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EFFECT OF SULFUR DIOXIDE ON ASBESTOS

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TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	ii
LIST OF FIGURES	iv
LIST OF TABLES	v
I. SUMMARY	1
II. INTRODUCTION	3
III. EXPERIMENTAL METHODS	4
A. Apparatus	4
B. Preparation of Sample	7
C. Methods of Investigation	7
IV. DISCUSSION OF RESULTS	9
V. CONCLUSIONS	12
VI. BIBLIOGRAPHY	13
APPENDIX A	14
APPENDIX B	16

LIST OF FIGURES

	Page
1. Diagram of Experimental Apparatus	5
2. Diagram of Sample Tube	6
3. Correlation of Magnesium Converted vs Time at 1200°F	11
4. Photograph of Experimental Apparatus	17
5. Photograph of Sample Tube	18

LIST OF TABLES

	Page
I. EXPERIMENTAL DATA	8
II. CALCULATED DATA	10

EFFECT OF SULFUR DIOXIDE ON ASBESTOS

I. SUMMARY

The purpose of this investigation was to determine the conversion of crysotile asbestos to magnesium sulfate and silicon dioxide, as affected by the concentration of sulfur dioxide, and the time of exposure. It was also desired to establish the optimum temperature for this reaction.

The material used was a commercial grade of crysotile asbestos. No change was made in the structure or composition of this asbestos before use.

The investigation was accomplished by exposing known weights of asbestos to a gas composed of air and sulfur dioxide. This was done in a sample tube with suitable heating element and a series of flowmeters for obtaining a constant flow and concentration of gas. The concentration of sulfur dioxide was determined by iodimetric titration and the magnesium converted by versinate titration.

Results reproducible within approximately ten per cent were obtained at temperatures below 1200°F and for temperatures above 1200°F if the concentration of sulfur dioxide was below two to three per cent. In the latter case the data fell into two conversion groups; a low conversion group for concentrations of one-half per cent sulfur dioxide, and a higher conversion group for concentrations of one to two per cent sulfur dioxide. At temperatures of approximately 1200°F, the dehydration

temperature for the asbestos studied, a conversion of sulfur dioxide to sulfur trioxide was observed for all concentrations. This reaction was only slight at concentrations below three per cent, but was observed to a considerable extent above this concentration. It is believed that the effect of dehydrated asbestos as a catalyst for this reaction is responsible for the erratic nature of results obtained at 1200°F with a sulfur dioxide concentration greater than three per cent.

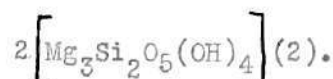
II. INTRODUCTION

This investigation was made as a study of the effect of gases containing sulfur dioxide on commercial asbestos. The objectives desired from this study were to obtain correlative data showing the extent of conversion of asbestos to magnesium sulfate at various concentrations of sulfur dioxide; the optimum temperature range for this reaction; and to provide a basis for estimating the time required for total conversion to be accomplished.

The problem was suggested by Dr. J. M. DallaValle, and was based on work done by him in 1930 involving the use of woven asbestos filter cloths. It was found that exposure to sulfur dioxide altered the structural characteristics of the filter cloths and substantially reduced their tensile qualities. Tests showed the presence of a considerable amount of sulfate.

A literature survey by the author revealed no previous work related to the investigation. This survey included Chemical Abstracts and Periodicals available.

The material studied was crysotile asbestos, a white fibrous form of serpentine having the structure



Tests on the sample showed a free magnesium content of 1.1844 mg. per gram of sample and a dehydration temperature of 1150°F.

III. EXPERIMENTAL METHODS

A. Apparatus

The experimental apparatus, shown schematically in Figure 1, was constructed of pyrex glass tubing with the exception of the sample tube, Figure 2, which was vycor glass. A system of stopcocks and by-pass lines was provided so that the concentration of the gas might be fixed before beginning a run, and then only pure air pulled through the sample tube while operating temperature was attained. The flow of sulfur dioxide entering through line B was controlled by a reduction valve on the gas cylinder and determined by passing the gas through a flowmeter. The air entering line A was first dried by passing through a tube of indicating silica gel. The gas composition was fixed prior to a run by closing line E, through the sample tube, and shunting the air-sulfur dioxide mixture through the flowmeter in line D and around the sample tube by way of lines F and G. The flowmeter calibration was obtained by passing the gas through H, into the sample jar of iodine solution. Once the composition was fixed, the sulfur dioxide was shunted into line C, and the air passed through line E. At this time the heating coils were turned on, allowing the sample tube and gas to reach a predetermined temperature. Temperatures below 750°F were recorded by use of a total immersion, high temperature distillation thermometer. For temperatures of approximately 1200°F an estimate was made based on the yield point of pyrex glass. The excess sulfur dioxide was removed from the exit gas by bubbling it through a solution of concentrated sodium hydroxide. The gas was then passed through a drying bottle before passing through a small diaphragm pump.

The preheater was partially suspended on a "track", whereby it

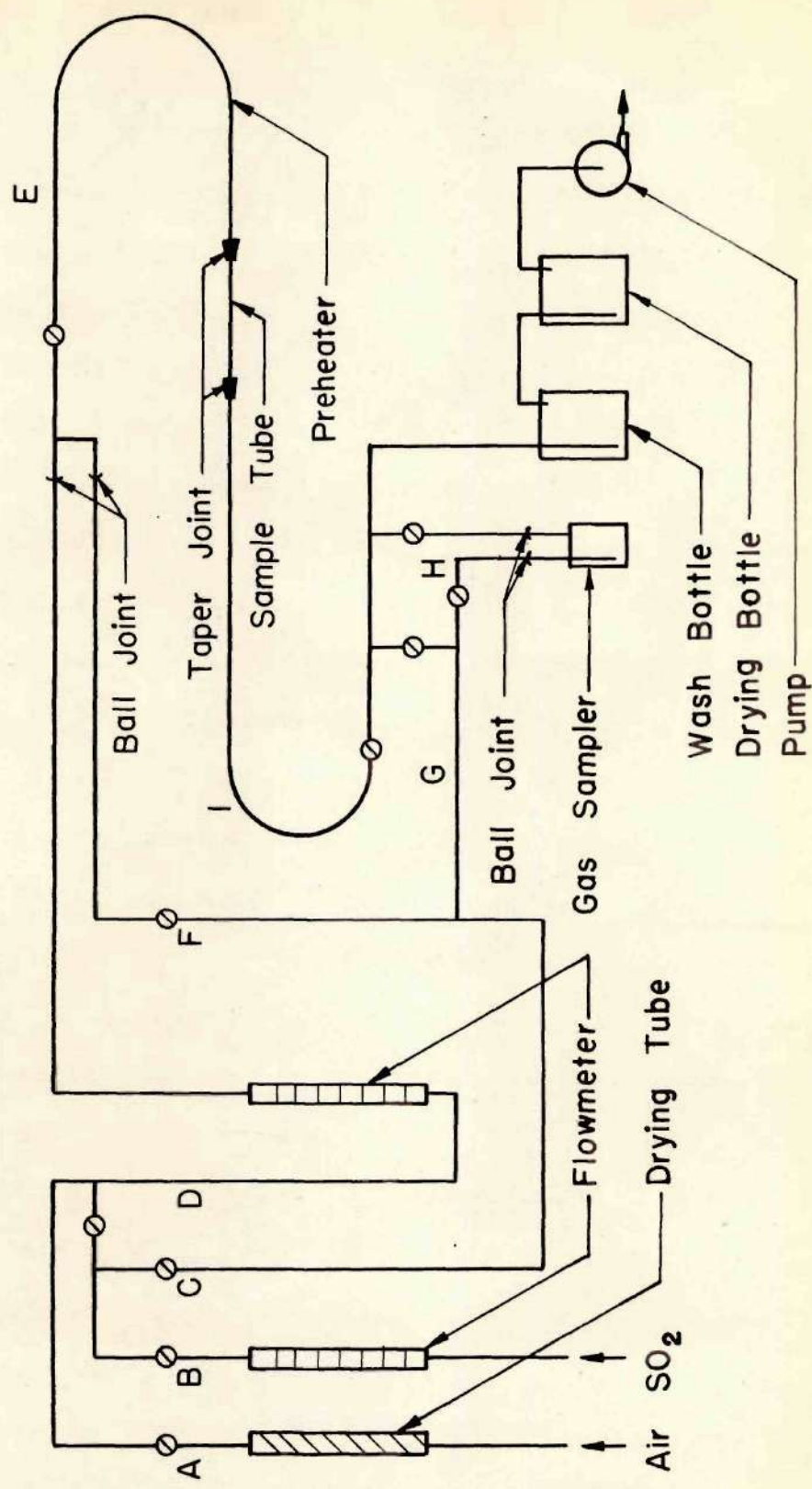


FIGURE 1. Diagram of Experimental Apparatus

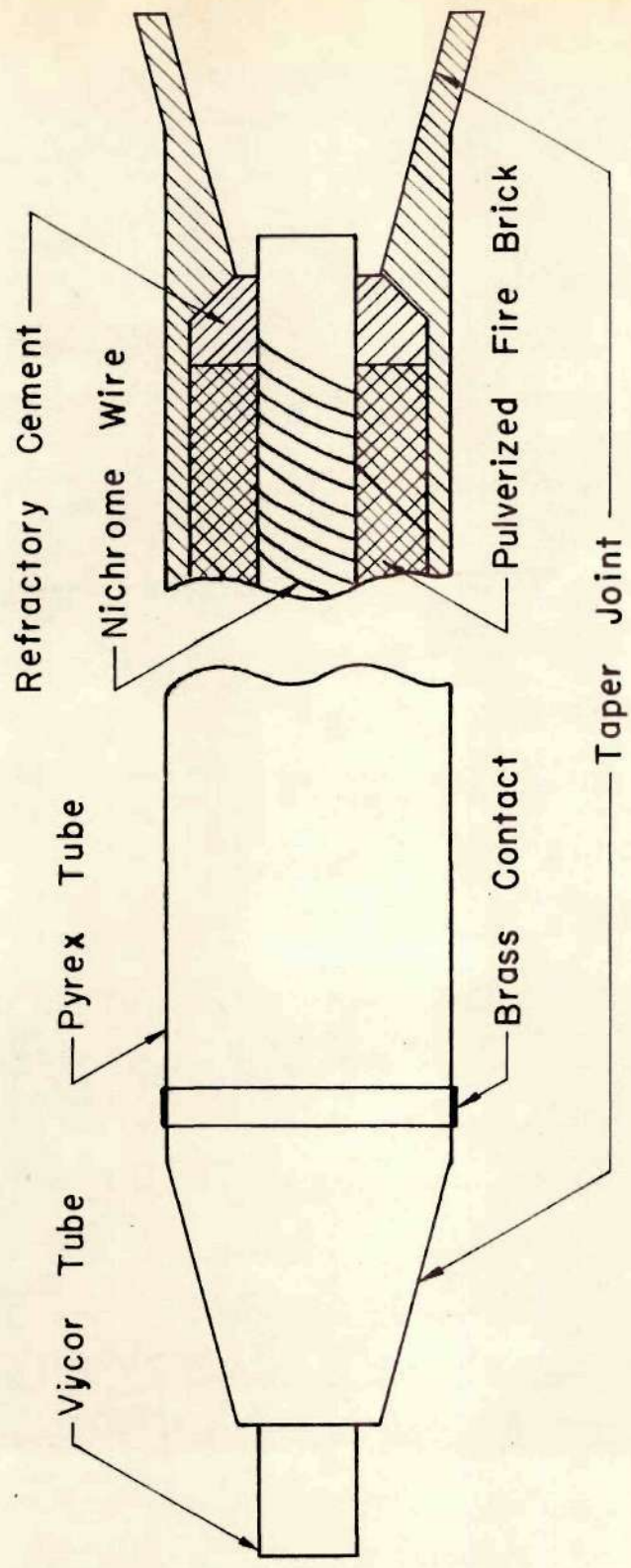


FIGURE 2. Diagram of Sample Tube

would slide to the right, thus enabling the sample tube to be removed. For this purpose the preheater was connected to lines D and F by ball joints and to the sample tube by a taper joint.

The heating coils for the preheater and sample tube were No. 20 and No. 30 nichrome wire respectively.

B. Preparation of Sample

As mentioned previously, the structure of the asbestos was not altered prior to use. It was found by experiment that the best results were obtained by forming the asbestos into a small rod-shaped sample. In cases where the sample was not preformed, unequal dispersion of gas was obtained by channeling. This was probably due to the fact that it was not packed uniformly. In most cases, this method also resulted in the sample being blown from the sample tube. The individual samples were dried at 250°F before being weighed.

C. Methods of Investigation

As can be noted in Table I, the first runs were made at temperatures below 1000°F and at concentrations of five per cent sulfur dioxide. Due to the small amounts of magnesium converted, it was decided to try several runs above the dehydration temperature of the asbestos. When the first runs under these conditions were observed to be erratic the concentration was successively lowered until reproducible results were obtained at two per cent. Successive runs were made at concentrations below two per cent for varying lengths of time. The experimental data is tabulated in Table I. Table II contains calculated data which was plotted in Figure 3.

TABLE I
EXPERIMENTAL DATA

Run No.	Temperature	Air	Rate	Concentration	Time	Sample Weight	Magnesium Titrated
	°F		cc/min	% SO ₂	hr	gm	mg
1	750	Dry	1000	5	1	1.0737	3.014
2	750	Dry	1000	5	2	1.1314	4.123
3	750	Dry	1000	5	4	1.1000	4.779
4	750	Wet	1000	5	1	1.1570	3.433
5	750	Wet	1000	5	2	0.8922	3.589
6	750	Wet	1000	5	4	0.8621	6.951
7	750	Dry	1000	2	1	0.8738	2.724
8	600	Dry	1000	5	1	0.9660	2.402
9	600	Dry	1000	5	2	1.0059	2.608
10	600	Dry	1000	5	4	1.5885	5.770
11	1200	Dry	350	10	0.5	0.5610	4.113
12	1200	Dry	350	10	0.5	0.4955	8.989
13	1200	Dry	350	10	0.5	0.4544	12.947
14	1200	Dry	350	10	1	0.6992	7.723
15	1200	Dry	350	10	2	0.4718	8.340
16	1200	Dry	350	5	0.5	0.6245	11.834
17	1200	Dry	350	4	0.75	0.3738	10.588
18	1200	Dry	350	3	0.5	0.5147	7.956
19	1200	Dry	350	2	0.25	0.4029	4.466
20	1200	Dry	350	2	0.5	0.5524	5.702
21	1200	Dry	350	2	1	0.5256	8.374
22	1200	Dry	350	2	2	0.4329	10.458
23	1200	Dry	350	2	4	0.4399	22.358
24	1200	Dry	350	2	8	0.3099	25.277
25	1200	Dry	350	1	0.5	0.4394	4.926
26	1200	Dry	350	1	0.75	0.3325	4.824
27	1200	Dry	350	0.5	0.25	0.3775	2.289
28	1200	Dry	350	0.5	0.75	0.3895	3.359
29	1200	Dry	350	0.5	1.5	0.5021	7.501
30	1200	Dry	350	0.5	2.5	0.2532	4.914

IV. DISCUSSION OF RESULTS

Although the conversion was small at temperatures below 1000°F, reproducible results were obtained which showed an increase in conversion as the time of exposure increased. Several runs were made at 750°F using air bubbled through water at 75°F rather than dry air. An inspection of Table II shows little effect due to moisture.

In an effort to obtain greater conversion, the temperature was raised to approximately 1200°F. The first runs made at the increased temperature were found to vary over a wide range of conversion. This is believed by the author to be attributed to the action of the dehydrated asbestos as a catalyst for the conversion of sulfur dioxide to sulfur trioxide. This conversion was noted at the higher concentrations as a dense, white stream of gas flowing from the sample tube, and completely filling the air spaces of the wash and drying bottles. This thick stream was not evidenced at concentrations below five per cent, but the conversion was detected by the clouding of the exit tubes. At concentrations below three per cent this appeared only as a faint haze.

Successive runs were made, lowering the concentration by stages, until reproducible results were obtained. The runs made at concentrations below three per cent, while showing evidence of sulfur trioxide, were found to give reproducible results. These results are plotted in Figure 3, showing the correlation between time and magnesium converted.

From the facts mentioned above it was concluded that the preponderance of the sulfur trioxide reaction occurs at concentrations between two and three per cent.

TABLE II
CALCULATED DATA

Run No.	Temperature °F	Air	Concentration % SO ₂	Time hr	Magnesium Converted mg/gm as- bestos
1	750	Dry	5	1	1.829
2	750	Dry	5	2	2.460
3	750	Dry	5	4	3.160
4	750	Wet	5	1	1.783
5	750	Wet	5	2	2.838
6	750	Wet	5	4	6.878
7	750	Dry	2	1	1.943
8	600	Dry	5	1	1.302
9	600	Dry	5	2	1.408
10	600	Dry	5	4	2.448
11	1200	Dry	10	0.5	6.148
12	1200	Dry	10	0.5	16.958
13	1200	Dry	10	0.5	27.308
14	1200	Dry	10	1	9.862
15	1200	Dry	10	2	16.492
16	1200	Dry	5	0.5	17.765
17	1200	Dry	4	0.75	27.140
18	1200	Dry	3	0.5	14.274
19	1200	Dry	2	0.25	9.901
20	1200	Dry	2	0.5	9.137
21	1200	Dry	2	1	14.756
22	1200	Dry	2	2	22.974
23	1200	Dry	2	4	49.641
24	1200	Dry	2	8	80.331
25	1200	Dry	1	0.5	10.026
26	1200	Dry	1	0.75	13.324
27	1200	Dry	0.5	0.25	4.879
28	1200	Dry	0.5	0.75	7.439
29	1200	Dry	0.5	1.5	13.756
30	1200	Dry	0.5	2.5	18.224

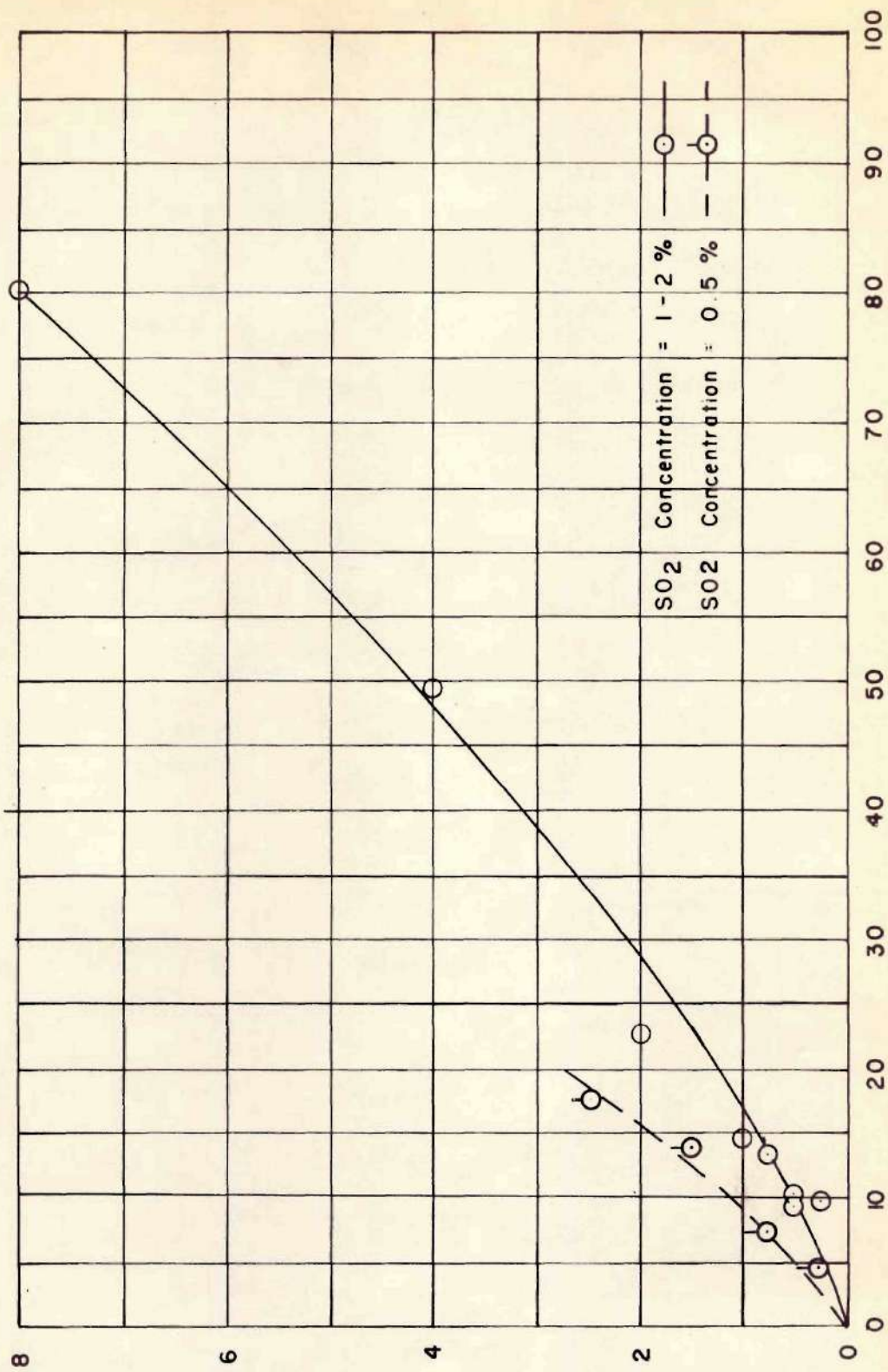


FIGURE 3. Correlation of Magnesium Converted vs Time at 1200°F

V. CONCLUSIONS

The following conclusions may be drawn as a result of this investigation of the effect of sulfur dioxide on chrysotile asbestos:

1. Conversion of magnesium in chrysotile asbestos to magnesium sulfate at temperatures below 1000°F is small but can be expressed as a function of time.

2. Conversion to magnesium sulfate is masked by the sulfur trioxide reaction at high concentrations of sulfur dioxide and temperatures above the dehydration temperature.

3. Maximum conversion is attained at temperatures above the dehydration temperature and can be expressed as a function of time for sulfur dioxide concentrations less than three per cent.

VI. BIBLIOGRAPHY

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2. Hey, M. H., Index to Minerals, Brit. Mus. Nat. Hist., 1950.

APPENDIX A

SAMPLE CALCULATIONS

The following illustrative calculations refer to Run No. 24.

1. Standardization of versinate solution.

weight $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ titrated = 0.0055 gm.

ml. versinate solution required = 4.35

$$\frac{0.0107 \text{ gm. MgSO}_4 \cdot 7\text{H}_2\text{O}}{4.35 \text{ ml. solution}} \times \frac{24.32 \text{ gm. Mg}}{246.38 \text{ gm. MgSO}_4 \cdot 7\text{H}_2\text{O}} =$$

$$0.125 \frac{\text{mg. Mg}}{\text{ml. solution}}$$

2. Test for free magnesium in sample.

weight dry asbestos = 0.4037 gm.

ml. versinate solution required = 3.83

Mg titrated = 3.83 ml. \times $0.125 \frac{\text{mg. Mg}}{\text{ml.}}$ = 0.47814 mg.

$$\frac{0.4781 \text{ mg. Mg}}{0.4037 \text{ gm. asbestos}} = 1.1844 \frac{\text{mg. Mg}}{\text{gm. asbestos}}$$

3. Test for magnesium converted.

weight of sample = 0.3099 gm.

ml. versinate solution required = 202.22 ml.

$$\text{Mg titrated} = \frac{202.22 \text{ ml.}}{0.3099 \text{ gm.}} \times 0.125 \frac{\text{mg. Mg}}{\text{ml.}} = 81.5656 \frac{\text{mg. Mg}}{\text{gm. asbestos}}$$

$$\text{Mg converted} = 81.5656 \text{ mg.} - 1.1844 \text{ mg.} = 80.381 \frac{\text{mg. Mg}}{\text{gm. asbestos}}$$

APPENDIX B

PHOTOGRAPHS OF EXPERIMENTAL APPARATUS

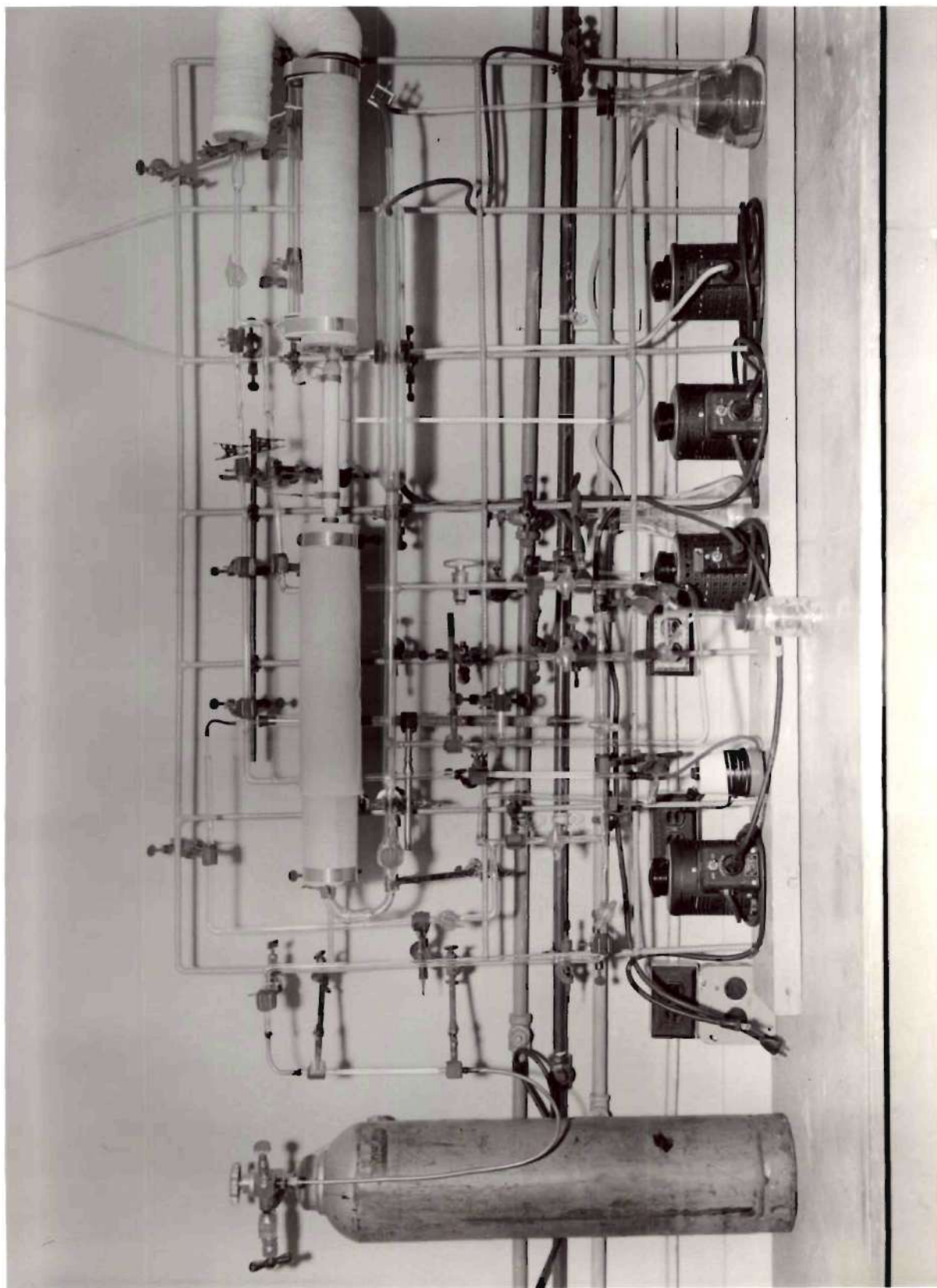


Figure 4. Photograph of Experimental Apparatus

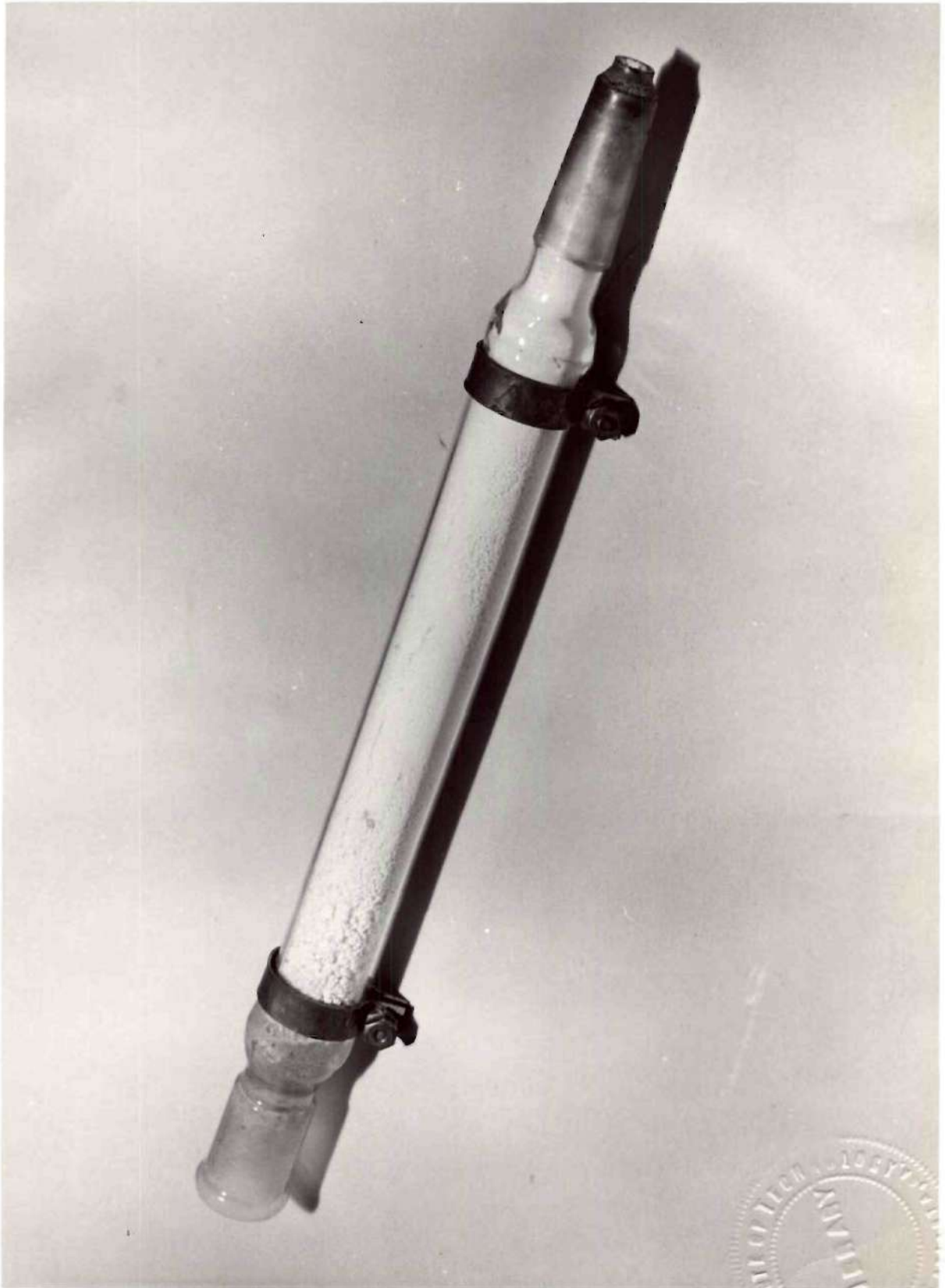


Figure 5. Photograph of Sample Tube