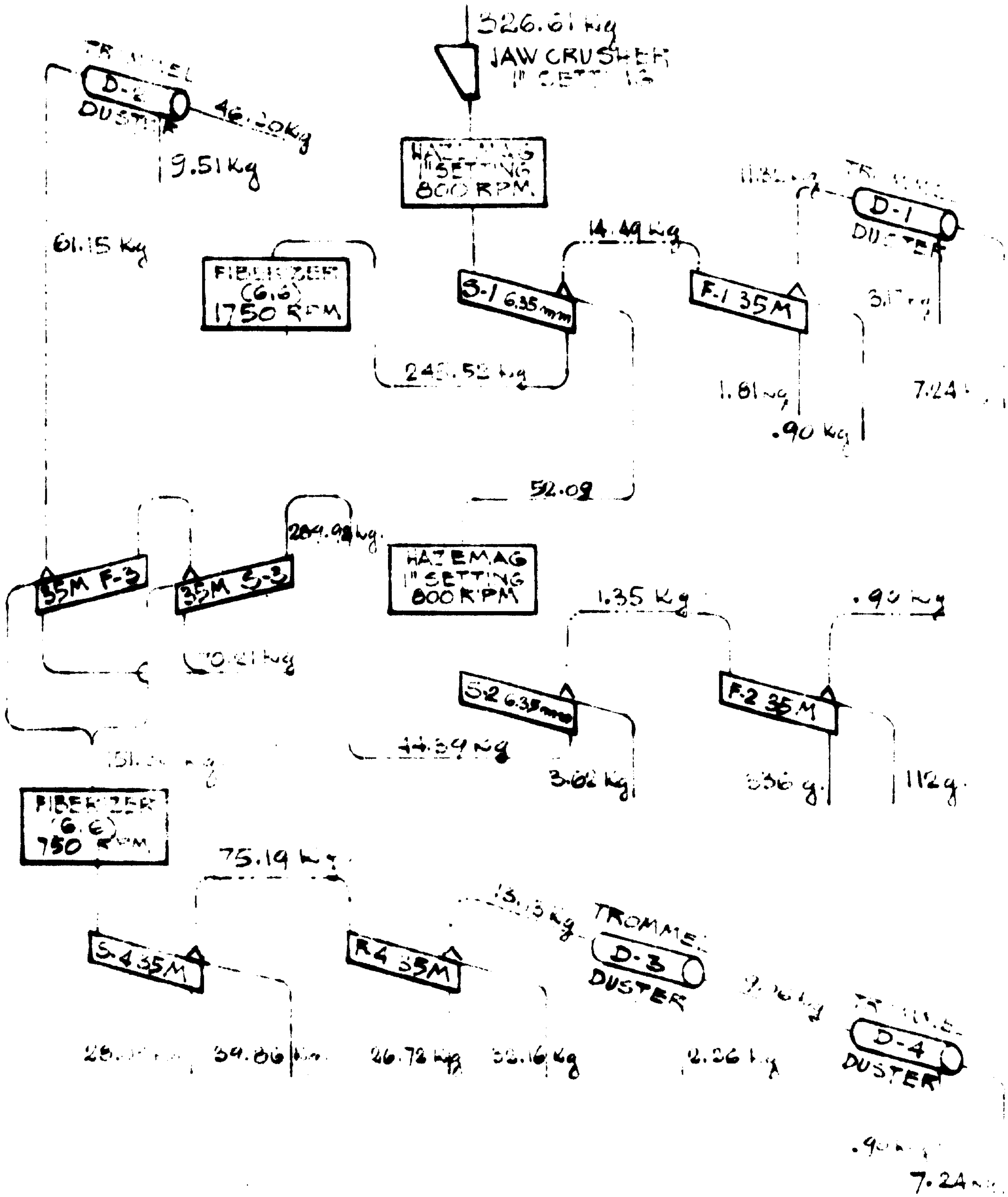
DESIGNED:	DRAWN:	CHECKED:	DATE
G. BLA. S	B. BENE	[illegible]	[illegible]

APPENDIX I
FLOW SHEET No. 3
SAN FRANCISCO MINE (FINE ORE)



DESIGNED	DRAWN	CHECKED	DATE
C. BLAS	BETETA	LEMBERG	JULY 21, 1970

APPENDIX I
FLOWSHEET No 4
TRES AMIGOS [illegible]



DESIGNED BY	DRAWN BY	CHECKED BY	DATE
[illegible] BLAIS	[illegible]	[illegible]	JULY 21, 197[illegible]

APPENDIX 2

LABORATORY TEST RESULTS

APPENDIX NO. 2

SAMPLE NO. 2

LABORATORY RESULTS

FILADELFIA MINE (ROCK SAMPLE)

Quebec Standard	Units	LIFT F-2	LIFT F-3	LIFT F-4	LIFT F-5	LIFT F-6	LIFT F-7	LIFT F-8	LIFT F-9	LIFT F-11
1/2"	ozs.	12.3	7.4							12.3
4 mesh	ozs.	1.7	5.3	2.6	4.8	3.2	1.3	TR.	6.8	1.1
10 mesh	ozs.	1.1	2.2	7.4	6.7	5.2	8.5	9.2	3.1	1.4
Pan	ozs.	0.9	1.1	6.0	4.5	7.6	6.2	6.8	6.1	1.2
McNett										
4 mesh	%	41.4	20.4	3.9	22.7	25.5	17.5	12.1	17.6	65.9
14 mesh	%	7.7	11.2	1.6	16.4	20.9	13.7	9.9	14.4	7.0
35 mesh	%	8.1	10.6	2.2	13.4	19.4	12.9	8.1	12.6	5.5
100 mesh	%	13.1	17.0	7.8	15.4	13.8	16.9	15.8	16.5	6.1
Pan	%	29.7	40.8	84.3	32.1	20.4	39.0	54.1	38.9	15.5
Freeness	Secs.	11.5	21.0	73.0	25.5	12.5	24.0	70.0	22.5	7.5
Surface Area	dm^2/gm	59	68	105	52	25	48	103	50	39
Magnetic Rating		0.32	0.23	2.88	0.28	0.25	0.24	0.24	0.22	0.24

APPENDIX NO. 2

SAMPLE NO. 3

LABORATORY RESULTS

FILADELFIA MINE (FINE ORE)

Quebec Standard	Units	LIFT F-2	LIFT F-3	LIFT F-4	LIFT F-5
1/2"	ozs.	6.5	2.4		
4 mesh	ozs.	5.9	9.9	2.0	7.9
10 mesh	ozs.	2.1	2.3	8.8	4.4
Pan	ozs.	1.5	1.4	5.2	3.7
McNett					
4 mesh	%	60.1	34.3	19.5	13.6
14 mesh	%	5.7	7.0	19.3	13.3
35 mesh	%	4.2	9.1	10.4	11.1
100 mesh	%	5.0	9.7	11.7	10.6
Pan	%	25.0	39.9	39.1	51.4
Freeness	secs	21.5	19.5	30.0	34.5
Surface Area	dm^2/gm	66	72	61	72
Magnetic Rating		0.14	0.14	0.14	0.14

APPENDIX NO. 2

SAMPLE NO. 4

LABORATORY RESULTS

SAN FRANCISCO MINE (FINE ORE)

Quebec Standard	Units	LIFT F-2	LIFT F-3	LIFT F-4	LIFT F-6
1/2"	ozs.	1.9			
4 mesh	ozs.	11.0	1.7	2.4	
10 mesh	ozs.	2.0	10.2	9.2	8.0
Pan	ozs.	1.1	4.1	4.4	8.0
McNett					
4 mesh	%	29.9	13.3	7.9	16.3
14 mesh	%	6.7	4.1	9.1	10.0
35 mesh	%	3.6	9.9	6.3	8.1
100 mesh	%	4.9	9.0	8.9	10.1
Pan	%	54.9	63.7	67.8	55.5
Freeness	secs.	49.5	78.0	53.0	26.5
Surface Area	$dm^2/gm.$	113	102	99	54
Magnetic Rating		0.13	0.13	0.13	0.15

APPENDIX NO. 2

SAMPLE NO. 5

LABORATORY RESULTS

TRES AMIGOS MINE (FINE ORE)

Quebec Standard	Units	OVERS D-1	LIFT F-2	OVERS D-2	OVERS D-4
1/2"	ozs.	3.6			
4 mesh	ozs.	7.1	0.5	1.8	
10 mesh	ozs.	3.2	7.4	10.0	11.0
Pan	ozs.	2.1	8.1	4.2	5.0
McNett					
4 mesh	%	20.4	5.6	7.1	7.9
14 mesh	%	4.4	2.7	6.6	9.5
35 mesh	%	7.1	1.9	8.0	12.2
100 mesh	%	10.5	6.0	11.4	12.0
Pan	%	57.6	83.8	66.9	58.4
Freeness	secs	39.0	47.5	60.0	44.5
Surface Area	dm^2/gm	111	76	108	101
Magnetic Rating		0.13	0.31	0.14	0.14

APPENDIX 1

LABORATORY TEST PROCEDURES

APPENDIX 3

LABORATORY TESTING PROCEDURES FOLLOWED

1. **Quebec Standard Test**

   "Testing Procedures for Chrysotile Asbestos Fibre" Second Edition 1966.

2. **McNett**

   "Test Methods for Blue and Amosite Asbestos Fibres". A 100 mesh screen was used in the fourth box.

3. **Freeness**

   "Testing Procedures for Chrysotile Asbestos Fibre", Second Edition 1966.

4. **Surface Area**

   The T & N Rapid Surface Area test was used to evaluate the surface area of Bolivian fibre as outlined in the Manual "Testing Procedures for Chrysotile Asbestos Fibres", Second Edition 1966.

5. **Magnetic Rating**

   Manual "Testing Procedures for Chrysotile Asbestos Fibres", Second Edition 1966.

6. **Strength Unit**

   The asbestos fibre had to be opened before testing for strength unit. Usually, the chrysotile asbestos fibre is opened in a ball mill and in a B.O.P. disintegrator. Since several laboratories have already proven that the ball mill does not give good results with blue asbestos fibre, only the B.O.P. disintegrator was used. The procedures outlined in the manual "Testing Procedures for Chrysotile Asbestos Fibre" Second Edition 1966, was followed except that the ball milling operation was omitted.

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