OFFICIAL TRANSCRIPT PROCEEDINGS BEFORE

THE UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

THE 3250 WILSHIRE BOULEVARD BUILDING, et al. Plaintiff,	:	
vs.	:	No. 87-06048 WMB (GHKx)
METROPOLITAN LIFE INSURANCE COMPANY, et al. Defendants.	:	

Deposition of RALPH J. BRAGG

Detroit, Michigan

December 9, 1988

ALDERSON REPORTING COMPANY
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UNITED STATES DISTRICT COURT

FOR THE CENTRAL DISTRICT OF CALIFORNIA

3250 WILSHIRE BOULEVARD BUILDING, et al., Plaintiffs, vs. METROPOLITAN LIFE INSURANCE COMPANY, et al., Defendants.	)	Case No. 87-06048 WMB (GHKx)

Detroit, Michigan

Friday, December 9, 1988

Deposition of RALPH J. BRAGG, a witness herein, called for examination by counsel for 3250 Wilshire Boulevard Building, et al in the above-entitled matter, pursuant to notice, the witness being duly sworn by CATHY SILVERMAN, a Notary Public in and for the State of Michigan, taken at the offices of Dickinson, Wright, Moon, Van Dusen & Freeman, 800 First National Building, Detroit, Michigan at 9:00 a.m., Friday, December 9, 1988 and the proceedings being taken down by Stenotype by CATHY SILVERMAN and transcribed under her direction.

APPEARANCES:

On behalf of the Plaintiffs, 3250 Wilshire Boulevard Building et al.;

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On behalf of Defendant W. R. Grace-Con;

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Los Angeles, California 90571

C O N T E N T S

E X H I B I T S

C O N T E N T S (continued)

PROCEEDINGS

Whereupon, Ralph J. Bragg, business address at 7133 Cortland Avenue, Allen Park, Michigan (313), 386-8807, was called as a witness by counsel for Plaintiffs, and having been duly sworn by the Notary Public, was examined and testified as follows:

EXAMINATION BY COUNSEL FOR
3250 WILSHIRE BOULEVARD BUILDING, ET AL
BY MR. BOUCHER:

Q Good morning Mr. Bragg, how are you today?

A Good morning.

Q Let me go through some admonitions with you, and introduction. You have had your deposition taken before; have you not?

A Yes.

Q You have had these admonitions, but let me go briefly through them with you. Do you understand you're under oath?

A I do.

Q Do you understand it's the same oath you would take in a court of law?

A Yes.

Q Do you understand the penalties of perjury attach to your testimony here today?

A I do.

Q Is there any reason why you can't go forward with your deposition?

A No.

Q You're not taking any kind of medications that would affect your ability to recall or recollect or anything?

A No.

Q Can you please give me your work history from the time that you first began working for W. R. Grace to the present time?

A I was hired by the Zonolite Company which was later purchased by Grace in August of 1959 and from that time until 1967, I worked in the Midwest, both in the Evanston, Illinois and Skokie, Illinois laboratories.

In February '67, I transferred to the Dewey and Almy Chemical division of W. R. Grace which later split off a group became the Construction Products Division of Grace and in September 1, 1987, I retired from the Grace Company.

control job outside of Massachusettes, then returned to research.

Q What were your job responsibilities as group leader of research between '69 and '73?

A As I indicated before, I did not have continuous research responsibility through that whole period, but my primary responsibility in '69 I would say was the reformulation of MK-3.

Q Who did you have working for you between 1969 and whatever up through 1963 -- excuse me, 1973 where your primary responsibility was the responsibility of Mono-Kote 3?

MR. JONES: Object to form, you can answer.

A As I recall, there were about ten or eleven people involved, there was two persons down in Washington Research Center which is the Grace Corporate Research Laboratory and there were one or two people in Travelers Rest, South Carolina. We had an outside consultant and the balance of the roughly ten or eleven people would have been made up of individuals assigned to research in Cambridge.

BY MR. BOUCHER:

Q When did you say that the Construction Products Division split off from Dewey and Almy, what years was that?

A I would guess that it was in early '69, but I'm not sure.

Q Beginning in February of 1967, what were your job responsibilities with Dewey and Almy?

A I was a chemist and assigned work in ad mixtures for concrete and cement block. That was my initial assignment.

Q Did your assignment at some point in time change?

A Yes, gradually I assumed research projects or tasks which were related to the old Zonolite product requirements.

Q Did you have any additional job responsibilities other than those that you've outlined between the years 1969 and 1973?

A My responsibilities increased between 1967 and '69 to the point that I was promoted to group leader of research and I was given the assignment of reformulating Mono-Kote. Then before 1973, and I don't recall the date, I was removed from research for half a year, quality

Q Who were the individuals in the Washington Research Department that were working on the reformulation of Mono-Kote 3?

A I can only recall one individual, John Kraus, K-R-A-U-S.

Q Who was at Traverlers Rest that you can recall working on the reformulation of Mono-Kote 3?

A Walter Payment and William Sims who is deceased.

Q Who was the outside consultant?

A I don't recall his name.

Q Do you recall what company?

A He was an individual working for himself.

Q What research individuals from Cambridge can you remember?

A It was Larry Shoe, Bob Stierli, S-T-I-E-R-L-I, John Colaneri, C-O-L-A-N-E-R-I, and that's about all I remember.

Q What to the best of your recollection were the dates wherein your primary responsibility was the reformulation of Mono-Kote 3?

A I think it began in late '69, but I don't know when it ended.

Q You don't know whether it ended prior to 1973 or not?

A It did end prior to '73, but I don't recall exactly when.

Q Did Rothfelder do any work on the reformulation of Mono-Kote 3 with you?

A He had the original idea of the substitution of the fiber and throughout the period that I was involved in reformulation, he assisted with advice and I think on a couple of occasions, he sent in samples of formulated candidate material for tests.

Q Is he the individual that came up with the idea of using cellufloc?

A Yes, sir.

Q Are there any other individuals that are in the capacity or a similar type work arrangement as Ray Rothfelder in terms of his assisting in the reformulation of Mono-Kote 3 that you haven't already mentioned?

A As I indicated, I don't have a good memory and I have forgotten.

Q What was Walt Payment's job responsibilities at W. R. Grace as best you can recall during the period of

time that he was assisting in the reformulation of Mono-Kote 3?

A His responsibilities in this particular assignment included the manufacture of trial batches of new compositions, the application of same, and the fire-testing of these compositions.

Q What individual or individuals did you have primary reporting responsibility to with respect to the reformulation of Mono-Kote 3?

A My direct supervisor was Keith Cranker, C-R-A-N-K-E-R, his title was Assistant Director of Research and he reported to Dr. Vance Dodson, D-O-D-S-O-N, who was Director of Research.

Q Did you have responsibility for reporting the progress being made by you in the team working on the reformulation of Mono-Kote 3 to anyone aside from Mr. Cranker or Mr. Dodson?

A Yes.

Q Who else?

A On request, I was expected to report to the marketing division.

(Discussion off the record.)

BY MR. BOUCHER:

Q You mentioned that upon request, you were expected to report to marketing division with respect to the progress being made on the reformulation of Mono-Kote 3, what do you mean by request?

A During the reformulation effort, it was made clear to me that we would have routine review meetings in which research personnel and those of other groups within the division would be present and it was my job to bring the status of the research up-to-date.

Q How routine would it be during that period of time?

MR. JONES: Objection as to form, you can answer.

THE WITNESS: I don't recall.

BY MR. BOUCHER:

Q Do you recall who was -- were there a regular group of people who were present during these routine meetings?

A I would say that generally there was the product Manager of Fireproofing, and then there would be the Director and Assistant Director of Research, myself, and anyone of the facts group that I deemed necessary to

attend.

MR. JONES: Could I have the answer read back, please?

(Record read.)

BY MR. BOUCHER:

Q Who was the Product Manager of Fireproofing at that period of time?

A It was Thomas Egan.

Q Did that ever change during the time that you were working on the reformulation of Mono-Kote 3?

A No.

Q When you mentioned earlier you were upon request expected to report to marketing division, was Tom Egan the person in the marketing division that you were to report to?

A Yes.

Q Is there anyone else other than Tom Egan in the marketing division that you requested to report to?

A No.

Q Anyone else within W.R. Grace who you were requested to report to on the progress being made on the reformulation of Mono-Kote 3 other than those that we have

discussed?

A Not that I recall except there is one little change and that is that Vance Dodson at some point in time was replaced as Director by a Mr. Powell, David Powell, and I don't recall whether it was during the reformulation effort or not.

Q During the meetings that took place where you discussed the status of the reformulation of Mono-Kote 3, were any of those meetings tape recorded to your knowledge?

A Not to my knowledge.

Q Did you take any notes during the course of the meetings where you discussed the reformulation of Mono-Kote 3?

A I probably did.

Q Was it your normal practice during that period of time to take notes during those types of meetings?

A Yes.

Q Did you keep a file on the notes that you took during meetings where you discussed the reformulation of Mono-Kote 3?

A No, I did not.

Q Did you have a regular practice of dictating the notes that you took during the meetings where you discussed the reformulation of Mono-Kote 3?

A No.

Q Did you have anyone type your notes for you?

A No, I did not. My practice would have been to write a report on the meeting and have that be typed.

Q Did you keep a file with the reports that you wrote concerning the meetins?

A No, I had correspondence files and project files while I was working for the Grace Company and probably copies of those are here on the table, but I have retained no documents in retirement.

Q While you were at Grace, did you have a separate file folder where you kept the reports that came out of the reports that you dictated as a result of the meetings where you discussed the reformulation fo Mono-Kote 3?

A Yes.

Q Was there a heading given to that file?

A I don't recall.

Q The reports that you dictated after the meetings where you discussed the reformulation of Mono-Kote 3, who

were they generally sent to?

A First of all, I did not dictate them, I indicated before I wrote them and had them typed. They would have been sent to my immediate supervisor with a copy to his supervisor; that is, to Cranker and Dodson and a copy, because of the interest involved, would have been sent to Egan.

Q Approximately how many reports, if you can give me an approximation, did you write up?

A I cannot, I don't recall how many reports.

Q Do you have any recollection that these meetins took place on at least a monthly basis?

A I think they were at least a monthly basis.

Q Can you tell me when the first time you recall being requested by anyone to look into the possibility of reformulating Mono-Kote 3?

A No.

Q Do you remember what year it was?

A I'm guessing 1969 -- wait a second, there were previous experiences of reformulating, but not for the purpose of the 1969 work.

Q When you say not for the purpose of the 1969

work, you're talking about reformulating in such a manner as to take out the asbestos that was added to the product?

A Yes, sir.

Q Do you remember who requested you initially to look into reformulating Mono-Kote 3 to remove the asbestos?

A Through the chain of command it was probably Keith Cranker.

MR. JONES: Only what you recall.

THE WITNESS: That's what I recall.

BY MR. BOUCHER:

Q Is he the person who you usually received job assignments or requests from?

A Yes.

Q During that period of time 1968 through 1973, did you ever receive a request directly from somebody in the marketing division of W. R. Grace to do any type of work that did not go through Mr. Cranker?

MR. JONES: Objection as to form. Are you changing the time period now because you have been '69 to '73. Are you going a year earlier?

MR. BOUCHER: '68 through '73.

THE WITNESS: Could you repeat the question?

BY MR. BOUCHER:

Q Between the period 1968 through 1973, was there ever any period where you can recall where somebody from the marketing division of W. R. Grace requested that you perform some task where that request didn't go directly through Mr. Cranker?

A No.

Q When you first received the request from Mr. Cranker, do you recall in what form the request was made?

A It was his habit to present a new idea verbally, but it was also his habit to document it and once agreement was reached as to whether or not we could handle this work.

Q Once it was agreed that you could handle the work, in what way would Mr. Cranker document his request?

A Generally, by memo.

Q Was there a general form which the memo took?

A Only in that it would have been addressed to me in this particular place with a copy to his supervisor and other interested people.

Q When you were first requested to look into the

possibility of reformulating Mono-Kote 3 so as to remove the asbestos, do you recall what priority was given to that work task?

A I recall it --

MR. JONES: Objection as to form, priority as to what, his other tasks?

MR. BOUCHER: As to any other tasks.

MR. JONES: The world at large, object to the form, you can answer if you can.

THE WITNESS: I recall it was relatively high.

BY MR. BOUCHER:

Q When you say you recall that it was relatively high, how do you recall that it was relatively high, do you recall that?

A In view of subsequent activities.

Q Did you ever gain an understanding as to why the reformulation of Mono-Kote 3 so as to remove the asbestos was a relatively high priority for you?

A Yes.

Q When did you gain that understanding?

A It was through a period of time that I became aware that asbestos was somewhat of an emotional issue and

that it was a decision by C.P.D. to remove themselves from this problem if possible.

MR. BOUCHER: Can you read back the last part of the answer, please?

(Record read.)

BY MR. BOUCHER:

Q What was your understanding as to why it was a high priority to remove asbestos from Mono-Kote?

MR. JONES: Objection as to form. He didn't testify it was a high priority.

BY MR. BOUCHER:

Q Relatively high priority?

A In comparison with the other research work that I have had done previously, I could tell that it was higher priority.

Q Did you gain an understanding as why it was a higher priority other than asbestos being an emotional issue?

A No.

Q Did the issue of the potential health hazard to individuals who were exposed to Mono-Kote 3 as a result of the contents of asbestos, play any role in your

understanding as to why it was a relatively high priority?
A Would you repeat that question?
Q Did anyone ever indicate to you that the potential health affect of exposure to asbestos from Mono-Kote 3 was one of the reasons why it was a realatively high priority for you to reformulate Mono-Kote 3?
A Can we go off the record?
Q Sure.
(Discussion off the record.)
MR. BOUCHER: Can we have the question read back?
(Record read.)
THE WITNESS: Yes, and I emphasize the word potential.
BY MR. BOUCHER:
Q Who at Grace indicated to you that the potential health hazard from exposure to asbestos contained in Mono-Kote 3 was one of the reasons why it was a relatively high priority for you to reformulate Mono-Kote 3?
MR. JONES: Objection as to form, misstates the prior testimony. You can answer.
THE WITNESS: I think Mr. Egan had written a memo

which referred to a perceived health hazard.

BY MR. BOUCHER:

Q Do you recall approximately when during the course of the reformulation work that you were doing on Mono-Kote 3, the memo from Tom Egan was written?

A No, I do not.

Q Was it during the beginning, middle or end, if you can recall?

A I don't recall.

Q At the time that you had received the memo frm Mr. Egan, had you done any independent research into the medical or scientific literature with respect to the potential health hazards from exposure to asbestos?

A First of all, I don't recall when I received the memo, and secondly, such research is not in my field.

Q So you have never or had never conducted any independent research yourself and to the medical scientific literature with respect to potential health hazards from exposure to asbestos?

A No, sir.

Q Did anyone else at Grace ever discuss with you, any potential health hazards associated with exposure to

asbestos as a result or from asbestos contained in Mono-Kote 3?

A Not to my recollection.

Q Were you ever asked to make any -- let me rephrase it.

Were you ever asked to conduct any tests in order to determine the friability of Mono-Kote 3 with respect to asbestos?

MR. JONES: Objection as to the form of the question. You can answer it if you can.

THE WITNESS: Would you repeat the question?

MR. BOUCHER: You'd better read it back.

(Record read.)

THE WITNESS: I was not directly asked to do so, but I do know that through a request by the General Services Administration, that high velocity air errosion tests were run on MK-3 with extremely favorable results.

BY MR. BOUCHER:

Q Did you participate in any other tests that would go to the issue of friability of Mono-Kote 3?

MR. JONES: Objection as to form, I don't know what you mean by issue of friability, but if that has some

meaning to you Mr. Bragg, you can answer the question.

THE WITNESS: The word friability is a confusing word. In my experience, I have attempted to formulate fireproofing compositions of proper density and hardness period.

BY MR. BOUCHER:

Q Let me go through some documents with you if I can. Let's have marked as Exhibit 1152, September 17, 1985 memo submitted by R. J. Bragg entitled Surface Hardness and Density of Zonolite Mono-Kote Sprayed Fireproofing.

A Did you say '85?

Q Excuse me, '65.

(The document referred to was marked Deposition Exhibit Number 1152 for identification.)

Q Have you had an opportunity to review Exhibit 1152?

A Yes.

Q Can you please tell us what 1152 corresponds with?

MR. JONES: Objection as to form.

THE WITNESS: I don't understand the question.

BY MR. BOUCHER:

Q 1152 entitled Surface Hardness and Density of Zonolite, what was the purpose of your writing Exhibit 1152?

A We had made efforts during the marketing of Mono-Kote to maintain a certain hardness and density. The two are directly related so that we would provide a relatively hard membrane of fireproofing at the ceiling level. This opposed to the sprayed fibrous materials which tended to be lower in density and if you had used the word friable before, much more friable, so this is an indication of a particular Mono-Kote which has a dry density of 23.2 pounds per cubic foot and a surface indentation resistance of 414 P.S.I.

Q Were any dust studies done to determine the amount of fibers that were released during the tests performed as set out in 1152?

A No, sir.

MR. JONES: Could I hear the question back, please?

(Record read.)

BY MR. BOUCHER:

Q Can you tell me how the test was set up that was conducted as reflected in 1152?

A Yes, the density would have been determined by dimensioning or measuring the dimensions of a dry sample of Mono-Kote obtaining its weight and then making the calculation to derive the pounds per cubic foot. As far as surface hardness, we had a device, which is called a pocket contrometer spring-loaded device which was depressed into the surface of the Mono-Kote and the force necessary to press that one quarter of an inch into the surface was recorded in pounds which is converted in the instrument to P.S.I.

Q Were any comparison tests ever done with any other type of spray-on fireproofing material to determine the relative surface hardness between Mono-Kote 3 and other types of spray-on fireproofing?

A Yes.

Q Do you recall when those tests were performed?

A It was one of my responsibilities in research not only for the Grace Company, but for whomever I worked to run competitive testing on products and I would obtain, in the case of the dry hose material, samples pretty much any

way I could. I recall one time I walked onto a competitive job and managed to get samples, took them back to the laboratory for tests, and invariably, these materials are so much softer and they exhibit dustiness at the time they're applied and at the time they're tested.

Q In testing these other materials, were you ever able to duplicate this same procedure that you used when you tested the surface hardness of Mono-Kote 3?

A Could you repeat the question, please?

(Record read.)

THE WITNESS: In general, I used the same procedure.

Q Let's have marked as Exhibit 1153, the -- a September 14, 1965 letter from Robert W. Hunt Company.

(The document referred to was marked Deposition Exhibit 1153 for identification.)

Q Have you had an opportunity to review Exhibit 1153?

A Yes.

Q Are you familiar with Robert W. Hunt Company?

A Somewhat, yes.

Q Did you ever have any interaction, did you ever

work with them in any way in your capacity at W. R. Grace?

A I don't recall specifically, I do know I have had some interaction with them.

Q Did you ever have any interaction with them with respect to Mono-Kote 3?

A Not to my knowledge.

Q Have you ever seen Exhibit 1153 prior to today?

A I don't remember it.

Q Let me take you back to Exhibit 1152. Is that your signature that appears on 1152?

A Yes.

Q Let me hand you a one-page article that appeared in Walls and Ceilings in May of 1970 and have it marked as Exhibit 1154 to see if you ever have seen it or reviewed it before?

(The document referred to was marked Deposition Exhibit 1154 for identification.)

MR. JONES: Is this the entire document as it appearing in the files produced to you or are there other things attached to it?

MR. BOUCHER: That is the entire document as it appeared.

MR. JONES: Now, wait until he asks you a question.

BY MR. BOUCHER:

Q Have you ever seen Exhibit 1154 before?

A No, I thought he asked if I read it.

MR. JONES: He may have.

BY MR. BOUCHER: Let me hand you what we will have marked as Exhibit 1155 and it is a 22-page document which is a xerox copy of a report at large, the Magic Mineral by Paul Brodeur, a reprint from the New Yorker issue November 12, 1968.

(The document referred to was marked Deposition Exhibit 1155 for identificaiton.)

Q Have you ever seen Exhibit 1155 prior to today?

A No, sir.

Q Have you ever heard of the article that appeared by Mr. Brodeur in the New Yorker magazine?

MR. JONES: Please fix a timeframe.

BY MR. BOUCHER:

Q 1968?

A I've never heard of it.

Q Let me hand you what we'll have marked as Exhibit

1156 and it is the July 15, 1970 memo titled Asbesto Fiber Concentrations in Air from Spray Fireproofing Operation Using Zonolite Products and it appears to be five pages long.

(The document referred to was marked Deposition Exhibit 1156 for identification.)

Q Have you had an opportunity to review Exhibit 1156?

A Yes, sir, I have scanned it, I have not seen this before.

Q Have you ever in your capacity at W. R. Grace, did you have any interactions with Tabershaw and Cooper and Associates?

A No.

Q Let me have marked as Exhibit 1157, an abstract of tests report dated April 30, 1964 signed by Robert W. T. Olson, P.E..

(The document referred to was marked Deposition Exhibit 1157 for identification.)

Q Have you had an opportunity to review Exhibit 1157?

A Yes.

Q Have you seen Exhibit 1157 prior to today?
A I think so.
Q Do you recall when the last time you saw Exhibit 1157 was?
A Probably while I was still employed by the Grace Company.
Q Did you have any interaction with Robert W. T. Olson in your capacity while working at W. R. Grace?
A I don't recall his name, but I do remember that we had interaction with Boyle Engineering Laboratory.
Q What would be the reason for you seeing a copy of 1157 while you were employed at W. R. Grace?
A I was probably involved in the preparation of the sample which they report here.
Q Would you have been present during the time that the test procedures were employed?
A No, sir.
Q Do you know whether or not any dust studies were conducted after the test to determine whether any asbestos fibers were emitted from the Mono-Kote that was being tested?
A Could you repeat that question.

(Record read.)

THE WITNESS: No.

BY MR. BOUCHER:

Q To your knowledge, did W. R. Grace commission any tests similar to the test that is reflected in Exhibit 1157 on any sprayed-on asbestos fireproofing materials that were manufactured or produced by any entities other than W. R. Grace?

A Not to my knowledge.

Q Let me then hand you what we will have marked as Exhibit 1158, it was a June 25, 1965 letter to Mr. Paul Martin Malter from Robert W. T. Olson.

(The document referred to was marked Deposition 1158 for identification.)

Q You have had an opportunity to review Exhibit 1158?

A Yes.

Q Have you seen Exhibit 1158 prior to today?

A I don't remember it.

Q What was Martin Malter's position at Grace in terms of his job responsibilities in 1965?

A His title in this memo is Manager of Plastics

Products which would have been the foam polystyrene product line of Grace, but subsequent to that, he was appointed Manager of Fireproofing Products proceeding Tom Egan.

Q Let me hand you what we'll mark as Exhibit 1159, it is a September 14, 1965 letter from Robert W. Hunt Company to Mr. Martin Malter.

(The document referred to was marked Deposition Exhibit 1159 for identificaiton.)

Q Have you had an opportunity to review Exhibit 1159?

A Yes.

Q Have you ever seen Exhibit 1159 prior to today?

A No, I have not.

Q Did you ever do any work with anyone from Robert W. Hunt Company?

A I recall that I have, but I don't remember specifically what it was.

Q The Exhibit 1159 reports bond test results; is that correct?

A Yes.

Q There is a column set out on line failure,

underneath it it indicates core broke. What does that mean to your understanding?

A It means, according to this letter --

MR. JONES: Not according to the letter, you have never seen the letter. If you have an independent understanding of what core broke means, you may testify to it.

THE WITNESS: The core in this case is Mono-Kote and the word core broke means that the material broke in cohesion not at the interface which was being tested and I might also add that the failure, in looking at the column, the second from the last of which is labeled powers per square foot indicate that the failure is in excess of eyeballing it a thousand pounds per square foot which is pretty good for material that can't weigh more than two pounds a square foot.

MR. JONES: Are you going to move to a new document at this point?

MR. BOUCHER: I think so.

BY MR. BOUCHER:

Q Do you know what the -- what were the specifications, if you can recall, in 1965 for tensile

strength with respect to pounds per square foot for Mono-Kote 3?

A I don't know if there was a specificaton for tensile strength, I doubt that there was and in this particular letter, they're referring to adhesive bond as opposed to tensile strength.

MR. JONES: Can we break?

MR. BOUCHER: Let me ask one question.

BY MR. BOUCHER:

Q Did you ever -- I don't know if this is already come up, did you ever do any work with or consult with Werby Laboratories?

A No.

Q During your work at W. R. Grace, did you ever get involved in air sampling or fiber counting with respect to Mono-Kote 3?

A No.

MR. BOUCHER: Let's take a break.

(Recess.)

BY MR. BOUCHER:

Q Let me hand you what will be marked as 1160. It is a three-page, May 9, 1969 memo to R. W. Sterrett from

K. R. Cranker.

(The document referred to was marked Deposition Exhibit 1160 for identification.)

BY MR. BOUCHER:

Q Have you had an opportunity to review Exhibit 1160?

A Yes, sir.

Q Have you received a copy of Exhibit 1160 prior to today?

A Yes.

Q The date of the memo is May 9, 1969, the first paragraph indicates

"Ralph Bragg and I have established priorities on a list of projects to be worked on during the rest of this year."

Was it your normal practice to set out priorities for projects to be worked on during the course of a year with Mr. Cranker?

MR. JONES: Objection as to form. This isn't Mr. Bragg's memo, so why would it be his normal practice?

MR. BOUCHER: It says Mr. Bragg and I have established.

MR. JONES: That's not your question.

BY MR. BOUCHER:

Q Go ahead.

A I would say it's Mr. Cranker's form to prioritize projects.

Q So you didn't participate in the prioritization of projects during the course of a year with Mr. Cranker?

A Yes, I did.

Q So it was your normal practice to participate with Mr. Cranker in prioritizing projects that would be worked on during the year?

A If he asked me.

Q The next paragraph indicates

"I am summarizing the projects in order of importance."

As you sit here now, does the order of importance as set out in this memo, appear to be correct as you recall it?

MR. JONES: Objection as to form, what does correct mean? Does he agree with the prioritization or agree that he agreed with it at that time?

MR. BOUCHER: Is it accuarately set out?

MR. JONES: It's not his memo, Mr. Boucher, he can't answer that question.

THE WITNESS: I agree that I agreed that this was the right order of priority at the time of May 1969.

BY MR. BOUCHER:

Q What criteria, if you can recall, was used in establishing the priorities, or the order of priorities, for these projects, as set out in the memo of 1969?

A Actually, there the criteria are too numerous to recall, but they would involve business decisions, requests from the various product managers which essentilly are business decisions.

Q The sixth priority is Mono-Kote. It appears on the second page. Do you see that?

A Yes.

Q It indicates

"We have one request to find a substitute for asbestos in this compound."

Is that correct?

A Yes.

Q Do you know or recall who made the one request to find a substitute for asbestos that is referred to in

Exhibit 1160?

A Not completely. I would expect it would have come from the marketing group of fireproofing.

Q The memo is dated May 9, 1969. Does that refresh your recollection as to when the first request was made to your department to find an asbestos-free substitute for Mono-Kote 3?

A Yes.

Q So that request would have been prior to May of 1969?

A Yes, sir.

Q Do you have any recollection, having reviewed Exhibit 1160, as to how many weeks or months prior to May of 1969 that request would have been made?

A No.

Q The second sentence in the first paragraph on page two under category 6 Mono-Kote reads

"Asbestos is a health hazard."

Is that something that you had discussed with Mr. Cranker with respect to Mono-Kote?

A I don't believe so.

Q Is Mr. Cranker still alive today, do you know?

A I don't know.
Q The next sentence reads
"We will assist only in an advisory capacity by selecting possible substitutes."
What was your job responsibility with respect to the advising capacity?
A I was responsible for determining potential candidates for test at this time.
Q By candidates for test, do you mean substitutes for asbestos?
A No, I would say I had total responsibility for the composition.
Q What do you mean by candidates?
A If one removes one component, there is a certain amount of readjustment that has to take place to come up with a viable product. It's not simply a matter of pulling out one ingredient and putting in another one.
Q The next sentence reads
"It appears Chapin's lab will do the testing."
Do you see that?
A Yes, sir.
Q What was Chapin's lab, or who was Chapin, if you

recall?

A W. R. Grace had at that time and still maintains an application laboratory in the town of Travelers Rest, South Carolina, and during this time period, Jim Chapin was manager of that laboratory.

Q Do you recall how many meetings you had with Mr. Cranker prior to May 9, 1969 where you discussed the reformulation of Mono-Kote 3 to find a substitute for asbestos?

A I don't, but I would have to assume that --

MR. JONES: Don't assume. What do you remember?

THE WITNESS: Minimal

MR. JONES: Only what you remember, not what you assume.

BY MR. BOUCHER:

Q Let me hand you a memo which will be marked as Exhibit 1161 dated July 8, 1969 from W. R. Sterrett -- excuse me, from G. S. Breslauer, B-R-E-S-L-A-U-E-R to R. W. Sterrett, subject fine wood fiber.

(The document referred to was marked Deposition Exhibit 1161 for identificaiton.)

Q Have you had an opportunity to review Exhibit

1161?

A Yes.

Q Did you receive a copy of 1161 prior to today?

A Yes.

Q Did you receive it at or about the time that the memo was dated July of 1969?

A Yes.

Q What was Mr. Breslauer's job responsiblity, if you can recall, in July of 1969?

A As I recall, he was manager of the Permadeck manufacturing facility in Brunswick, Georgia.

Q The first item of the memo indicates that, or states

"In the search for a substitute fiber for asbestos in Mono-Kote"

was Mr. Breslauer involved in research or aiding you in finding a substitute for asbestos in Mono-Kote?

A Not directly.

Q The third paragraph, there is an underlined sentence

"I personally doubt that the flammability of the material would make any difference in the product."

Did you underline that?

A Yes, I think I did.

Q What was the purpose for underlining that sentence?

A It's an important concept.

Q How so?

A Well, at the time, we were doing reformulation on MK-3, the general belief was that we needed a reinforcing fiber in the composition which would withstand the high temperatures of fire exposure. Now, all of a sudden, here is an idea where a fiber is recommended which certainly not would withstand those temperatures.

Q Did you agree with Mr. Breslauer that the flammability of the material wouldn't make any difference in the product at that time?

A Not at that time, but I had occasion to change my mind once or twice since then.

Q What was the purpose served by the use of asbestos in Mono-Kote 3?

A There were several purposes. First of all, the wet mixing of Mono-Kote, it produced a homogeneous product. Also, asbestos fiber has a large affinity for

water, and again, in the wet mixing to get proper consistency, we have to add quite a bit of water which also increases the yield of the product, makes it more attractive to the contractor. Asbestos fibers of pumpability aid, it reduces the friction through the long hoses that the Mono-Kote has to traverse and then once in place on the beam or column or deck, it has a reinforcing role both during the drying of the Mono-Kote and in the event a fire occurs.

Q You say reinforcing role, is that similar to the role as a binder in the product?

A Yes, it's not the prime binder, it ties things together.

Q Sort of weaves things together?

A Right.

Q Was fine wood fiber tested to determine whether it could be used as a substitute?

A Yes, it was.

Q What was the results?

A As a matter of record, fine wood fiber, not the form that was recommended in this particular memo, but a more refined form did eventually replace asbestos and was

patented as Mono-Kote 4, and at that time, we concluded pretty much the same as Mr. Breslauer that one did not need an inorganic fiber, that a cellulosic was acceptable, but events happened afterward which changed our thinking on it. I won't say our, I'd say my thinking.

Q Let me hand you what will be marked 1162 which is an October 1, 1961 -- October 1, 1969 memo, subject Mono-Kote from R. J. Bragg to W. R. Payment at Travelers Rest.

(The document referred to was marked Deposition 1162 for identification.)

Q Have you had an opportunity to review Exhibit 1162?

A In general.

Q Is that your signature that appears on the second page of 1162?

A Yes.

Q Why did you send a copy of 1162 to W. R. Payment?

MR. JONES: Object to the form, you can answer.

THE WITNESS: Evidently, I didn't review this carefully enough. What is 1162?

Q It is this document that's before you.

A In the first paragraph, I state that

"I'm requesting that Mr. Payment run additional tests"

So the reason is to outline what it is I'd like him to do.

BY MR. BOUCHER:

Q As of October 1, 1969 then, had you been put in charge of primary responsibility of finding an asbestos substitute for Mono-Kote 3?

A I would say yes.

Q One of the cc's of Exhibit 1162 is to Ray Rothfelder. Do you have any recollection as to why he received a copy of Exhibit 1162?

A Yes, in the second paragraph, I indicated I'd had a conversation with Ray and that I am writing to ask him or provide him certain information and request present status of his work.

Q Having reviewed Exhibit 1162 --

A Again, that's the number, okay.

Q Having reviewed Exhibit 1162, does it refresh your recollection as to the role that Ray Rothfelder played in the reformulation of Mono-Kote 3?

A No, I indicated before that he had the original idea of paper fiber and that he had been of assistance in subsequent months.

Q The first sentence indicates

"Because of the urgency of Mono-Kote reformulation, I have requested through T. Egan and J. K. Chapin that you run additional tests."

Why did you use the term urgency of Mono-Kote reformulation?

A That state of being was obviously passed on to me through Mr. Cranker.

Q Do you have a recollection in what manner it was passed on to you?

A No, I do not.

Q Do you recall approximately how many meetings you had with Mr. Cranker between May of 1969 and October of 1969?

A I don't recall, but our desks were almost side by side, so there were numerous.

Q Did you receive any correspondence from Mr. Egan between May of 1969 and October of 1969 that led you to believe that there was some urgency in the reformulation

of Mono-Kote 3?

A Again, I don't recall.

Q Between May of 1969 and October of 1969, did you gain an understanding as to why there was an urgency for the reformulation of Mono-Kote 3?

A Yes.

Q What was the understanding that you gained at that period of time?

A That there was such an urgency.

Q Why?

A I would say that the fireproofing segment of C.P.D. business was significant and also that I am assuming our management considered that asbestos might be a potential problem.

Q By October of 1969, hadn't Mr. Egan indicated to you by correspondence or during conversation that he viewed asbestos as being a potential problem in Mono-Kote 3?

A He may have, but I don't have specific recollection.

Q Having reviewed -- let me rephrase that.

Exhibit 1162 indicates that there has become some

urgency of Mono-Kote reformulation. Does that mean that between May of 1969 and October 1 of 1969 that tasks that were outlined in the memo which has been previously marked as 1160, were reprioritized and that Mono-Kote became a higher priority than number six on the list?

A Certainly.

Q By October of 1969, would you say that Mono-Kote became the highest priority with respect to the tasks in your work group?

A Yes, sir, I would.

Q The second paragraph indicates, there is a sentence that starts off

"T. Egan has asked me to correlate all of this work so that we now appear to have a trio involved here."

The trio that you're referring to would be yourself, Mr. Payment and Mr. Rothfelder?

A Yes.

Q Do you have any recollection as to in what manner Mr. Egan asked you to correlate all of the work on the reformulation of Mono-Kote 3?

A I don't have a recollection.

Q As you sit here today, do you know whether or not

that request was made through Mr. Cranker or whether it was made directly to you from Mr. Egan?

A I say that Egan has asked me, so it would have been made direct to me.

Q Is that something unusual for somebody from marketing to ask you specifically to do a task?

A Somewhat unusual, yes.

Q As you sit here, do you have any recollection or understanding as to why Mr. Egan asked you to correlate the work?

A No.

Q Let me hand you then what we will have marked as 1163.

(The document referred to was marked Deposition Exhibit 1163 for identification.)

Q Have you had an opportunity to review Exhibit 1163?

A Yes.

Q Did you receive a copy of 1163?

A Yes.

Q Do you remember receiving a copy of that?

A I do now that I read this.

Q When is the last time you saw Exhibit 1163, if you can recall?

A I would guess it's December 1, 1969, but I'm not sure.

Q In what capacity was Mr. C. R. Babb working for W. R. Grace at that period of time?

A As I recall, he was assitant to Mr. Sterrett and Mr. Sterrett was the Vice-President, but I think that Roy Babb had another title which I do not recall. He might have been Marketing Manager.

Q Did you have any conversation with Mr. Egan about the substance of what is discussed in Exhibit 1163?

A Yes, I did. I recall arguing with him about products which have asbestos in free-form, for example, the dry hose applied fireproofing materials versus Mono-Kote 3 which had what I considered very tightly encapsulated asbestos fibers and I had concern of why Mono-Kote 3 would be grouped with fireprooging in general when most of the fireproofing materials were of the dry fiber type.

Q How many times did you argue with Mr. Egan on that point?

A I wouldn't say it was an argument, I would say it was a healthy discussion and perhaps at least half a dozen.

Q What was Mr. Egan's reponse to you?

A I think it would have been pretty much as outlined in this memo.

Q In other words, he had very strong feelings that asbestos should be taken out of Mono-Kote; is that correct?

A That's what he says here, yes.

Q That's what he said to you during the healthy discussions that you had with him on the subject?

A As I recall, he had a sympathetic ear for my position, but I think he was driven by other considerations which I probably was not aware of.

Q During the healthy discussions that you had with Mr. Egan on this topic, he indicated to you, did he not, that he felt the use of asbestos in Mono-Kote created a health hazard?

A I don't think he put it that way, no.

Q What way did he put it?

A I think he said the use of asbestos was a

perceived health hazard and as of yet, had not been proven at the levels that even the spray fibrous materials were evolving.

Q Did he indicate to you why he felt that Grace had an ethical obligation to get asbestos out of Mono-Kote 3?

A No.

Q Did you ask him what he meant by that?

A No.

Q What else did he say to you during these healthy discussions that you had with him with respect to the reformulation of Mono-Kote 3?

A I think most of the rest of the conversation would have been what our progress was at the time on the reformulation effort.

Q Did he ever indicate to you during these healthy discussions that he felt it was taking too much time to develop an asbestos-free substitute for Mono-Kote 3?

A I think it was Tom's normal manner to be anxious to get jobs done.

Q Was the reformulation of Mono-Kote 3 one of the jobs that he was anxious to get done?

A Yes, sir.

Q Did he indicate to you at various times that he was -- that he believed it was taking too much time to develop an asbestos-free alternative to Mono-Kote 3?

MR. JONES: Objection, asked and answered. You can tell him again.

THE WITNESS: Tom was very supportive of the work I was doing and rather than be irritated, would offer all help possible.

BY MR. BOUCHER:

Q I didn't mean to imply by my question that he was irritated, but did he seem to be disappointed that it was taking --

A Not to my knowledge.

Q Was anyone else present during any of the healthy discussions that you had with Mr. Egan on the reformulation of Mono-Kote 3?

A Probably, but I can't recall who it was.

Q Did you ever take any notes during any of the healthy discussions that you had with Mr. Egan with respect to the reformulation of Mono-Kote 3?

A No.

Q During any of the healthy discussions that you

had with Mr. Egan on the reformulation of Mono-Kote 3, did you discuss specifically the situation that was occurring in New York and Philadelphia with respect to the use of asbestos in spray fireproofing?

A No, because I had no knowledge of what was happening in the field.

Q At the time that -- during the time that Mr. Egan had these healthy discussions with you, did he indicate to you a desire to develop an asbestos-free alternative to Mono-Kote 3 or was it an asbestos-free substitute for Mono-Kote 3?

MR. JONES: Obejection as to form.

THE WITNESS: I don't know the distinction between alternative and substitute.

BY MR. BOUCHER:

Q Was it your understanding that Mr. Egan wanted to take Mono-Kote 3 with asbestos off the market and substitute an asbestos-free Mono-Kote in its place?

A It was my impression that Mr. Egan wanted to replace Mono-Kote 3 with an asbestos-free Mono-Kote of similar properties, one which would hopefully win the same listings that Underwriter's Laboratories that MK-3 had

enjoyed for years.

Q The next-to-the-last paragraph indicates "We need a reallignment of work assignments so that Ralph and/or others can get on this matter at once", underlining at once.

After the December 1, 1969 memo by Mr. Egan, was there a reallignment of work assignments to help you get on this matter at once?

A I think that Egan was not aware at the time he wrote this that we were on it at once, so this might be after the fact.

Q So by the December 1, 1969 memo, it was already the highest priority matter in your work group?

A Yes.

Q So the best you recall after December 1, 1969, there was no further reallignment of work assignments to help get the job done?

A No, that's not correct.

Q Was there any reallignment of work assignments to help you get the work done after December 1, 1969?

A There was a continual review pretty much on my part and reassignment of individuals for picking up new

people or dropping people as we went along as the needs dictated.

Q So by December 1 of 1969, the importance of reformulating Mono-Kote 3 was high enough that as work assignments needed to be reassigned to help on the reformulation efforts, those reassignments took place?

A Yes.

Q Again, in the next-to-the-last paragraph in Exhibit 1163, the last sentence reads

"It's been much too long already that we've been looking at this problem."

As of December 1, 1969, did Mr. Egan indicate to you that he felt it had been much too long that you had been looking at the problem?

MR. JONES: Asked and answered twice, I'll instruct the witness not to answer.

THE WITNESS: I don't choose to answer.

BY MR. BOUCHER:

Q Are you going to follow your attorney's instructions and refuse to answer the question?

A Yes.

Q Having reviewed the last sentence in the

next-to-the-last paragraph again, does it refresh your recollection at all the fact that Mr. Egan had indicated to you by December 1 or 1969 that it had been much too long that the problem had been looked at?

A I might -- could I confer with counsel?

Q Sure.

MR. JONES: The question was?

MR. BOUCHER: Please read the question.

(Record read.)

THE WITNESS: Yes, it refreshes my memory.

BY MR. BOUCHER:

Q In what way does it refresh your memory?

In other words, by December 1 of 1969, having reviewed the last sentence in the next-to-last paragraph, does it refresh your recollection that in fact Mr. Egan had indicated to you by that time he felt it was taking much too long?

A I know that he is promising all the help possible to let us go forward from here.

MR. BOUCHER: Let's take a couple minute break.

(Recess.)

BY MR. BOUCHER:

Q Let me have marked as Exhibit 1164, this hand-written memo dated 12/21/69 Re: Mono-Kote reformulation to W. R. Payment from R. J. Bragg.

(The document referred to was marked Deposition Exhibit 1164 for identificaiton.)

Q Have you had an opportunity to reveiw Exhibit 1164?

A Yes, I would say, though, it doesn't appear to be complete, there is no signature and there might be additional information on another page.

Q That's sort of my sense.

Is that your handwriting that appears on Exhibit 1164?

A Yes.

Q Was it your normal practice to sign hand-written memos such as this one which is marked as 1164?

A Yes.

Q Does it appear that a page or so is missing from 1164?

A Certainly a signature.

Q The first paragraph reads

"As a result of this morning's meeting with K.

Harrison, R. W. Sterrett, V. H. Dodson, K. R. Cranker, T. Egan and myself, the following decisions were made."

I don't remember talking about Mr. K. Harrison. Can you tell me what his job responsibilities were as of 12/69 to your understanding?

A At that point in time, he was Executive Vice-President of C.P.D.

Q Who did he report to if you know, at that time?

A Mr. Vining.

Q Was it unusual for Mr. Harrison to participate in a meeting with you with respect to your work at W. R. Grace?

A With most of my work, but on Mono-Kote reformulation it was not unusual.

Q Did he participate on a regular basis with you during meetings that you had with others on the reformulation of Mono-Kote?

A Either he or Mr. Vining, sometimes both.

Q Did you gain an understanding as to the reason for Mr. Harrison's participation in these meetings?

A I think it had to do with the urgency of the

situation.

Q Did he ever give you that indication?

A Yes.

Q What did he say or do to give you that indication?

A I don't recall.

Q Did you have any understanding or gain any understanding as to why Mr. Vining participated in these meetings with respect to the reformulation of Mono-Kote 3?

A Yes.

Q What was that understanding?

A Urgency.

Q And from what did you gain that understanding?

A Verbal comments made at openings of such meetings.

Q By Mr. Vining or Mr. Harrison?

A By Mr. Vining, I think we're speaking of him.

Q What did Mr. Vining say in terms of verbal statements at the openings of meetings?

A I can't recollect.

Q Do you recall at all the substance or gist of his comments?

A No.
Q Do you recall anything that Mr. Vining ever said to you in substance with respect to the reformulation of Mono-Kote 3?
A Not specifically, no.
Q But he did give you an indication that he felt there was some urgency to the reformulation process?
A Yes.
Q Did he give you the indication that he felt it should be a top priority?
A Yes.
Q Did Mr. Harrison confirm that -- did Mr. Harrison likewise indicate to you that the reformulation of Mono-Kote 3 was a top priority?
A Yes.
Q Do you remember anything that Mr. Harrison ever said to you during this period of time about the reformulation of Mono-Kote 3 or the gist of his conversations with you?
A No.
Q Did Mr. Vining or Mr. Harrison participate -- let me rephrase that.

Did Mr. Vining or Mr. Harrison make any suggestions to you during the courses of these meetings that took place with respect to the reformulation of Mono-Kote 3?

MR. JONES: Could I hear the question, please?

(Record read.)

MR. JONES: Any suggestions as to what he should do?

MR. BOUCHER: Right.

THE WITNESS: I don't recall specific discussion.

BY MR. BOUCHER:

Q The first paragraph of Exhibit 1164, the last three words are

"Lower cost alternatives."

To what extent was cost a factor in the development of an asbestos-free Mono-Kote product?

A Just in general, we knew that we could not introduce a product which would be out-priced in the marketplace, there were other fireproofing materials available, so we had to place this in a reasonable position. Also, at that point, I had identified cellufloc as a viable alternative. I knew the price of this, it was

expensive, and so, I'm thinking of looking for lower costs than cellufloc alternative.

Q What is cellufloc?

A It's a highly refined sulfate pump fiber, a wood fiber.

Q Similar to newspaper?

A Yes, but much more refined, much more expensive.

Q So by 12/21/1969, you were successful in finding an asbestos-free alternative to Mono-Kote; is that correct?

A Up to the point of bench research, but mind you, one has to go beyond that in this type of research. We had to confirm candidate compositions by pilot fire testing, by certainly full-scall Underwriter Lab testing, and this is a procedure that can spend ten to twelve months.

Q So by 12/21/1969, there had been no UL testing on the cellufloc alternative to Mono-Kote 3?

A I think that's correct.

Q Do you have any recollection of how soon after 12/21/1969 the first UL tests were performed on an asbestos-free Mono-Kote?

A I don't have any fixed data in mind, but it seems to me that we would have had another four or five, maybe six months of pilot fire testing and additional laboratory work before we were ready to go to UL.

Q Based on your -- let me rephrase that.

Did you gain an understanding from Mr. Vining that he was interested in the development of an asbestos-free replacement for Mono-Kote 3?

A I think that understanding was acquired sometime before Mr. Vining got involved in review meetings.

Q Did he at any point in time confirm that understanding?

A I believe that he did, but I can't specifically recall how or when.

Q Let me hand you what will be marked as Exhibit 1165. It is a February 24, 1970 memo from Thomas Egan to T. P. Feit re-equivalency at UL.

(The document referred to was marked Deposition Exhibit Number 1165 for identification.)

Q Have you had an opportunity to review Exhibit 1165?

A Yes.

Q What was Mr. Feit's responsibilities at W. R. Grace in February 1970, as best you can recall?

A I think he was Assistant Product Manager of Fireproofing.

Q And what was his role, if any, in interacting with you on the formulation of an asbestos-free Mono-Kote?

A He didn't have much of a role interacting with me, but he did have interacting with the Underwriter's Laboratories.

Q Do you remember receiving a copy of Exhibit 1165?

A Now that I see it in front of me, I do, yes.

Q What was Mr. Ottinger's role at W. R. Grace in February of '70, if you can recall?

A John was a sales capacity in New York City selling, among other things, Mono-Kote.

Q Did he have any interaction with you during this period of time with respect to the reformulation of Mono-Kote 3?

A No.

Q The first paragraph indicates that "Spraydon has developed an asbestos-free assembly and that Cafco has intimated that they have passed

Underwriter Laboratory tests."

Is that information that you obtained from anyone other than through this memo from Tom Egan?

A I think you're correct, I didn't -- did not obtain it from anyone except through this memo.

Q Did anyone ever indicate to you that as a result of the fact that Spraydon and Cafco had tested material, were about to test asbestos-free materials, that there was any additional urgency to the reformulation of Mono-Kote 3?

A I think this perhaps is Egan's way of reminding me, and certainly Tom Feit, of the urgency.

Q The second sentence in the middle of the paragraph indicates that

"It's important that we get an answer on equivalency for fiber-free Mono-Kote."

Do you see that?

A Yes, sir.

Q What did -- what was your understanding of what Mr. Egan meant there?

A There is a situation in UL where if one has composition A, which I will call MK-1, for example, and

composition B, which might be MK-3, if you test the two of them side by side on one identical panel and they behave similarly, then you will be rewarded all of the listings which compound A had for compound B.

Q In other words, compound B doesn't have to go through all the same tests that compound B originally went through?

A That's correct, and as a matter of record, that's exactly what happened to give MK-3 all the ratings that MK-1 had. We had quite a bit of problem trying to do this with MK-4 using MK-3 as a control, in fact, it was not done.

Q It was done on some, but not all of the --

A Correct.

Q The statement "it's important that we get an answer on equivalency for fiber-free Mono-Kote" does that indicate to you or, having reviewed it, does it refresh your recollection at all as to whether by February of 1970 there were UL tests done on the equivalency of Mono-Kote 4?

A In reading this memo, I would say that there were not UL tests done on MK-4.

Q Reading this memo, does it refresh your recollection at all as to how soon after February 1970 UL tests were done?

A No, this doesn't give any indication how soon it would have begun.

Q Understanding that the Exhibit 1165 doesn't say one way or the other when UL were begun, having reviewed it and sitting here, do you independently recall how soon after February 1970 the tests were begun, or was it soon after or --

A I would assume from this memo

MR. JONES: Don't assume.

THE WITNESS: I am reasonably certain that we would have asked Underwriter's Laboratores to construct the frames, the concrete back-up decks that we would think that we would need in the future for qualifying MK-4, so that's as far as I can go. I think that that work had been initiated at this point in time.

BY MR. BOUCHER:

Q By February of 1970, had Mr. Egan given you a clear indication that he wanted to get the first asbestos-free fireproofing material on the market?

A I don't remember exactly, I think you showed me a memo earlier this morning that indicated that he wanted that, that it was one of his desires. I can't remember exactly.

Q Let me hand you what will be marked as Exhibit 1166. For the record, 1166 is a March 16, 1970 memo to K. R. Cranker from R. J. Bragg, subject Mono-Kote reformulation.

(The document referred to was marked Deposition Exhibit 1166 for identification.)

Q Have you had an opportunity to review Exhibit 1166?

A Yes.

Q Is that your signature that appears on 1166?

A Yes.

Q Do you recall sending Exhibit 1166, the memo, to Mr. Cranker?

A Yes.

Q The memo appears to concern itself predominantly with the issue of costs for Mono-Kote reformulation. Does that provide you with any additional understanding or information as to whether -- where you were with respect

to the reformulation of Mono-Kote 3 as of March of 1970?

MR. JONES: I object to the form, you can answer.

THE WITNESS: Regarding costs, that's a normal part of industrial research, it has to be reported especially if it varies from a standard product, but I am reminded by this memo that we were zeroing in on a composition which contained cellufloc as the fiber to replace asbestos.

Q In other words, as of March 1970, you were pretty close to a reformulation of Mono-Kote 3 with an asbestos-free alternative?

A Yes. In fact, in the first paragraph, I have indicated that we have had five successful successive fire tests on material containing cellufloc.

Q The five successful successive fire tests, are those fire tests that were performed in your laboratory as oppossed to UL tests?

A Yes, these would have been small-scale four foot by four foot panels.

Q The first sentence, the last fragment of the sentence indicates "replacement of asbestos within trained error or non-hazardous fibers". Why do you use the term

non-hazardous fibers?

A I think by that time it was general terminology in this project. It does not reflect any personal opinicns.

Q So as of March 1970, you didn't have any personal opinions one way or another whether or not asbestos was a hazardous material?

A No, I did have an opinion, I think it's to the degree how much asbestos fiber is hazardous and what the risk is and so forth.

Q So as of March of 1970, it was your opinion that asbestos was a hazardous fiber?

A Except that it wasn't quantified.

Q And the efforts you were taking as of March 16, 1970, which were successful, were with non-hazardous fibers?

A They certainly were with non-asbestos fibers, yes. In this case, we were working with cellulosic fibers and looking at other types of fibers.

Q Let me hand you what will be marked as Exhibit 1167. For the record, it is a March 30, 1970 memo to O. F. Stewart from R.J. Bragg subject asbestos.

(The document referred to was marked Deposition Exhibit 1167 for identification.)

Q Have you had an opportunity to review Exhibit 1167?

A Yes.

Q Is that your signature that appears on 1167?

A I'm not sure. I wrote the memo, but I think it was signed by my secretary in my absence.

Q Do you recall writing the memo?

A Yes.

Q What was the purpose of sending the memo to O. F. Stewart?

A I asked him in the memo to give some expression of whether or not asbestos-free Mono-Kote was free of asbestos.

Q Did you have any understanding of -- strike that, let me rephrase it.

What was your understanding of what was meant by the term asbestos-free?

A My original understanding was free of added asbestos and that was my assignment on the reformulation work.

Q Did you come to a different understanding of what was meant by the term asbestos-free at some point in time?

A I think that at the time this was written, the specifications, the hazard specs had not been set yet, but there was discussion on the fact that they would probably be extremely low, in minimums that is, and I wanted to be assured that there was not a problem with the vermiculite itself contained in asbestos.

Q What hazards specs are you speaking about?

A Although this was not in my sphere of responsibility, I was aware that there were EPA specifications and Federal specifications. I didn't know their levels, but I did understand at the time that they were being discussed, and they had not yet been set.

Q As of March of 1970, you understood, or knew, that tremolite was a contaminant of vermiculite and that vermiculite was being used in Mono-Kote 4?

A Yes, sir.

Q And so it was the tremolite aspect of Mono-Kote 4 that you were concerned with with respect to whether or not it could be termed asbestos-free for you?

A Yes, that was my interpretation.

Q Did you, as a result of this memo, subsequently gain an understanding from anyone at Grace whether or not Mono-Kote 4 was "an asbestos-free" product despite the presence of tremolite contamination in the vermiculite?

A I did not receive an answer to this memo. That's not to say it wasn't sent, but I did not receive it.

Q Have you -- what is your present understanding of what is meant -- let me rephrase that.

As of 1973, what was your understanding of what the term asbestos-free meant?

MR. JONES: Objection as to form, meant where, used in what context?

MR. BOUCHER: What was his understanding of the term asbestos-free?

MR. JONES: You haven't located a term in use. You mean just the word out of the context with nothing?

I'll instruct the witness not to answer, totally improper question.

BY MR. BOUCHER:

Q Are you going to follow your attorney's instructions?

A Yes, sir.

Q You had previously indicated an understanding of the term asbestos-free and that understanding was of March 1970, between March 1970 and the end of the year 1972. Did that understanding of what is meant by asbestos-free change?

MR. JONES: Do you mean what was meant in the memo?

MR. BOUCHER: How he used the term asbestos-free.

MR. JONES: You may answer that question.

THE WITNESS: No, I had received no further education than I was seeking in this memo.

BY MR. BOUCHER:

Q What was your understanding of the level of contamination on a percentage basis of tremolite and vermiculite that used in the reformulation of Mono-Kote 4?

A That it was very insignificant.

Q Do you have a percentage idea of the nature of significance?

A No, I do not.

Q Your understanding, would it have been less than 1 percent?

A Certainly.

Q Would it have been less than 5.5 percent?
A I'm reasonably sure, but beyond that, I can't say.
Q The first sentence in Exhibit 1167 indicates "We're coming down to the wire on our Mono-Kote reformulation work."
What did you mean by coming down to the wire?
A I think what I meant is that we had probably selected a composition and were either ready to spray it on Underwriter Laboratory specimans or had recently done so.
Q I'm going to hand you a document dated June 15, 1970 to T. Egan from R. J. Bragg with an attachment entitled Problem with Mono-Kote.
(The document referred to was marked Deposition Exhibit 1168 for identification.)
Q Have you had an opportunity to review 1168, sir?
A Yes.
Q Is that your signature that appears on 1168?
A Yes.
Q A copy of Exhibit 1168 was sent to R. J. Anderson. What was his job responsbility?

A He was Product Manager of Roof Decks.
Q And it was also sent to W. R. Wright, why did Mr. Wright receive a copy?
A General Manager of Production.
Q And D. G. Powell also received a copy, why would he receive a copy?
A He was the new Director of Research.
Q J. N. Beveridge also received a copy, why would he receive a copy?
A Nelson Beveridge was Product Manager of the foam polystyrene products.
Q Exhibit 1168 refers to a copy of the status report presented June 15 at the Zonolite research committee meeting. What was the Zonolite research committee as of June of 1970?
A I don't have a very good memory of this, but I believe that these individuals who were copied, were members of a committee who reviewed Zonolite-type research in Cambridge as oppossed to the concrete and cement-type research that other people did at Cambridge.
Q Attached to it is an outline entitled Problem with Mono-Kote. Is that an outline that you drafted?

A I believe I did.
Q Is that the topic headings that you discussed with the committee?
A Yes, I believe so.
MR. JONES: Is this an entire document, counsel, or is this an excerpt from it, do you know?
THE WITNESS: Just an outline.
MR. JONES: I'm saying that document as produced.
MR. BOUCHER: My understanding is it's the entire document.
BY MR. BOUCHER:
Q Under Problem with Mono-Kote, the first sentence indicates
"Contains asbestos alleged to be carcinogenic and to cause asbestosis."
That was your understanding as of June, 1970?
A That was the allegation referring to asbestos per se, not necessarily asbestos in Mono-Kote or in the ground or any other place.
Q But it's under the title Problem with Mono-Kote as of March -- as of June, 1970. It was your understanding, was it not, that the problem with -- the

perceived problem with Mono-Kote was that it contained asbestos and that asbestos was an alleged carcinogen?

A Yes, sir.

Q And that that was the reason why you were told to work on a reformulation of Mono-Kote 3?

A That's correct.

Q To get the asbestos out of Mono-Kote 3 because it was perceived as being a carcinogenic agent?

A Right.

Q And below that is the heading Performance Objectives and those were the objectives that you were given with respect to the reformulation of Mono-Kote 3 in light of the problem?

MR. JONES: Can I hear the question?

(Record read.)

MR. JONES: That's not the heading. You said the heading was Performance Objectives, that is not the heading.

MR. BOUCHER: Excuse me, thank you.

BY MR. BOUCHER:

Q Below that is a section entitled Reformulation Objectives and those were the objectives you had with

respect to the reformulation of Mono-Kote 3 in light of the problem with Mono-Kote 3?

A Yes, they were the general objectives.

Q Let me hand you what will be marked as Exhibit 1169, it is dated September 21, 1970 to T. Feit from R. C. Ericson subject UL procedures for MK-4 consisting of a two-page letter with a two-page attachment.

(The document referred to was marked Deposition Exhibit 1169 for identification.)

Q Have you had an opportunity to review Exhibit 1169?

A Yes, in general.

Q Do you recall receiving a copy of 1169?

A Not exactly, but I probably did.

Q It's the type of document you would have normally received in the course of your work at W. R. Grace?

A Yes, sir.

Q Whenever documents were cc'd to individuals at Grace, they were generally sent to and received by those individuals in inter-office mail?

A Yes.

Q Having reviewed Exhibit 1169, does it aid you in

your ability to place when Mono-Kote 4 was first tested by Underwriter's Laboratories?

A Somewhat. What Mr. Ericson is discussing is UL procedures for Mono-Kcte 4. Now, it's typical, when a new composition is submitted to Underwriter Laboratories, that the formula is given to Underwriter Laboratories and at that time, one discusses the formula and the variation permissible in each component so that this document could have been prepared before a fire test, but certainly after commission of the formula to Underwriters.

Q Would the tests, the fire testing performed by Underwriters, have been soon after September 21, 1970 based upon your previcus experience with Grace?

A It would have been either slightly before or slightly after this date of September 21st.

Q Let me have marked as Exhibit 1170, an August 14, 1970 memo to K. R. Cranker from R. J. Bragg subject Trip Report.

(The document referred to was marked Deposition Exhibit 1170 for identification.)

Q Have you had an opportunity to review Exhibit 1170?

A Yes.

Q Is that a copy of your signature?

A Yes.

Q The Exhibit 1170 talks about a trip and sets out the purpose of the trip and the work accomplished. In the first paragraph,

"The purpose of the trip to assist W. R. Payment in implementing sample preparation of MK-3 and MK-4 as relates to our moderate risk Mono-Kote program."

Moderate rist Mono-Kote program, was that a program that MK-3 had been approved for, and you were seeking to determine how MK-4 -- let me rephrase it.

What is meant by moderate risk?

A It's a rating of degree of technical success. It can either be a low-risk, moderate-risk or high-risk research program and here I'm talking about somewhere in the middle, moderate-risk approach.

Q And you're trying to compare MK-4 performance versus MK-3?

A Yes.

Q Do you hava any recollection of the results of that comparison?

A No, this memo is sc general in nature that it doesn't even mention what samples were prepared except MK-3 and 4.

Q The next-to-the-last paragraph

"If it raises to that level is writing of 'white paper' on Mono-Kote R & D."

Do you recall what white paper is?

A I think at one time I was asked to write a white paper, but in effect, my memos and monthly reports probably took care of the need, so --

Q I take it from that statement that you didn't subsequently write a separate white paper on research and development with respect to Mono-Kote; is that true?

A Not to my recollection.

Q Let me hand you a letter from R. Ericson to -- strike that, from W. R. Payment to R. Ericson dated February 3, 1971. It is a letter with an attachment, the attachment is a bar graph and in addition, we will attach a clearer copy of the February 3, 1971 letter which unfortunately does not have the beginning part legible on it, so we will make all three of them Exhibit 1171.

(The document referred to was marked Deposition

1171 for identification.)

Q There is no need to read the whole thing, I just have a couple of brief questions about it.

Have you had an opportunity to review Exhibit 1171?

A Yes.

Q Do you recall receiving a copy of Exhibit 1171?

A Yes, I do.

Q In the Exhibit, it talks about JM asbestos fibers. Do have a recollection of the grade of asbestos fibers that was being used in Mono-Kote 3 as of February, 1971?

A No, I do have a recollection that there were a group of asbestos fibers permissible to be used in MK-3 at that time, and they were generally classified as asbestos shorts.

Q Would a seven series fiber be classified as asbestos shorts?

A Yes.

Q Let me have marked as Exhibit 1172 a two-page letter with two attachements dated June 26, 1973 from H. C. -- from J. C. Yang to H. C. Duecker otherwise known

as Duke Duecker.

(The document referred to was marked Deposition Exhibit 1172 for identification.)

Q Have you had an opportunity to review Exhibit 1172?

A Just generally.

Q Have you seen Exhibit 1172 prior to today?

A No.

Q Let me just ask you one question about it. If you look at the first paragraph, first sentence indicates "Vermiculite contains a small amount of asbestos in the range of 0.5."

Does that -- is that an accurate reflection to the best of your recollection of the amount of asbestos found in vermiculite?

A Actually, this area is beyond my expertise.

MR. JONES: I would point out of the record, though, that your prior question to him, though, involved the percentage of the product, not vermiculite.

MR. BOUCHER: I understood that.

BY MR. BOUCHER:

Q Mr. Bragg, it has been a pleasure, I appreciate

your time, I've got no other questions.

MR. SMITH: I have no questions.

MR. JONES: I have no questions.

(Proceedings concluded at 12:10 p.m.)

- - -

_____
Signature of Witness

Subscribed and sworn to before me this _____day of _____, 19_____.

_____
Notary Public

My Commission expires _____.

I do hereby certify that the witness whose attached deposition was taken before me, in the above-entitled matter, was by me first duly cautioned and sworn to testify the truth, the whole truth and nothing but the truth in the cause aforesaid; that the testimony contained in said deposition was by me reduced to writing in the presence of said witness by means of stenography, and afterwards transcribed upon a typewriter. The said deposition is a true and correct transcript of the whole of the testimony given by the said witness as aforesaid.

I do further certify that I am not connected by blood or marriage with any of the parties or their agents, and that I am not an employee of either of them, nor interested, directly or indirectly, in the matter of controversy, either as counsel, attorney, agent or otherwise.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal at Detroit, County of Wayne, State of Michigan, this 15th day of December, 1988.

Cathy Silverman

CATHY SILVERMAN
Notary Public, Oakland County, Michigan
My commission expires: 3/2-9/92

Deposition
EXHIBIT NO. 115z
12-9-88
C. SILVERMAN

ZONOLITE DIVISION
W. R. GRACE & CO.
RESEARCH LABORATORY
[redacted]

SURFACE HARDNESS AND DENSITY OF ZONOLITE MONO-KOTE SPRAYED FIREPROOFING

September 17, 1965

Test Report No. 1219

Laboratory Data Book No. 72, pp. 56, 119, 120, 123 & 129

Work done by: Ralph J. Bragg

Work requested by: N. Halter

Abstract: Surface hardness of a granular type sprayed fireproofing material such as Zonolite's Mono-Kote is over 400 psi.

Data:

Type of Material Tested	Specimen Density (pcf)	Pressure Required to Force: 1/20 sq. in. Flat Plunger 1/4 in. into Specimen
Mono-Kote	23.2	414 psi

Respectfully submitted,

Ralph J. Bragg

R. J. Bragg

Approved:

E. L. Perrine
Manager
Skokie Laboratory

095864

ROBERT W. HUNT COMPANY, ENGINEERS
CHICAGO 9, ILLINOIS
September 14, 1965

File No. 1301-1
Order No. L-4403

Report P-97
Page 1

Zonolite Company
8055 Lawndale Avenue
Skokie, Illinois 60076

Gentlemen:

We have made Salt Spray Test on six (6) 12" x 12" steel panels prepared and submitted by you. Three (3) of the steel panels had been galvanized and coated with your "Zonolite Monokote", the other three (3) steel panels had a prime coat and the "Zonolite Monokote", which is a cementatious mixture for fireproofing. The six (6) panels were tested in a Salt Spray Cabinet in accordance with ASTM B 117-61. The test was conducted for 240 hours.

At the conclusion of the test, the cementatious material was removed from the panels and surface underneath observed.

Observations:

Galvanize	Rusting on outer edges. Light rusting on panels.
Prime Coat	Rusting on outer edges. No rusting on Prime Coat.

Respectfully submitted,

ROBERT W. HUNT COMPANY

SS:fa-3

Chemical Laboratory Division

095828

Walls & Ceilings
formerly Plastering Industries
MAY 1970

Sprayed Asbestos Viewed With Growing Alarm

Careless spraying of asbestos insulating and fireproofing material is an air-pollution problem that has become a serious health hazard, Dr. Irving J. Selikoff, professor in medicine and environmental medicine, Mt. Sinai School of Medicine, warns.

Regulations should be stringent, rapidly prepared and quickly enforced, Dr. Selikoff contends. His dramatic presentations at the Las Vegas convention of the IAWCC and many personal appearances since have produced a sobering shock upon his audiences, since much of his material is backed with dramatic slides, scientific experiments and results of his intensive investigation of the problem.

Dr. Selikoff says that one out of every 4 or 5 asbestos workers dies of lung cancer. The very fine mineral fibers are found almost invariably in the lungs of persons autopsied in New York City.

Once the fibers get into the lungs, there is no way to remove them and they cannot be dissolved, he maintains. Dust counts taken during asbestos-spraying jobs show "on the order of 20 times the normal amount" of dust in the air, he says.

Entire buildings are sometimes "contaminated for life" because asbestos fibers are left loose on pipes, columns and beams and these "dead spaces" are often used as return air ducts for the building's circulation system, which exposes occupants of the building to constant peril.

A means has been found, observes Dr. Selikoff, for minimizing the circulation of loose particles in wrapped asbestos coverings, but no thoroughly satisfactory method of control for the spraying process has yet been perfected. Until such a means is determined, the only procedure which can save large segments of the population from serious respiratory problems is to keep spraying areas well protected and dampened, and use the most careful housekeeping procedures in clean-up and removal of loose material. Workers are warned to use protective masks at all times, to always apply material "away from prevailing winds" and to carefully wash both their bodies and clothes as soon as possible after exposure. Entrants of buildings should be thoroughly covered.

"Even at best, however," contends Dr. Selikoff, "these are interim measures," for no thoroughly safe method has yet been found to control the hazards involved in the spray-application process, since after the material dries, loose particles are free to thoroughly contaminate large areas both in and surrounding a building thus treated.

"I urge manufacturers and industry to view this threat seriously and find immediate means for controlling the hazards to millions of innocent citizens."

OFFICIAL PUBLICATION INTERNATIONAL ASSOCIATION OF WALL & CEILING CONTRACTORS
(Formerly Contracting Plasterers and Lathers International Association)

A REPORTER AT LARGE

THE MAGIC MINERAL

by PAUL BROOKS

REPRINTED *from* THE NEW YORKER

Issue of OCTOBER 12, 1968

THE MAGIC MINERAL

BACK in the nineteen-twenties, when the word "ASBESTOS" frequently appeared in large black letters on the fireproof drop curtains that closed off the proscenium openings of theatre stages, it was customary in certain parts of the country for youngsters attending Saturday-matinée performances of "Charley's Aunt" or "The Vagabond King" or "Mrs. Wiggs of the Cabbage Patch" to greet the raising of the asbestos curtain with the chant "All school boys eat stewed tomatoes on Saturday!" This was not, of course, an exercise in mnemonics but an expression of youthful exuberance, and, to a lesser extent, perhaps, a reflection of the tendency in an era celebrated for parochialism and flippancy to dismiss strange and exotic substances with jokes. Among older people, it was certainly common knowledge that asbestos was noncombustible, for when "Joe and Asbestos"—the syndicated comic strip about horse racing—first appeared in the Baltimore *Sun*, in 1925, the stableboy named Asbestos explained to the readership that he had acquired his odd moniker because "no matter how hot my tips are, they'll never burn a hole in your pocketbook." Such knowledge was hardly universal, however, for it was also true that a popular put-on of the flapper age consisted of solemnly assuring a susceptible theatre companion that the funny-looking word on the curtain meant "Welcome" in Latin. The fact of the matter is that although asbestos was linked one way or another in the

was a trademark, few people knew that it was being utilized in a wide variety of industrial products, only a handful of medical researchers were just then beginning to suspect that it was affecting the health of the workers who handled it, and virtually no one had any idea that it would one day prove to be one of the most important industrial causes of cancer in the world.

ASBESTOS, which comes from the Greek adjective *asbestos*, meaning inextinguishable or unquenchable, is a broad term embracing a number of fibrous silicate minerals that are found in practically every country in the world. According to geologists, chrysotile asbestos—a variety of the mineral that accounts for ninety-five per cent of the world's production—had its origin millions of years ago, when subterranean upheavals provided fractures in serpentine rock which were penetrated by water heated in the earth's interior. Subsequently, these waters dissolved some of the serpentine, and as the solutions cooled, fibrous silicate crystals began to grow within the fractures. The two other major varieties of asbestos—crocidolite and amosite—originated through somewhat different dynamic and thermal processes in metamorphic rock, and their fibers, though similar to chrysotile, possess different structural and chemical properties. Although known to man as early as the Stone Age, when it was used in pottery, asbestos was considered a novelty until the late eighteen seventies, when

mous industrial importance because of its unique and astonishing physical properties. It appears to be highly combustible, yet it can withstand the fiercest heat. It seems as perishable as grass, but by virtue of being almost immune to the forces of corrosion and decay under almost every condition of temperature and moisture (and of being resistant as well to the action of most acids, alkalies, and other chemicals) it is just about indestructible. It looks extremely fragile, yet its fibers have a tensile strength equal to that of piano wire. Apparently as light and feathery as thistle- or cattail-down, it is actually as heavy and dense as the rock from which it is extracted. In one sense, then, it is a fiber of stone. In another sense, however, it is a mineralogical vegetable whose fibers are so soft and flexible that they can be carded, spun, and woven as easily as fibers of cotton or flax.

Asbestos is the only mineral that can be woven into cloth, and its fibrous structure is, if anything, even more amazing than its remarkable ability to withstand heat. In fact, if it were not for the electron microscope, the extent to which asbestos is fibrous would be difficult to believe, for there are approximately a million individual fibrils lying side by side in a linear inch of chrysotile asbestos, whereas only thirty-eight hundred glass fibrils, such as those found in various insulation materials, or six hundred and thirty human hairs can be aligned along the same distance. Moreover, in addition to their extreme fineness, high tensile strength, unusual flexibility, spinnability, and resistance to heat and the elements, asbestos fibers possess great powers to adsorb and to bind. Small wonder, then, that when asbestos, which had been known to the ancients as "the magic mineral," was, in effect, rediscovered less than a hundred years ago, it was hailed as a miracle material.

Since that time, the demand for asbestos has risen almost as fast as the stuff could be mined from the earth and milled from its host rock. In 1879, when the world's first commercial asbestos mine was opened at Thetford, in the Province of Quebec, only three hundred tons of the mineral was produced. By 1910, annual world production had jumped to thirty thousand tons; by the middle thirties, it had increased to five hundred thousand tons; and today the total output is more than four million tons a year. Up until a few years ago, asbestos was often called "the mineral of a thousand uses" by those who sold it, but this label has become obsolete, especially in the United States, where it is estimated that asbestos may have as many as three thousand different industrial applications. The United States is the largest consumer of asbestos in the world, importing nearly a million tons a year, mostly chrysotile from Canada, and since fully ninety-five *per cent* of this amount is used in combination with other raw materials—such as Portland cement, asphalt, and vinyl and other plastics—asbestos is present as an invisible and anonymous ingredient in a myriad of industrial products, many of which are never identified as containing asbestos even though it may constitute up to fifty per cent of their content.

The asbestos-cement industry, which is the principal consumer of the mineral, makes shingles for roofing and siding, sheets for exterior and interior walls, insulation board, clapboard, casings for electric motors, pipes to carry water, sewage, and gas, and numerous other products. Asbestos textiles are used not only in fireproof theatre curtains but also in lagging and other insulating wrapping, in conveyor belting and motion-picture screens, as fibers in gas masks and in the processing of fruit juices, acids, beer, and medicines, and in mailbags, prison-cell padding, airplane fittings, stove and lamp wicks, sparkplugs, and fire hose. The electrical-equipment industry has depended for years on asbestos yarn and tape for insulating conductors ranging from fine-gauge wire to heavy cable, and woven asbestos friction materials—such as brake linings and clutch facings—are found in cars, trucks, tractors, power shovels, hoists, and other industrial machines, as are asbestos-cloth packings, seals, and gaskets. Asbestos papers and felts are used for roofing, for piano padding, for lining stoves, heaters, filing cabinets, military helmets, and the mufflers and hoods of automobiles, and they also are found in armored cars, carpets, and cartridges, and as boiler jackets and radiator covers. Asbestos millboard, which is a heavier version of asbestos paper, is used for acoustical ceilings, as plasterboard and fireproof wallboard, and in electric switch boxes, safes, table pads, stove mats, ovens, and dry kilns. Vinyl and asphalt floor tiles contain anywhere from thirty to fifty per cent, by weight, of short asbestos fibers, and the floor-tile industry has become the second-largest user of the mineral. Since the development of phenol-formaldehyde resins in 1909, asbestos has been used in large quantities as a reinforcement and filler by the plastics industry, and today there are countless plastic products that contain asbestos, ranging from frying-pan handles to cricket score covers. Asbestos is also an ingredient of many paints and sealants, of compounds used for road coating and road building, of putties, caulking, and other crack fillers, of clays used for pottery and sculpture, of artificial snow, of [illegible] and of natural steel, and of undercoating sprayed on automobile bodies.

As a result of these multiple and miscellaneous applications, asbestos has become practically ubiquitous in modern society. There is not an automobile, airplane, train, ship, missile, or engine of any sort that does not contain asbestos in some form or other, and it has found its way into literally every building, factory, home, and farm across the land. And, because its minuscule fibers are eminently respirable, asbestos has also found its way into the lungs of man, where, by remaining as indestructible as it does in nature, it can wreak terrible havoc.

THE adverse biological effects of asbestos were observed as early as the first century by the Greek geographer Strabo and by the Roman naturalist Pliny the Elder, both of whom mentioned in passing a sickness of the lungs in slaves whose occupation was to weave asbestos into cloth. Strabo and Pliny were calling attention for the first time in history to a disease that would one day be known as asbestosis—a form of pneumoconiosis (the general term for all dust diseases of the lungs) caused by the inhalation of fine fibers and particles of asbestos—but the ancients were much too awed by the magic of the mineral to be concerned with the possibility that it might constitute a health hazard. Indeed, their attitude toward asbestos sometimes bordered on veneration. Strabo and Plutarch noted that the "perpetual" wicks used in the sacred and unextinguishable lamps of the vestal virgins were made of asbestos, and Pliny described asbestos cloth, which had been used for centuries in cremations, as the rare and costly "funeral dress of kings." It was generally assumed in ancient times that asbestos was of vegetable origin—

the second-century Greek topographer Pausanias referred to it as "the only linen that is not consumed by fire"—and this misconception endured for centuries. Only a few years ago, a corporation shareholder of an English asbestos company who was visiting the source of its supplies in South Africa asked the resident manager where the plantations were. The Romans were especially impressed by the fact that when cloth made of asbestos was exposed to flame it always came out whiter than before—hence the Latin word for asbestos, *amiantus*, meaning unpolluted or undefiled—and they are said to have cleaned asbestos dinner napkins by tossing them into the fire.

The use of asbestos in Europe appears to have diminished greatly during the Dark Ages, although it is said that the Emperor Charlemagne convinced some wavering guests from a rival kingdom that he possessed magic powers by throwing an asbestos tablecloth into the fire and then withdrawing it, unscathed, from the flames. In the latter part of the thirteenth century, when the indefatigable Venetian traveller Marco Polo was traversing a part of Siberia then known as the Great Empire of Tartary, he was shown some cloth that would not burn, and was told by his Tartar hosts that it was made from salamander's wool. Too wise to be taken in by a story like that, Marco examined the material carefully and, after making some inquiries, learned that there was a mineral in the mountains of the district that contained threads like those of wool. In 1720, asbestos deposits were discovered in the Ural Mountains, and forty years later a factory was built to manufacture asbestos products. Because the known uses of the mineral were few and the demand was limited, this first commercial attempt to revive the long-dormant asbestos industry was a failure, but the second attempt, which took place slightly more than a century later, succeeded beyond the wildest dreams of its backers. As a result, the fact that asbestos could produce lung disease, which had been forgotten since Strabo and Pliny first recorded it around the time of Christ, soon manifested itself again.

Modern knowledge of asbestosis dates from the year 1900, when a post-mortem examination was performed by Dr. H. Montague Murray, a physician in London's Charing Cross Hospital, on the body of a thirty-three-year-old man who had worked for fourteen years in an asbestos-textile factory. The patient, found to have been suffering from severe pulmonary fibrosis, which is scarring of the lungs, had been the last survivor of a group of ten men who were working in the carding room of the factory in 1886, and since Dr. Murray found spicules of asbestos in the lung tissues at autopsy, he was able to establish a presumptive connection between the man's occupation and the disease that killed him. A few years later, an inspector in the Department of Labor at Caen, whose name was Auribault, reported the results of what was undoubtedly the first study of mortality among asbestos workers. According to Auribault, whose account appeared in the *Bulletin de l'Inspection du Travail et de l'Hygiène Industrielle*, an asbestos-weaving mill had been established in 1890 at Condé-sur-Noireau, in Calvados, and during its first five years of operation, when there was no artificial ventilation and the employees were heavily exposed to dust from the looms, fifty of them died. Moreover, the director of the factory, who had previously owned a cotton mill at Connerville, in Manche, had recruited seventeen workers from his former staff, of whom sixteen were not a physician, mistakenly described as chalicosis—a pneumoconiosis common among stonecutters.

Unfortunately, neither Murray nor Auribault realized the importance of their findings. Testifying before a Departmental Committee on Compensation for Industrial Diseases, in 1906, Murray said, "One hears, generally speaking, that considerable trouble is now taken to prevent the inhalation of dust, and as the disease is not so likely to occur as heretofore," and the concluding recommendation of Auribault's report was simply that people under eighteen years of age should not be allowed to work in dusty conditions. Because of ignorance about the cause of the disease, and because it manifested itself slowly and insidiously over a period of from ten to twenty years or more, asbestosis was probably more often than not misdiagnosed in the early part of the century as pulmonary tuberculosis, silicosis, or fibrosing pneumonia. In addition, coupled on the part of industry, timidity on the part of labor, and obscurantism on the part of the medical profession often combined to make early investigations into the health of asbestos workers meaningless. As a result, even though the asbestos industry was growing very rapidly in all the industrialized countries of the world, almost nothing was done to control dust levels in asbestos factories, and almost no medical information on asbestosis was gathered during the quarter of a century that followed the disclosures of Murray and Auribault—although asbestos workers were probably dying like flies of it.

It was 1924 *before* the first clear case of death due to asbestosis appeared in medical literature. In that year, Dr. W. E. Cooke, an English physician, who gave the disease its name, performed a post-mortem examination on the body of a forty-five-year-old woman patient who had started working at the age of thirteen in an asbestos-textile factory in which there was no provision for the removal of dust. By 1917, after thirteen years of exposure, she had been coughing and in bad health, and from then on her attendance at work had been intermittent because of shortness of breath and lassitude. The autopsy showed extensive pulmonary fibrosis and dense strands of abnormal fibrous tissue connecting the lungs and the pleural membranes surrounding them. In addition, Cooke noted the presence of solid yellowish-brown particles, which he called "curious bodies," in the areas of fibrosis. "We have never seen anything parallel to this in pneumoconiosis due to other dusts, nor have we been able to find such occurrence in literature," he declared, and he added, "We cannot think there is any reasonable doubt that the particles in the lung are the heavy, brittle, iron-containing fragments of asbestos fibre."

Cooke's discovery, which was published in the *British Medical Journal* of July 26, 1924, and republished in 1927, provided the point of departure for a scientific journey that started on an apparently straightforward path of occupational hygiene and that has since branched out into epidemiology, oncology, physical chemistry, physiology, and experimental pathology. As a result of studies made between 1927 and 1931, a whole literature relating to asbestosis appeared in Great Britain, which included clinical and X-ray findings, descriptions of the histology of the disease, and the hypothesis (soon widely accepted) that the strange-looking yellowish-brown bodies noticed by Cooke were asbestos fibers that had been altered by the reaction of lung tissue, and coated with a colloidal substance such in turn. In fact, Cooke's "curious

lungs of autopsied asbestos workers, many of which contained literally billions of them, that they quickly came to be called "asbestos bodies."

The most important investigation of this period was conducted by Dr. E. R. A. Merewether, a medical inspector for the Factory Department of the British Home Office. Between 1928 and 1929, he examined three hundred and sixty-three asbestos-textile workers out of an estimated total of twenty-two hundred asbestos workers employed in Great Britain at the time, and found that ninety-five, or slightly more than twenty-five per cent, showed evidence of suffering from pulmonary fibrosis. He also demonstrated that the incidence of fibrosis increased in direct proportion to the number of years of exposure, reaching eighty-one per cent in the group of workers who had been employed in the industry for twenty years or more. As a result of Merewether's report, Parliament passed legislation in 1931 that made asbestosis a compensable disease, required improved methods of exhaust ventilation and dust suppression in asbestos-textile factories, and instituted periodical medical examinations for workers engaged in particularly dusty processes in the asbestos-textile industry.

After this promising burst of activity, however, progress in the field of asbestosis was depressingly slow, for, as things turned out, the doctors had only begun to scratch the surface of a problem of bewildering complexity. Many investigators assumed that the new regulations would prove effective in controlling the disease, thus failing to appreciate the fact that, once inhaled, asbestos, which is virtually indestructible, continues to recur within the lungs for a lifetime, and to heed the warning of Merewether, who, when asked if two years of exposure was sufficient to cause asbestosis in a young girl, replied, "Yes, if she lives long enough." Moreover, techniques of dust sampling were primitive and inaccurate, and dust levels varied so greatly—not only from factory to factory but from area to area within a given factory—that it would have been almost impossible to establish criteria upon which to recommend a safe level of exposure. But as time went by, the generally lowered dust levels that did result from the regulations of 1931 appeared to be showing down the attack rate of the disease, at least in Great Britain, and the life expectancy of the average asbestos-textile worker was further increased by the advent of antibiotics, which drastically reduced the death rate from infectious pulmonary diseases that often had to be feared as a complication of asbestosis. The totally unforeseeable consequence of all this was that asbestos workers, instead of dying of asbestosis, began living long enough to develop asbestos-induced cancer.

The first published suggestion of an association between asbestosis and malignant disease was made in 1935 by Dr. Kenneth M. Lynch, professor of pathology at the Medical College of South Carolina, who described the case of a fifty-seven-year-old asbestos weaver who died of asbestosis and in whose lungs cancer was also found. Because the regulations of 1931 required British coroners to conduct autopsies on users who had been suspended from work with asbestosis on account of pulmonary disability or when their length of service rendered it likely that their occupation was a contributory cause of death, pathologists in Britain were able to investigate the suggested link between asbestosis and lung cancer much more easily than their counterparts in the United States, where few states had workmen's compensation laws covering dust diseases, and where there were no specific regulations requiring post-mortem examinations of asbestos workers. The British investigations were not made the subject of official comment until 1949, however, when Dr. Merewether, who was then Chief Inspector of Factories, published a review of data that had been accumulated from 1924 to 1946, which revealed that lung cancer was present in thirty-one out of two hundred and thirty-five deaths that were caused by asbestosis or in which asbestosis was found at autopsy. This was an incidence of slightly more than thirteen per cent, and Merewether found it highly significant, for lung cancer, according to its incidence in the general population, should only have been present in approximately one per cent of the cases. At the time, no formal claim of an association between the two diseases was made, but during the next few years an increasing amount of evidence began to establish one. Then, in 1955, Dr. Richard S. Doll, director of the Statistical Research Unit of the British Medical Research Council, completed a study of a hundred and thirteen consecutive autopsies of men with more than twenty years of exposure in a large asbestos-textile factory, which showed that the extent to which they had risked lung cancer over the whole period was eleven times as great as that of men in the general population of England and Wales. From then on, many doctors were convinced that a causal relationship between asbestos exposure and lung cancer had been demonstrated, although almost no part of the vast asbestos industry either acknowledged the relationship or found it advisable to aid the independent researchers who were investigating it.

AT this point, many epidemiologists had concluded that the hazards to human health presented by asbestos group of heavily exposed workers engaged in making asbestos textiles. The trouble was that very few studies had been made of the tens of thousands of workers engaged in other branches of the industry, which was then expanding at an enormous rate all over the world, so that no one really had any way of knowing whether there was any danger from moderate or light occupational exposure—or, for that matter, from indirect, non-occupational exposure. Such studies were under way in a number of countries, however, and when the results began to appear, in the late fifties, it became evident that the hazard posed to man by asbestos had once again been underestimated.

The most dramatic development was the discovery of an association between exposure to asbestos and mesothelioma, an almost always malignant tumor of the pleura, which is the delicate membrane that encases the lungs, or of the peritoneum, a similar membrane that lines the abdominal cavity. Previously, mesothelioma had been so rare that it was considered a pathological curiosity. It was found in only one out of every ten thousand autopsies, it was not listed in most medical books, and it was not even coded separately in the World Health Organization's International Classification of Diseases. In 1956 and 1957, however, sixteen cases of this rare tumor—tantamount to an epidemic—were diagnosed at the Pneumoconiosis Research Unit in Johannesburg, South Africa, by a pathologist named J. Christopher Wagner. Two circumstances led Dr. Wagner and his associates to suggest that asbestos might play some part in the mysterious outbreak: asbestos bodies had been found at autopsy in the lungs of the very first case, and ten of the cases had come from a hospital to which patients suspected of suffering from

large crocidolite-asbestos mining area.

At the beginning, this hypothesis seemed rather tenuous, for none of the sixteen patients who suffered from mesothelioma had ever worked in asbestos mines or mills. Within a short period, however, cases of mesothelioma began to crop up elsewhere in South Africa, and when Wagner and his associates discovered that the father of one of their new mesothelioma patients had been the manager of an asbestos mine, and that the patient had played around the mine and on the adjacent dumps as a child, they undertook to reinvestigate the sixteen original cases and to obtain detailed life histories in all future cases. By the end of 1961, they had diagnosed a total of eighty-seven mesotheliomas of the pleura and two mesotheliomas of the peritoneum. Only twelve of the cases proved to have had industrial exposure to asbestos, but all the rest came from the arid, windswept region of the Cape asbestos fields, where they could easily have sustained exposure simply by living in the vicinity of asbestos mills and dumps. A particularly striking case was that of a woman who was born in a town on the asbestos fields, left the region at the age of five, and died of a pleural mesothelioma at the age of fifty-seven. Detailed questioning about her childhood revealed that she had attended a kindergarten near an asbestos dump and that she and her playmates (two of whom also died of mesothelioma) used to enjoy sliding down the dump on their way home from school. Another example was provided by the youngest patient of the series—a man who died at the age of twenty-one. He had been exposed to asbestos from the age of six weeks until he was weaned—a period during which his mother took him along with her when she went to work at [illegible] Even among those patients who had worked in asbestos mines, the actual exposure appeared to have been slight, for in most cases the lungs showed no evidence of asbestosis but only a few asbestos bodies and fibres in the air spaces. From this, Wagner drew the chilling conclusion that mesothelioma might result from an exposure to asbestos dust that was considerably less than that needed to produce fibrosis—the condition that had always been considered essential for the development of asbestos lung cancer. (In some areas of South Africa, occupational exposure to asbestos dust was so heavy, however, that fibrosis of the lungs was almost certainly killing people before cancer could develop. According to Dr. G. W. H. Schepers, a native of South Africa who is now director of the Bureau of Laboratories in the Department of Health in Washington, D.C., conditions of industrial hygiene in the asbestos mines and factories were often "deplorable." In 1949, when Schepers was sent into the northeastern Transvaal to make the first official radiological and clinical survey of the asbestos industry for the South African government, he found barefoot Bantu children spending their days inside large jute shipping bags, where they were forced by overseers armed with whips to trample down fluffy amosite asbestos as it came cascading over their heads into the bags. Schepers found that a number of these children had developed asbestosis with cor pulmonale—right-sided heart failure, which often accompanies the disease—before the age of twelve, and he has said that he would be very surprised if any of them had lived long enough to develop either lung cancer or mesothelioma.)

In 1960, the year that Wagner published the first of his disturbing reports [illegible] grave concern among scientists investigating the asbestos problem. One of them occurred in Finland, where Dr. Raimo Kiviluoto, a radiologist, had been surveying the general population for tuberculosis; he detected deposits of calcium on the pleura, which had previously been seen almost exclusively in asbestos workers, in four hundred and ninety-nine out of sixty-three hundred and twelve people (mostly farmers and their wives) who lived in a county where asbestos had been mined and milled for many years, and no pleural calcifications in seventy-one hundred and one people who lived in a neighboring county where there was no asbestos industry. The other development took place back in South Africa, where Dr. J. G. Thomson, professor of pathology at the Medical School of the University of Cape Town, was examining lung-fluid smears from five hundred consecutive autopsies to determine the extent to which the ordinary urban dweller was exposed to the inhalation of asbestos; he found asbestos bodies in twenty-five per cent of the total. Thomson's discovery astonished the medical world, for up until that time no one suspected that asbestos bodies might be present in the lungs of people who did not work in asbestos mines or factories. He pointed out, however, that there had been a tremendous increase in the use of asbestos throughout the world over the previous twenty years—three million tons were marketed in 1960—and that asbestos was being incorporated into an increasing number and variety of industrial products with which the ordinary urban dweller came into intimate daily contact. He also suggested that the air of city streets was a likely source of asbestos exposure, and that the average motor vehicle, which wears out three or [illegible] lifetime, might well be a major source of the liberation of asbestos dust. Thomson reminded his colleagues that, compared to a half-life of twenty-eight years for strontium 90, the half life of asbestos fibre was an infinity of years, and he concluded that, because of the continuous disintegration of asbestos products such as brake linings, floor tiles, and roofing materials, as well as the demolition of buildings containing numerous other asbestos products, asbestos was constantly finding its way into the atmosphere as an everlasting contaminant. He even went so far as to predict that in future decades, as the accumulation of asbestos in urban areas led inexorably to higher concentrations of asbestos fibres in the lungs of urban dwellers, asbestos-induced neoplasms would rival cigarette-induced lung cancer as a cause of death.

As might be expected, the disclosures made by Wagner, Kiviluoto, and Thomson provided a powerful stimulus for further investigation of the problem of asbestos exposure. During the next few years, a hunt for mesotheliomas and asbestos bodies was undertaken by pathologists all over the world. Thomson's observations were confirmed by studies made in Miami, in London, and in Belfast, while in Pittsburgh asbestos bodies were found in the lungs of forty-six of a hundred consecutive autopsies at Presbyterian-University Hospital. And Wagner's findings were corroborated by investigations that associated mesothelioma with exposure to asbestos in half a dozen cities in Europe and the United States. Perhaps the most striking confirmation of Wagner's data came from London, where Dr. Muriel L. Newhouse and Dr. Hilda Thompson, of the Department of Occupational Health at the London School of Hygiene and Tropical Medicine, investigated the life his-

lioma that had been confirmed by autopsy or biopsy in London Hospital. To no one's surprise, thirty-one of the seventy-six patients had worked with asbestos, but eleven of those who had died had simply lived within half a mile of an asbestos factory, and nine others—seven women and two men—were relatives of asbestos workers. Most of these women had washed their husbands' work clothes regularly. The investigators learned that one of the husbands, a docker, had come home "white with asbestos" every evening for three or four years, and that his wife had brushed him down. Both of the men in this group, when boys of eight or nine years, had had sisters who worked in asbestos-textile factories. One of the sisters had been employed as a spinner from 1925 to 1936, and had died of asbestosis in 1947, at which time it was determined at an inquest that "she used to return from work with dust on her clothes." Her brother, who had apparently sustained no other exposure to asbestos in his lifetime, died in 1956 of a pleural mesothelioma.

Further corroboration of Wagner's findings came from southeastern Pennsylvania, where Dr. Jan Lieben, then head of the Division of Occupational Health at the State Department of Health, in Harrisburg, investigated the backgrounds of forty-two people who had died of mesothelioma between 1958 and 1963. Of the forty-two patients, ten proved to have had definite occupational exposure to asbestos, there were relatives of asbestos workers, eight either lived or were employed in the vicinity of an asbestos factory, and ten others were discovered to have had at best some minor exposure to the mineral. The ten people with minor exposure included a self-employed worker of Swiss cheese who used a five-hundred-gallon boiler covered with asbestos insulation that flaked off on contact, a salesman who had mixed and applied asbestos-cement insulation to boilers in his home, and a fourteen-year-old boy who at one time had helped his father saw up and install plasterboard during an extensive remodelling of their home.

From an epidemiological point of view, the investigations that tended to support the findings of Wagner and Thomson were weak, because they lacked a defined population as a base against which the data could be measured. On the other hand, the presence of asbestos bodies in the lungs of such a large percentage of consecutive autopsies in so many widely distributed cities of the world was sufficient to indicate that asbestos fibres were probably being inhaled by a majority of urban dwellers everywhere, and the association between asbestos and mesothelioma was striking enough to suggest that a history of exposure to the mineral was likely to be found whenever a positive diagnosis of the tumor was made. As a result, epidemiologists were forced to revise their idea that asbestos was only an industrial hazard, and to give serious consideration to Thomson's prediction that it might prove to be dangerous for untold numbers of unsuspecting people in the general community.

IN October of 1964, in order to review the data collected in the past and to discuss the problems awaiting solution in the future, the New York Academy of Sciences sponsored an International Conference on the Biological Effects of Asbestos, at the Waldorf-Astoria. The conference enabled more than four hundred scientists from all over the world to discuss the immensely complicated epidemiological and clinical problems that had appeared in the forty years since Dr. [illegible] described the first clear case of asbestosis, and its planning was largely the work of one of its co-chairmen, Dr. Irving J. Selikoff, who is head of the Division of Environmental Medicine at the City University's Mount Sinai School of Medicine, director of its Environmental Sciences Laboratory, and a pioneer in the field of modern asbestos epidemiology.

Like many of his colleagues at the conference, Dr. Selikoff became interested in asbestos in a roundabout way. A native of New York City, he interned at Beth Israel Hospital in Newark; did his pathology at Mount Sinai, where he has been a member of the staff since 1947; and became a chest physician at the Sea View Hospital on Staten Island, specializing in tuberculosis. In 1951, he participated in the basic research on isoniazid—the antibiotic drug that, by effectively killing tubercle bacilli, has provided a cure for tuberculosis—for which he received the American Public Health Association's Albert Lasker Award in Medicine. In 1953, Dr. Selikoff founded a medical clinic in Paterson, New Jersey, where, by chance, seventeen of his early patients were men referred for chest-disease consultations who worked in a local factory that had been making asbestos-insulation materials since 1940. When the factory closed down in 1954, the seventeen men went into other work, and at that point Dr. Selikoff decided to continue his observation of these patients with X-ray examinations and pulmonary-function tests in order to determine the history and the natural course of asbestosis in men who would not be subjected to further exposure.

At the time, Dr. Selikoff was chiefly interested in asbestosis because, as he has explained, "I was still unconvinced of the relationship between asbestos and cancer, and what there was recently seemed to indicate that it would prove to be much of a problem." As things turned out, he changed his mind. In 1954, all seventeen men from the Paterson factory were able-bodied and working. By 1961, however, six of them were dead, and today only six of them are alive. Of the eleven who died, four were victims of lung cancer, three of other cancers, one of mesothelioma, and two of asbestosis. Of the six who are still alive, two are disabled because of respiratory insufficiency caused by fibrosis of the lungs, and one has recovered from surgery for cancers of the lung and larynx. Dr. Selikoff shook his head in describing the fate of these patients, but as early as 1961 their ranks had been thinned out so drastically that, as he said, "I was forced to the awful realization of what could happen to men who were occupationally exposed to asbestos." After the company that owned the factory said it was unable to make its employment records available, he wrote to several other large asbestos manufacturers in the United States, inquiring about the health experiences in their plants, and was unable to obtain information from any of them. Meanwhile, he and Dr. Jacob Churg, chief pathologist at Barnert Memorial Hospital, in Paterson, who had been finding asbestosis and lung cancer in a large number of workers from the Paterson factory, took their data to Dr. Roscoe P. Kandle, Commissioner of the New Jersey State Department of Health, and Dr. Kandle applied to the United States Public Health Service for funds to undertake a study of the Paterson factory and to make a systematic survey to determine how many people were being occupationally exposed to asbestos. However, the request was denied for lack of resources.

men who had worked in the factory that made insulation materials were dying of asbestosis and lung cancer at an alarming rate, he considered that men who were installing such materials might also risk disease, and early in 1962 he made contact with officials of New York Local 12 and Newark Local 32 of the International Association of Heat and Frost Insulators and Asbestos Workers. The asbestos insulators had been trying for years to interest doctors and various government agencies in their medical problems, so they were only too glad to cooperate, and urged Dr. Selikoff to make a study in depth of the effects of asbestos exposure among their members.

During the next six months, Dr. Selikoff and his administrative assistant, Mrs. Janet S. Kaffenburgh, pored through the unions' records and compiled a list of the names and addresses of the six hundred and thirty-two men who had been members of either of the two locations both on December 31, 1962, and of the eight hundred and ninety men who had joined between then and December 31, 1962. From the unions' employment records, they obtained detailed work histories of the total membership of fifteen hundred and twenty-two men, including data on their withdrawal from work for other employment, war service, retirement, or illness. This enabled them to calculate the onset and duration of exposure to asbestos for each worker. Records of the unions' health and welfare funds provided them with the dates and places of death of the two hundred and sixty-two workers who had died between 1942 and 1962, and copies of the death certificates of all but one of them were obtained. In addition, autopsy protocols, histological specimens, and hospital records were reviewed by Dr. Selikoff and Dr. Churg in those deaths (approximately one-half of the total) which occurred in hospitals.

In the next phase of the study, Dr. Selikoff and Dr. Churg were joined by Dr. E. Cuyler Hammond, Vice-President for Epidemiology and Statistics of the American Cancer Society, who had participated in an analysis of the medical effects of the atomic explosions that devastated Hiroshima and Nagasaki, in 1945, and whose large-scale epidemiological studies of more than a million men and women provided a major basis for the conclusions drawn in the 1964 Surgeon General's report on the effects of cigarette smoking. Since previous studies had suggested that lung cancer associated with asbestosis seldom develops until twenty years after initial exposure to asbestos dust, Dr. Selikoff and Dr. Hammond decided to limit their first report to the six hundred and thirty-two men who were on the union rolls as of December 31, 1962. Taking the men's ages into consideration, Dr. Selikoff and Dr. Hammond then set about comparing the number and causes of death among them with those of the general male population in the United States. The results were depressing. According to the standard mortality tables, two hundred and three deaths could have been expected among the six hundred and thirty-two workers. Instead, there were two hundred and fifty-five, not counting seven men who had died before incurring twenty years of exposure—an excess of twenty-five per cent. The reason for the excess was not hard to find. The fact that twelve of the deaths were attributed to asbestosis was not particularly surprising, but only six or seven deaths from cancer of the lung, pleura, or trachea were to be expected, whereas there were forty-five. And where nine or ten gastro-intestinal cancers were to be expected there were actually twenty-nine. Since the lung-cancer death rate was known to be more than ten times as high among cigarette smokers as among non-smokers, Dr. Selikoff and Dr. Hammond realized that they would have to take the smoking habits of the asbestos-insulation workers into account if their findings were to have any validity. It was, of course, impossible for them to ascertain this with accuracy in the cases of the two hundred and fifty-five men who had died, so, for purposes of calculation, they assumed that all six hundred and thirty-two men had smoked a pack or more of cigarettes each day, and they demonstrated that even if this had been the case it would have produced a lung-cancer death rate only three and a half times that of the general male population. Cigarette smoking, therefore, could not explain the fact that in this group of asbestos-insulation workers the rate of death from lung cancer was seven times the expected rate.

Because of its objectivity, its scope, and its thoroughness, this study conducted by Drs. Selikoff, Churg, and Hammond had a great impact on the medical community when it was published, in the spring of 1964, in the *Journal of the American Medical Association*, and when it was delivered before the Conference on the Biological Effects of Asbestos that October. It was the first study ever made that had taken a large enough group of asbestos workers from a point far enough back in time and followed them long enough to determine unequivocally what their health experience had been. Unlike almost all the previous investigations, which simply indicated that there was an association between asbestos and various kinds of cancer, it was based upon the incidence of disease within a defined population, and thus answered a fundamental epidemiological question of how many cancers had developed during us, it furnished the first incontrovertible evidence that industrial exposure to asbestos was hazardous, established sound methodology for future studies, and it marked a turning point in the views held by doctors and health officials around the world.

IN the autumn of 1962, Dr. Selikoff, using donations from private sources and a grant awarded by the Health Research Council of New York City, headed by Dr. George S. Minish—had set up informal clinics at union halls in New York and Newark and started giving X-ray examinations, pulmonary-function tests, and blood tests to the members of the two asbestos workers' locals. During the next year, he examined eleven hundred and seventeen workers, and he also questioned them closely about their smoking habits, the kinds of materials they used, and the conditions under which they worked. "The insulation workers, an intelligent and highly skilled group of craftsmen, patiently educated me concerning their trade," he once said. "I learned that they had had comparatively light and intermittent exposure as asbestos workers go, because they often worked out-of-doors on construction projects, and because most of the materials they used had an asbestos content of less than fifteen per cent. I also found out how their problems had been neglected. Most of them had never seen a labor inspector in their lives, and only a handful could remember seeing anyone make a dust-level count in the areas where they were at work." Dr. Selikoff also learned that although some of the workers knew they ran a risk of developing asbestosis (which they usually referred to as asbestos) almost none of them had any idea that they also risked cancer because of their ex-

found radiological evidence of asbestosis in fully half of the eleven hundred and seventeen men. The extent of the disease varied directly with the duration of exposure. Of three hundred and forty-six men whose exposure had begun less than ten years before, only ten per cent showed any abnormality, and of three hundred and seventy-nine men who had been exposed for between ten and nineteen years more than half still had normal X-rays; in neither group was there any discernible evidence of cancer. On the other hand, Dr. Selikoff found that among three hundred and ninety-two men with more than twenty years of exposure three hundred and thirty-nine had developed asbestosis, which had by that time become moderate or extensive in more than fifty per cent of the cases; he also found that eleven of the men had developed cancers of the lung or pleura.

Aided by yearly grants from the Health Research Council, Dr. Selikoff has maintained a close watch on the asbestos workers' health, paying particular attention to those men with more than twenty years of exposure by examining them once or twice a year. As a result, he has been able to detect symptoms of illness in many of the men much earlier than they might have been detected and to observe with great accuracy the mortality experience of the three hundred and seventy whom he found in 1961 to be survivors of the original six hundred and thirty-two members of the union in 1942. It continues to be disastrous. Between January of 1961 and March of 1968, fifty deaths would normally have been expected to occur among these men. Instead, there were a hundred and thirty-two. Thirteen of them were caused by asbestosis, and, as with the earlier study, the rest of the excess turned out to be caused by cancer of various kinds. Twenty-three deaths from lung cancer would have been normal, but twenty-eight occurred, and where the actuarial tables predicted only two gastro-intestinal cancers there were eight. An unexpectedly sharp rise in the number of mesotheliomas was observed. In the earlier study, there had been only four in two hundred and fifty-five deaths; between 1963 and 1968, however, thirteen of these rare tumors were found in a hundred and thirteen deaths. Dr. Selikoff suspects that the latent period for mesotheliomas may be longer than that for either asbestosis or lung cancer, but so far he regards the heavy incidence of mesotheliomas among the insulation workers as something of a mystery.

Dr. Selikoff and Dr. Hammond found special significance in the fact that all twenty-eight bronchogenic carcinomas occurred among asbestos workers who smoked cigarettes regularly. None were found among eighty-seven men who never smoked cigarettes. Dr. Selikoff and Dr. Hammond have reservations about these data, which suggest that asbestos workers who smoke cigarettes are ninety times more likely to die of lung cancer than men who neither work with asbestos nor smoke, because they are based upon the experience of a relatively small number of people. They do conclude from it, however, that an important co-carcinogenic effect exists between asbestos exposure and cigarette smoking, and in a recent article published in the *Journal of the American Medical Association* they recommend "that asbestos exposure be minimized, that asbestos workers who do not smoke should never start, and that those now smoking should stop immediately." It has been suggested in some quarters that asbestos fibres, which are known to be highly absorbent as well as virtually indestructible, may retain the carcinogenic hydrocarbons from cigarette smoke for long periods of time in lung tissue, thus tending to produce lung cancer by a synergistic effect. No one knows for sure, however, and Dr. Selikoff will not hazard a guess about the matter until more information is gathered. He expresses certainty about the effects of asbestos exposure only when he has epidemiological proof. He knows, for example, that one out of every five asbestos-insulation workers who die in the New York-New Jersey metropolitan area dies of lung cancer, and that almost half of the three hundred and sixty-eight deaths he has recorded among these men in the past twenty-five years have been caused by cancer of one type or another. Last March, citing these figures before a House subcommittee on labor, he warned that "if they are projected to the country as a whole, and if no improvement in the health hazards these men face is achieved, we may look forward to perhaps six thousand deaths from lung cancer and to perhaps fifteen thousand deaths from cancer in general among men in this single asbestos trade alone." Considering that the total membership of the International Association of Heat and Frost Insulators and Asbestos Workers is only eighteen thousand men, and that there are about the same number of non-union asbestos workers, his prediction has staggering implications.

I RECENTLY spent several days with Dr. Selikoff in the Environmental Sciences Laboratory at Mount Sinai, where he has assembled a team of thirty men and women to work on various aspects of the asbestos problem. The rooms include laboratories for histology, pathology, electron microscopy, chemistry, and mineralogy, and among the imposing array of equipment they contain is an electron microscope that magnifies to a functional size. Dr. Selikoff's office is large and modern. Its walls are lined with shelves and cabinets containing hundreds of bound volumes of scientific papers and reports on asbestos, and at one end are a large conference table and a blackboard. The place gives an immediate impression of rather cold efficiency, but this is tempered to a great degree by the affability of the director. As we talked, Dr. Selikoff, a large, soft-spoken man in his early fifties, was frequently interrupted by telephone calls and by questions from staff members, but he generally responded—often with an enthusiastic "Where were we?"—and rattled off statistics about asbestos disease the way some baseball fanatics recite the batting averages of big-league ballplayers. On the day of my first visit, however, he received a call from a doctor in New Jersey who informed him that a lung cancer had just been diagnosed in another of the insulation workers. Dr. Selikoff told the physician that the patient's last X-rays showed moderate asbestosis, that he had had more than twenty years of exposure, and that he smoked a pack of cigarettes a day. When he hung up the phone, he was visibly upset, and fell silent. A few moments later, he said one that he had taken more calls like that than he cared to remember. "I don't relish the role of Cassandra, but I feel we've got to forge ahead on this problem as quickly as possible," he said. "There are about thirty-six thousand insulation workers union and non-union in the United States. All in all, including asbestos-textile workers and people engaged in manufacturing other asbestos products, there are probably more than a hundred thousand workers who are regularly and directly exposed. The hazard would be serious enough if they were the only groups at risk, but it's also

simply because floating asbestos fibers do not respect job classifications. Dr. William H. Stewart, who is the Surgeon General of the United States, told the House subcommittee that the asbestos-insulation workers are probably sharing their exposure to some extent with more than three and a half million other construction workers—steam fitters, electricians, welders, carpenters, insulators, plumbers, masons, tile setters, and the like—who are employed on the same projects, often in the same room or general area, and who therefore must be inhaling the same dusts."

Because of their concern with the possible effects of such indirect occupational exposure, Dr. Selikoff and his assistants have spent months compiling the names, addresses, and work histories of twelve hundred tile setters, three thousand roofing workers, and three thousand sound, insulation, and asbestos workers in the New York metropolitan area. They plan to examine these men for possible health problems as they did the insulation workers, and to determine whether they have significant indirect occupational exposure, and, if they do, whether it is associated with risk of asbestos disease. "We will study defined populations that have been selected in terms of what appear to be diminishing levels of exposure to a known risk," Dr. Selikoff told me. "It's as if a rock had been thrown into a pond and we're watching how far the ripples extend. Since the pond in our case is the general community, you can see how difficult the epidemiological detective work will be. If we discover, for example, that the tile setters run a significant risk of developing asbestos disease—and there are some preliminary indications that they might—then we must look into the operation of fiber fallout from the construction sites where they're employed. We're not going to wait for the results of the tile-setter study, however, because the problem is too urgent. We're initiating a whole cluster of studies designed to provide information on whether environmental asbestos pollution carries a risk for the general population. At the same time, by analyzing the ripples, we can determine which rocks thrown into the pond make the biggest splash. By thus identifying the sources of contamination, appropriate control measures will become feasible. Our plan of attack is to discover where asbestos-associated disease may occur, and to control the sources in such a way as to eliminate them as a hazard. It must be a team effort, of course, including epidemiologists, basic scientists, engineers, public-health officials, and industry and labor."

One of Dr. Selikoff's studies will examine the possible health problems arising from interrupted exposure by tracing thirteen hundred and sixty-seven men who worked at the asbestos-insulation plant in Paterson—closed down in 1956—where Dr. Selikoff's first seventeen patients were employed. Another will look into the matter of neighborhood exposure by tracing and investigating the health experience of seventy-five hundred people who lived within a half-mile radius of the plant in 1942. "The question of neighborhood exposure was emphasized as a result of the mesotheliomas discovered by Christopher Wagner in South Africa, and later by Molly Newhouse and Hilda Thompson in London and by Jan Lieben in Pennsylvania," Dr. Selikoff told me. "Since current evidence suggests that the tumor rarely occurs without a history of exposure to asbestos, epidemiologists consider it a 'marker' disease, and we'll be looking for it when we trace the medical history of the people in Paterson. Incidentally, there's one preliminary indication that we've already found. In 1955, the proprietor of a junk yard next to the Paterson insulation plant died of a pleural tumor." A third study in Dr. Selikoff's cluster will aim at the protection of relatives of asbestos workers. As in the case of neighborhood exposure, previous investigators of this group had no population base against which to measure the occurrence of the disease they discovered. Dr. Selikoff, however, has a definitely established group to work with. It is composed of the wives and children of all the insulation workers, and their health problems will be carefully scrutinized, especially for evidence of mesotheliomas. In Dr. Selikoff's opinion, this study will be of tremendous importance, because its subjects have been far removed from direct exposure. "If the families of insulation workers turn out to be in trouble, the implications will be very serious indeed," he said. "On the other hand, if we find no trouble among them—and this is my hope—we'll be on safer ground. Our observations will also enable us to recommend whether special facilities should be provided so that insulation workers can change their work clothes before going home to their families."

With the aid of a grant from the United States Public Health Service, Dr. Selikoff and his associates are currently conducting an investigation that covers an even wider range, by studying samples of lung tissue from three thousand consecutive autopsies that have been performed at three different hospitals in New York City and tracing the work histories of each of the dead people. So far, they have examined two thousand lung samples, and have found asbestos bodies in nearly half of them. According to Dr. Victor Hadem, a histologist at the Environmental Sciences Laboratory, from one to five or more asbestos bodies are found in fifty

Since each slide is composed of seven sections that together represent less than one half-millionth of an entire lung, and since it is widely assumed that asbestos bodies are evenly distributed throughout a lung, the finding of just one of them can be projected to mean that half a million may be present.

Dr. Selikoff and his fellow-epidemiologists do not know whether the relatively small amounts of asbestos now being inhaled by the general public carries a risk of inducing mesothelioma, or whether the presence of what appear to be asbestos bodies in the lungs of many people in the general population represents a serious public-health problem. Nor do they know whether relatively light inhalation of asbestos is associated with a special lung-cancer risk in cigarette smokers. "At present, we simply have no way of telling what the dose-disease relationships are," Dr. Selikoff said. "Is it better to have breathed in only fifty asbestos fibers than fifty thousand or fifty million? Does each fiber have the potential of causing a cell with which it comes in contact to turn cancerous? The answers to these immensely complicated questions will have to come from epidemiology over a long period of time. An eightfold increase in asbestos production over the last forty years would appear to make it likely that asbestos cancers will increase, but only the future will tell. Remember that current cases of mesothelioma must be associated with inhalation that took place twenty, thirty, or more years ago, when world consumption of asbestos was only about five hundred thousand tons a year, and that the mesotheliomas associated with today's production of over four million tons a year will not be evident until the nineteen-nineties. Moreover, we have found that [illegible]

theliomas, and not just crocidolite, as some of us had hoped following Wagner's observations in South Africa. The problem would have been simple if only one variety of asbestos had been related to this tumor. Control procedures could have been narrowly focussed. As it is, however, a control program will have to be concerned with asbestos in general."

I asked Dr. Selikoff if he thought that asbestos air pollution was responsible for the occurrence of asbestos bodies in the lungs of people in the general population, and he replied that although there was relatively little direct confirmation, he felt it was at least partly responsible. Pointing out again that direct and indirect occupational exposure were much more common than had been suspected, especially in the construction and shipbuilding industries, he went on to say, "The possible sources of environmental contamination are numerous. Mining and milling operations, manufacturing processes, and the delivery and storage of finished products constitute just one part of it. The constant use of asbestos materials in the construction industry is another, and the destruction and demolition of asbestos products in the community at large constitutes a third. There's no question in my mind that unsuspecting people are being exposed to small quantities of fibers from such sources as oven ironing-board covers and pot holders, and who knows how much asbestos is inhaled by hobbyists engaged in do-it-yourself projects around the house—like sawing up wallboard, mixing crack-filler compounds, insulating pipes with asbestos materials, and repairing furnaces and boilers with asbestos cement? I agree with those who suggest that small numbers of fibers may be liberated from many products in widespread use, such as asbestos-

are employed in the food and pharmaceutical industries, but we have no information that this carries a disease potential. What troubles me is that relatively few people are aware of the fact that it can be dangerous to inhale asbestos. Not long ago, we discovered that children in a number of kindergartens in New York, California, and other states were being allowed to mix raw asbestos with water to make a cheap form of play dough. We have also learned that the powders in some children's cosmetics kits and in certain powder-water-mix jewelry kits contain asbestos. In addition, within the past couple of years two different thoracic surgeons have published articles in leading medical journals which advocate the sprinkling of asbestos on surgical incisions in order to promote the adhesion and healing of tissue. This is very bad advice. Why, Dr. William E. Smith, who conducts animal studies at Fairleigh Dickinson University, has readily induced mesotheliomas in hamsters by injections of asbestos fibers into their pleural cavities!"

Dr. Selikoff went on to say that he understands full well that asbestos is an extremely valuable material, and that it has become essential in modern industrial society. "We epidemiologists recognize and study its dangers so that we may devise ways of minimizing or avoiding them," he said. "Improvements in the practice of industrial hygiene are needed to eliminate unnecessary exposure among asbestos workers and men in other building trades, and awareness of the potential risks of environmental contamination is needed until our studies indicate just how far out into the general population the problem extends. All I can say is that the public should be made aware of the problem, and that no one, particularly

undully exposed. After all, today's children are almost certainly inhaling more asbestos than their parents did, and we now know that if a person inhales significant amounts of asbestos dust, he carries a burden that will provide a latent potential for the development of cancer for the rest of his life. Here's an example I'll never forget. A couple of years ago, just after Cuyler Hammond, Jack Chorg, and I published an article about asbestos and mesotheliomas in the *New England Journal of Medicine*, I received a phone call from a doctor in Massachusetts who said that when he read the piece he immediately told his forty-three-year-old wife about it, because her sister had died of mesothelioma the year before. 'Imagine my horror,' this physician went on, 'when my wife proceeded to tell me that in 1943, while she and her sister were students in college, they had responded to a patriotic appeal and spent six weeks in a shipyard insulating pipes in destroyer escorts.'" Dr. Selikoff paused. "Two sisters with six weeks of exposure in 1943," he murmured. "Twenty-three years later, one of them dies of mesotheliomas. And today, the other one—the doctor's wife—is being examined every few months to keep track of some suspicious-looking shadows on her X-rays."

AS I was arriving at the Environmental Sciences Laboratory one day, I happened to notice a newspaper clipping tacked up on a bulletin board near the entrance. The story, which was from the *Times* of September 2, 1967, started out as follows: "The scene looked wintry on Madison Avenue, between 57th and 58th Streets, yesterday. Flurries of what seemed to be snowflakes fell on the area from between the 25th and 30th floors of

the former Savoy Plaza Hotel." The article went on to say that residents of the neighborhood had complained to the contractor, and that one of the project engineers had explained that the white flakes were fallout from fireproofing material that was being sprayed on the structural steel girders, beams, and decks of the fifty-story skyscraper. According to the *Times*, the engineer would not identify the insulating material, which was being applied with spray guns, "because I don't want to read newspaper stories about how we are messing up city streets." He was also quoted as saying, "This is a job condition all over the city." The last paragraph of the article read, "The city's Buildings Department said that it had not received any complaints about the Madison Avenue 'snowfall.' The department said the use of tarpaulins was required for spraying operations in construction work to prevent inconvenience to neighborhoods."

Beneath the article was this typed notation: "Examined in our laboratory, the material was found to contain amorphous glass fibers (presumably 'rock wool'), and chrysotile asbestos. It is known that other sprayed insulation materials contain amosite asbestos plus rock wool, while still others contain asbestos fibers alone."

When I asked Dr. Selikoff about the bulletin-board items, he said that the mineralogist in the laboratory, Dr. Arthur M. Langer, had collected a sample of the material and identified its contents by means of electron diffraction and electron microscopy, and with the aid of the electron microprobe. Then he went to a shelf and took down a small glass jar that contained a grayish wad of fibrous-looking stuff, about the size of a half dollar. "This is the sample Dr. Langer brought back

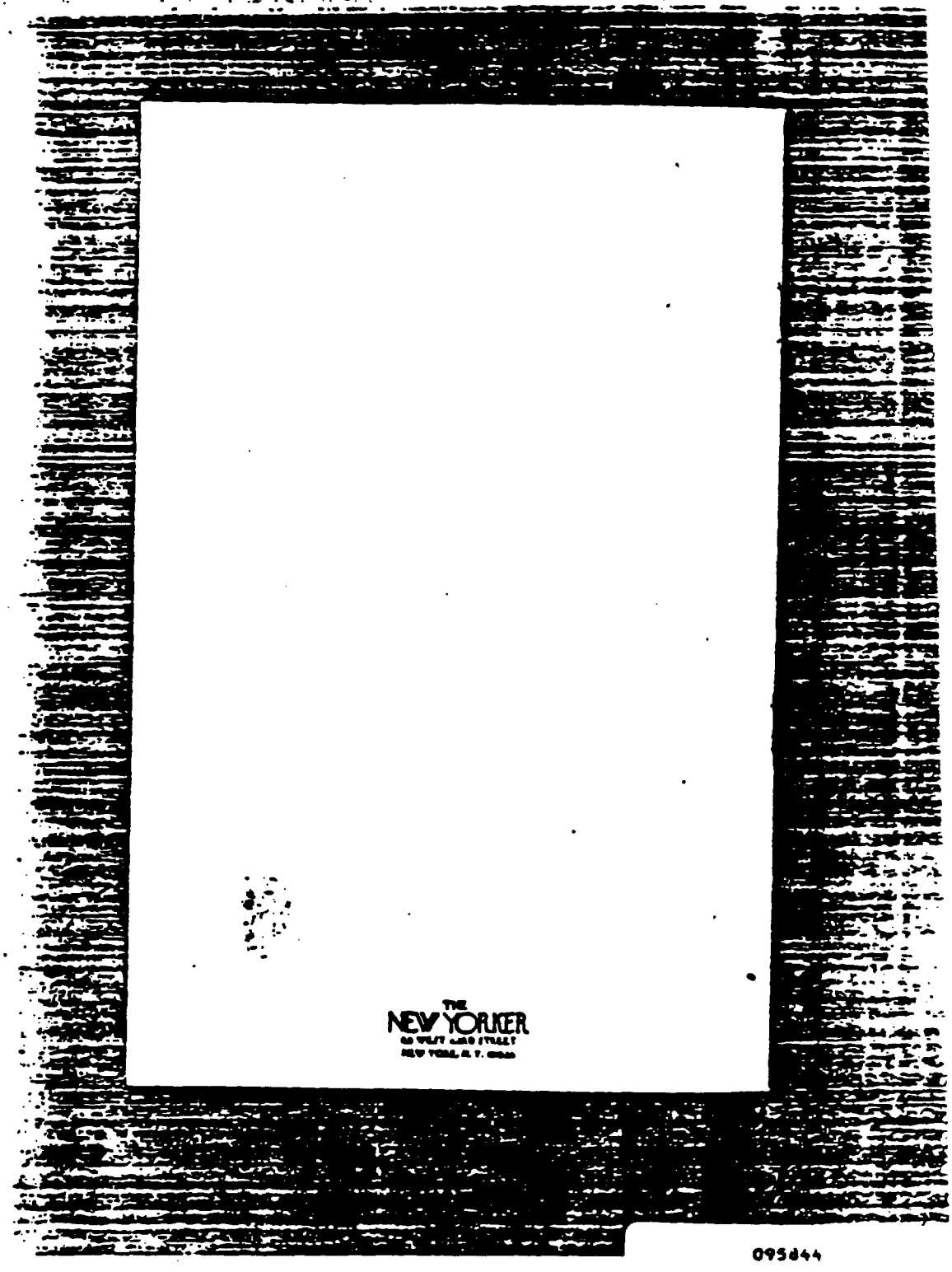
is about twenty-five per cent asbestos, and in this tiny wood alone there are literally billions of fibres. Of course, the 'snowfall' these people saw and complained about was not what may have been hazardous. What may have been hazardous was what they couldn't see—an untold number of sub-microscopic and highly respirable particles. The 'snowfall' was a perfect, easy example of how asbestos gets into the ambient air, and that engineer was right when he said it's a job condition all over the city. You'll see the same material floating down from many other building projects in town. It's sprayed on by men in the Plasterers and Cement Masons Union. Incidentally, as far as I know, no one has ever made a study of their health."

It was a blustery day, filled with intimations of the season's changing, and when I left the hospital I took a Fifth Avenue bus downtown. I sat by a window, and was looking idly out at people strolling along the sidewalks when the bus came to a stop in the upper Forties beside a dump truck parked in front of a small office building that was being gutted. Several workmen were carrying canvas sacks of refuse across the sidewalk and heaving them up to a tall, well-built Negro who stood in the rear of the truck, emptying the sacks at his feet. As he did, clouds of dust rose into the air around him. Some of it showered the window beside me. It appeared to be ordinary cement dust, but then I saw that the pile of debris on which the man was standing contained broken pieces of acoustical panelling and wallboard, both of which often contain asbestos, and lengths of pipe coated with crumbling white insulation material that looked very much like asbestos.

When I got off the bus, I walked west along Forty-fourth Street. Halfway down the block a large rectangular container from a pickup truck and carry it into a building. The container was full of white powder, some of which was being blown away by the wind, and the men's clothes were covered with white dust. When I looked into the truck, I saw half a dozen large paper sacks labelled "Fireproof Plaster." One of the workmen returned for his tools, and I asked him if the plaster contained asbestos. "Sure," he replied. "That's what makes it fireproof."

I walked on to the corner of Sixth Avenue, where a forty-four-story office building had been under construction for several months. During that period, I had passed the building nearly every day, but now, for the first time, I looked up and scrutinized it carefully. About halfway up its side, I saw some tarpaulins billowing in the wind. Above the tarpaulins, the steel girders and beams were reddish brown; between the tarpaulins and the ground, however, they had been sprayed with asbestos insulation, which clung to them like gray frosting. Then, all at once, I saw wads of the same gray stuff falling out of the area that had been curtained off by the tarpaulins. Some of the pieces were carried away on the wind; others that were heavier came tumbling down around me. One fell on the sidewalk at my feet. I picked it up, crumbled it between my fingers, and saw dozens of tiny fibres float away. It was the same color and texture as the material that Dr. Selikoff had shown me half an hour before. The sidewalk was covered with it, and even as I stood there more of it came showering down. A woman hurrying to make the light with a friend brushed some off the sleeve of her coat, and said, "What the devil is this stuff!" I watched her cross the avenue, and saw asbestos insulation blowing over the pavement like thistle-

southerly, and most of the asbestos was travelling north, in the direction of Mount Sinai Hospital, where Dr. Selikoff and his associates are still following the trail Dr. Cooke set out on in 1924. But I was not thinking about Dr. Selikoff or the difficulties of epidemiology just then. I was thinking about the children who play in Central Park every day, and about all the other children who live in this city and breathe its air. —Paul Brodeur



095844

ZONOLITE

CONSTRUCTION PRODUCTS DIVISION

Excerpts From Tabershaw-Cooper Associates Report

Dated July 13, 1970

ASBESTOS FIBER CONCENTRATIONS IN AIR FROM SPRAY FIREPROOFING OPERATIONS USING ZONOLITE PRODUCTS

In order to determine concentrations of airborne asbestos during and after the application of vermiculite-asbestos cement materials in the fireproofing of structural steel, observations were made at three construction sites in San Francisco on May 26, May 28 and June 4, 1970. Consideration was given to the actual and potential exposures of (a) workman carrying out the spray operation, (b) workers in allied trades nearby, and (c) the general public.

Sites studied. Three spray operations were surveyed: (1) the Embarcadero Center, where Mr. G. Connell was spray contractor; (2) the P.G. and E. Headquarters Building, where the spray contractor was C & R Plastering, Inc. (Mr. Rasmussen); and (3) the Hilton Towers, where Mr. G. Connell was also the contractor.

Methods. Airborne fiber concentrations were determined by drawing air through Millipore type AA filters, with 0.8μ mean pore size. Samples were taken in the breathing zones (3s) of men working with the material and at various locations surrounding the operations. Air flows ranged from 0.11 cubic feet per minute (cfm) in breathing zones to 1.8 cfm in areas more distant. Portions of the filters were mounted on slides, and the fibers in 100 microscopic fields counted, using phase contrast microscopy at a magnification of 430x. The numbers of asbestos fibers seen were converted to concentrations, expressed in fibers per milliliter of air, by taking into account the area counted, the flow rate, and the sampling time.

GRACE

095852

TABLE I

EMBARCADERO CENTER AIR SAMPLES

Sample Number	Area	Asbestos fibers total f/ml	Asbestos fibers f/ml (> 5 um)*
54 (A)	Spray operator's BZ	7.96	6.54
51 (A)	" " "	2.63	2.18
49 (A)	" " " (Held near back of head to protect face of filter)	3.56	3.18
47 (A)	Stage mover's BZ	1.86	1.55
2249 (B)	Area near spray (1-30 feet distant, some direct spray on filter)	0.030	0.028
2250 (C)	Background area, 43rd floor (air flow past spray-encrusted drapes)	0.020	0.016
56 (D)	Investigator's BZ	0.79	0.50
48 (E)	Mixing Operator's BZ	0.775	0.710

*Present tentative occupational threshold limit value of 5 f/ml is based on fibers greater than 5 micrometers in length.

095d53

TABLE II

PCAE AIR SAMPLES

Sample Number	Area	Asbestos Fibers Total f/ml	Asbestos Fibers f/ml* (> 5 um)
53 (A)	Spray operator's BZ	3.32	2.91
1 (A)	" " "	3.15	2.64
55 (B)	BZ of investigator, close to spray stage, walking with bag-carrier	0.16	0.14
2 (C)	Area, ± 40 feet upwind of single stage (air flow variable)	0.13	0.11
3 (C)	Area, ± 40 feet downwind of stage (air flow variable)	0.25	0.23
60 (D)	Mixing operator's BZ (wind away from)	0.50	0.42
52 (D)	Mixing operator's BZ (wind toward)	1.42	1.25
59 (E)	Mixing area (between two mixing operators)	1.09	0.98
61 (E)	Mixing area (between two mixing operators)	1.36	1.14
2147 (F)	Background, 1 floor below spray operations, most air flow not through the building to filter, but variable.	0.014	0.011
4 (G)	Area, between two stages (current to pump cut off at variable times, total flow through filter uncertain)	0.038	0.036
5 (G)	Area, ± 30 feet from stages (2)	0.071	0.061
2149 (G)	Area, ± 35 feet from stage, (air flow in area uncertain and variable)	0.36	0.34

*Present occupational threshold limit value of 5 f/ml is based on fibers greater than 5 micrometers in length.

095854

TABLE III

[illegible] TOWERS AIR SAMPLES

Sample Number	Area	Asbestos Total f/ml	f/ml* (> 5 um)
62 (A)	Spray operator's BZ	2.48	2.20
64 (B)	Hod Carriers' BZ	0.49	0.33
2264 (C)	Upwind of stage	0.0007	0.0007
2262 (C)	Downwind of stage	0.0147	0.0137
73 (D)	Upwind of 35th floor - Background (Prob. non-iso-kinetic flow at filter face; validity as a final measure of fiber background level?)	none seen	none seen
2259 (E)	Downwind of 17th floor (four floors below spray operators)	0.0017	0.0017
57 (F)	Mixing operator's BZ	1.61	1.43
69 (F)	Mixing operator's BZ	0.55	0.50
63 (G)	Mixing Area	0.43	0.35

*See note table I. and II.

095855

TABLE IV

Air Sampling Results

(fibers/ml)

	Upwind	Sensitivity*	Downwind	Sensitivity*
Morning				
Stationary	0.024	0.005	0.016	0.016
Moving	0.014	0.005	0.042	0.009
Afternoon				
Stationary	0.077	0.009	0.015	0.005
Moving	0.009	0.005	0.005	0.005

*Minimum fiber concentration on filter is 1 fiber per 100 fields observed. Sensitivity is inversely proportional to the volume of air passed through the filter.

TABLE V

CONCENTRATIONS OF ASBESTOS FIBERS IN AIR EXPRESSED IN FIBERS PER LITER

Value or site	Range: fibers/liter
Proposed occupational threshold limit value (ACGIH).....	5,000*
Spray crew breathing zones	
Gun operator.....	2,480 - 7,950
Stage mover.....	490 - 1,360
Mixing operator.....	500 - 1,610
Adjacent work areas on same floor.	1 - 360
Work areas on other floors.....	<1 - 14
Vicinity of buildings being sprayed.	
Upwind.....	9 - 77
Downwind.....	5 - 42
Ambient air in Bay Area.....	<1 - 12

*Fibers over 5 um in length other values not corrected for this.

BOYLE ENGINEERING LABORATORY

DIVISION OF ROTHERN ENGINEERING COMPANY, Inc.

CONSULTING AND EXPERIMENTAL ENGINEERING

7280 W. DEVON AVENUE • CHICAGO 31, ILL. • PHONE ROdney 3-8579

SUBJECT: Abstract of Test Report, April 30, 1964

TITLE: Report on Effect of High Velocity Air Stream upon the Surface of Mono-Kote Material.

TEST PERFORMED FOR: Zonolite, Division of W. R. Grace & Company.

OBJECTIVE: Determine if high velocity air stream flowing parallel to and over the surface of Mono-Kote Material would erode surface of Mono-Kote.

TEST SPECIMENS: Three (3) flat aluminum pans, 10½"W x 15½"L x 3/4"D filled with Mono-Kote Material having a density of approximately 26.84 lbs. per cu. ft. Surfaces had machine texture finish.

TEST CONDITIONS: Air velocity = 104.8 MPH
Air temperature = 79°F (dry bulb)
Mono-Kote exposed to air stream for 87 hours.

PROCEDURE: Test specimens oven dried for six (6) hours at 118°F to eliminate moisture and then weighted. Test specimens mounted in cut-outs in a triangular shaped duct so that surface of Mono-Kote was flush with duct wall. Velocity traverse taken and test specimens exposed to air stream for 87 hours. Specimens oven dried for seven (7) hours at 115°F and reweighed to determine if erosion of Mono-Kote had occurred.

RESULTS: No erosion of Mono-Kote as indicated by no weight change in test specimens.

BOYLE ENGINEERING LABORATORY

Robert W. T. Olson

Robert W. T. Olson, P.E.

Boyle Engineering Laboratory

EXHIBIT NO. 2

2-9-65

C. SILVERMAN

095870

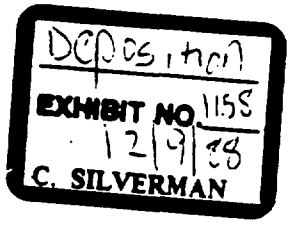
BOYLE ENGINEERING LABORATORY

DIVISION OF ROTHERM ENGINEERING COMPANY, INC.

CONSULTING AND EXPERIMENTAL ENGINEERING

7280 W. DEVON AVENUE • CHICAGO 31, ILL. • PHONE ROdney 3-8579

June 25, 1965



Zonolite
Division of W. R. Grace & Company
8055 Lawndale Avenue
Skokie, Illinois 60076

Attention: Mr. Martin Malter, P.E.
Manager, Plastic Products

Dear Mr. Malter:

At your request I have reviewed the requirements of the General Services Administration Specification designated as "Sprayed Fire Protection, Section 30, Materials, Paragraph 30-05" which describes an air velocity-dusting test for Sprayed Fire Protection Materials. Requirements indicate that dusting of material shall not exceed 0.01 grams per square foot when exposed to an 800 foot per minute air velocity for 24 hours.

The air velocity-dusting test Boyle Engineering Laboratory performed on Mono-Kote in April of 1964 (Report on Effect of High Velocity Air upon the Surface of Mono-Kote Material, Project 8528) for Zonolite exposed this material to an air velocity of 9200 feet per minute (104.8 MPH) for 87 hours with no erosion of Mono-Kote material, or measureable loss in weight of test specimens.

It is the opinion of the writer that the air velocity-dusting test performed by Boyle Engineering Laboratory is equivalent to or a more severe test than required by the aforementioned General Services Administration Specification.

Yours very truly,

BOYLE ENGINEERING LABORATORY

Robert W. T. Olson

Robert W. T. Olson, P.E.
Chief Engineer

RWTO:vh

BOYLE ENGINEERING Laboratory

ROBERT W. HUNT COMPANY, ENGINEERS
CHICAGO 7, ILLINOIS

September 14, 1965

File No. 1301-1
Order L-4403

Report 23214
Page 1

DEPOSITION
EXHIBIT NO. 159
12/19/85
C. SILVERMAN

Zonolite
Division of W. R. Grace & Co.
8055 Lawndale Avenue
Skokie, Illinois, 60076

Attention: Mr. Martin Malter

As authorized by you, we have made bond tests of "Zonolite, Mono Kote," a cementatious mixture for fireproofing.

BOND TESTS

Bond tests were made on 15, approximately 2" x 2", samples and tested in accordance with ASTM specification C 297.

The following results were obtained:

Designation	Lab Marks	Tensile Strength P.S.I.	Tensile Strength P.S.F.	Failure
UC ✓	1	8.35	1202	Core broke
	2	7.88	1134	Core broke
	3	8.42	1213	Core broke
	4	7.80	1123	Core broke
	5	6.85	986	Core broke
SC ✓	1	9.10	1310	Core broke
	2	7.05	1015	Core broke
	3	8.63	1242	Core broke
	4	8.82	1270	Core broke
	5	11.9	1735	Core broke
G ✓	1	8.20	1180	Core broke
	2	7.83	1126	Core broke
	3	8.96	1289	Core broke
	4	8.12	1170	Core broke
	5	7.30	1051	Core broke

WE CERTIFY THAT the above is a true record of tests performed by us in our laboratory.

Respectfully submitted,
ROBERT W. HUNT COMPANY

Robert L. Dillon

RD/rs-3

Physical Laboratory Division

095871

R. V. Sherrett — May 9, 1969

E. E. Graber — Zonolite Research

Harry Brown
V. E. Dodson
R. J. Bragg
J. E. Chapin, Jr. - A-T.S./S.C.

Ralph Bragg and I have established priorities on a list of projects to be worked on during the rest of this year. We have reviewed several of these projects with Travelers Rest and have agreed to coordinate our efforts with them on certain phases of the work.

I am summarizing the projects in order of importance (as judged by our conversations with Zonolite personnel). If you have another opinion concerning project priority, please let us know.

I. Group III Vermiculite

We are arranging to have the South Carolina plant mill a run, using 50% Group III ore and 50% Group I ore (Harry Brown will request). A 50/50 blend of the two is satisfactory for Zonolite Insulating Concrete but no plant and furnace tests have been conducted) this ratio.

We are also planning to look for new uses for Group III vermiculite since the reserves of this ore are over three million tons. We have done a little work with vermiculite for fireplace logs but have not tried 100% Group III. The Washington Research Labs have groups working with vermiculite on the oil slick problem and also have a government contract to find a way to use vermiculite in recovery of phosphate ore. Perhaps Group III products could be evaluated for these applications.

II. Permadock ESC

We are going to try to assist Brookhaven on any research needed to reduce his ESC. Ralph Bragg was in Brunswick last week and assisted in making a series of pilot runs using no silicate, no calcium chloride, no silicate or chloride, and no silicate or chloride with General Portland Regulated set cement in place of Type I cement. Panels were made and will be sent to us for testing. In addition, a run of two panels was made using 0.01" multi-type wood chips that are much cheaper than the excelsior.

III. Roof Deck Studies

Based on Fisher's research planning meeting, we are going to construct four roof decks in our back yard near Building #89. The roof decks will be as follow:

(1) wood plank base, Servistik, Dyfoam with protective coating,
(2) Zonolite lightweight concrete, Servistik, Dyfoam plus coating,
(3) Concrete slab, Servistik, Dyfoam with protective coating,
(4) Formdeck, Servistik, Dyfoam with protective coating.
(5) Gypsum Board, Servistik, Dyfoam with protective coating.

In addition, Ralph Bragg is working with F. Decker of Travelers Rest to obtain test reports and measurement data on some 13-15 roof decks exposed at Travelers Rest during the past several years. We shall attempt to interpret the data to determine if some of the systems may be of immediate interest for our new studies.

IV. Insulating Foams

We shall co-operate with Skroyer and review current literature and field application data available on other insulating foams that may be a future threat to Dyfoam. This review should highlight information on urethane, phenolic and urea-formaldehyde foams.

V. Sound Transmission Lab's Study

Ralph has agreed to assist Bjorklund and Babb by offering to obtain field measurements of partitions containing sound absorbing and/or deadening materials. Buildings will be selected in the Boston portion of the United States. Equipment designed by Cece Perkins and the Silvertuck Acoustical labs will be shipped from Chicago for our use. Buildings will be selected by Bjorklund and Babb, their designs reviewed and, if favorable, measurements will be taken.

VI. Nano-Rate

We have one request to find a substitute for asbestos in this compound. Asbestos is a health hazard. We will assist only in an advisory capacity by selecting possible substitutes. Chapin's lab will do the testing.

Bragg will also coordinate a project at Mellon Institute where they would like to computerize structural systems in respect to prediction of fire endurance time of the system. In the past, Underwriters' have had us submit for every new design and this has been very costly. When a design is changed by the steel company, we hope to obtain Nano-Rate approval without tests.

VII. Fire Endurance Testing

(1) Zonolite and the Vermiculite Institute would like to have as much help as possible in the review and construction of full scale fire test specimens (we have failed some recent tests chiefly due to faulty test design). Ralph Bragg shall review designs.

(2) The Prevelert test laboratory will assume the responsibility of the application of the fireproofing material, and will have a man present when the tests are conducted.

VIII. Cryogenics - Magna Report

We were asked by J. Chapin to discuss the measurements of No. 4 and 5 expanded vermiculite at -250°F. for thermal conductivity. We are to contact Union Carbide (customer) to judge their requirements and then approach the Dynatech Corp. of Cambridge, Mass., to do the work.

Perlite is generally more effective than vermiculite but the abrasiveness of the perlite particle has disturbed the industry and they are desirous of taking a look at vermiculite.

Measurements of conductivity are requested on bone dry vermiculite and on vermiculite with 1% moisture.

E. E. Gruber

EEG:mlr

CONCRETE PRODUCTS DIVISION

TO R. W. Sterrett - Cambridge DATE July 8, 1969

FROM C. S. Breslauer SUBJECT Fine Wood Fiber

CC: Ralph Bragg - Cambridge

Dear Bob,

In the search for a substitute fiber for Asbestos and Mono-kote, I know that wood fiber has been looked at — among other things — but this idea has been discarded due to the fact that a proper size fiber could not be located.

The thought has occurred to me that the same type of fine fiber now being manufactured and utilized around the country in the various flake board mills could be the type of fiber you are looking for. This material is made in hugh quantities at many different locations and I would guess that a suitable supply point could be found if it was useable.

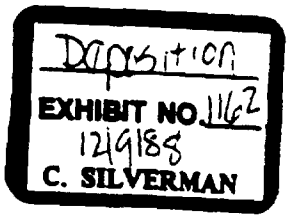
A wood fiber would be hardly more flammable than most of the synthetics and would probably do the job. I personally doubt that the flammability of the material would make any difference in the product. As far as wood fiber and gypsum are concerned, they have been used together for many years and are certainly compatible.

I would like to suggest that someone from Cambridge make the trip to the Flake Board Company Limited, Milltown, New Brunswick, Canada and see that operation. Mr. Jim Chandler, the Plant Manager, has invited us to visit with him at any time and I think it would be a worthwhile trip. The process used in the manufacture of flake board is similar in many respects to the one you described for the manufacture of the French board. Some good ideas could be picked up from such a visit and at the same time, I am sure that he would provide you with an adequate sample of the fine wood fibers that are used in the process for experimental work in Mono-kote.

Sincerely,

C. S. Breslauer

CSB:lv



CAMBRIDGE

TO: W. R. Payment/Travelers Rest DATE: October 1, 1969

FROM: R. J. Bress SUBJECT: Mono-Kote

CC: V. H. Dodson
K. R. Crowker
T. Egan
J. K. Chapin, Jr./Travelers Rest
R. E. Rothfelder (Box 41077), L.A. 9-241

Because of the urgency of Mono-Kote reformulation, I have requested through T. Egan and J. K. Chapin that you run additional tests. This request is also related to the results of our present series; while not yet concluded, they don't seem to offer much promise of elimination of asbestos.

Also, I had a conversation with Ray Rothfelder last week. He is currently attempting to reformulate Mono-Kote with paper fiber. T. Egan has asked me to correlate all of this work, so that we now appear to have a trio involved here. I am writing to Ray to provide him certain data and to request the present status of his work. You will receive copies of all such communications.

At this time I believe you should broaden your investigations to formulate, mix, spray, cure and fire test the following compositions.

Three mixes using paper fiber: We will obtain the fiber from Ray Rothfelder, and test at his recommended concentration as well as 15% above and below this concentration. Do not start this work until Ray gives his recommendation. No asbestos will be used in these mixes.

Two mixes using fibered gypsum from USG or National to replace our conventional ZOU: I suggest you make up one mix, using the same formula as MK-3, omitting asbestos and the other mix, replacing asbestos with an equal volume (not weight) of vermiculite.

As a third approach, I would like to see some lean mixes with all fiber omitted, but with a high strength binder. These will utilize alpha gypsum to replace ZOU. Both US Gypsum and Certainteed can provide such a binder. To offset the increased cost of the binder, try progressively leaner mixes such as 1:8 as a control, 1:10, 1:12 and 1:14. Base your Dupont content on the gypsum concentration.

W. R. Payment October 1, 1969

I suggest you make up a couple of MX-1 control samples for the above variations on Mono-Kote. Please handle procurement of the fibered gypsum and the alpha gypsum. In your work with alpha, be particularly careful of water requirement since this grade needs much less water than ZOU.

If you or Jim Chapin have additional ideas, please try them. Also, Walt, I would appreciate a status report as soon as possible on your present series of six mixes. The report should include all data on composition, set time, w/c, yield, etc.

Ralph J. Bragg

RJB:mlr

092202

TO: V. H. Dodson

DATE: December 1, 1969

FROM: T. F. Egan

SUBJECT:

CC: R. W. Sterrett
C. R. Babb
K. R. Crankey
R. J. Bragg

THIS COPY FOR

Vance:

Knowing the building pressure against the use of asbestos in sprayed fireproofing, particularly in the New York, Philadelphia area, and with concern spreading rapidly throughout the country, there are two prime reasons we should get asbestos out of Mono-Kote. They are:

1. We are going to get included in the indictment since we have asbestos in Mono-Kote.
2. Mono-Kote without asbestos would give us a tremendous sales increase at once.

Also, we have an ethical obligation to get it out.

We need a realignment of work assignments so that Ralph and/or others can get on this matter at once. It's been much too long already that we've been looking at this problem.

Let everyone know what you need so we can get it behind us.

ORIGINAL SIGNED BY:
THOMAS F. EGAN

T. F. Egan

TFE:dlc

EXHIBIT NO.
C. SILVERMA

092245

To W. R. Payment 12-21-69

from K. J. Bragg Mono-Kote Reformed

V H Dodson

cc K R Granker

T Egan

As a result of this morning's meeting with K Harris R W Sterrett, V. H. Dodson, K. R. Granker, T. Egan and myself the following decisions were made:

1. Regarding use of an organic fiber such as Cellufloc we will search the W R Grace Company to locate our best talent in this area and assign him the job of locating acceptable lower cost alternates.

2. In the area of replacement of asbestos with equal or similar volumes of lightweight fillers, more work is requested

T. P. Feit

February 24, 1970

T. F. Egan

Equivalency at UL

R. J. Bragg

THIS COPY FOR

Dear Tom:

John Ottinger has related that Spraydon has sprayed at Underwriters' Laboratories, Inc. and Underwriters' Laboratories of Canada an asbestos free assembly. Also, Cafco has intimated that they have passed Underwriters' Laboratories, Inc. test on C.F. (Ceramic Fiber product).

This means that equivalency tests are or have been formulated with Underwriters' Laboratories. I remember your statement about comments with R. Parks that there is much to be gained from small-scale studies along with a full-scale test, and it's important that we get an answer on equivalency for fiber free Mono-Kote. This is the only positive goal. Please remove H. H. Robertson from any consideration unless to include them would be to our definite advantage on the equivalency test. Maybe we can include this as some small-scale study.

Sincerely,

[redacted] SIGNED BY
[redacted]AS F. EGAN

Thomas F. Egan

TFE/jac

CONFIDENTIAL

CANDIDATE

TO: K. R. Cranker DATE: March 16, 1970

FROM: R. J. Bragg SUBJECT: Mono-Kote Reformulation

CC: V. H. Dodson
T. F. Egan

To date we have approached the subject in two manners: replacement of asbestos with entrained air or with non hazardous fibers. Concerning the latter program, our efforts have been rewarding at low density with five successive successful fire tests on compositions containing Georgia-Pacific P-32 unbleached cellulosic fiber.

During a meeting with high ranking officers of Canadian Johns-Manville Co., Ltd., Asbestos Fibre Division on 3/10/70 in South Carolina, I learned the cost figures we had used in our previous costing were low. For example, I was given a laid-down cost in Travelers Rest of $.0260/lb. for asbestos. Actually the correct cost is #.03625/lb.

In addition, Mr. Payment and I made a substitution of air entrainment, changing from Du Pont's Duponal WA Dry @ $.480/lb. to half again as much Proctor & Gamble's Orvas A B Granules @ $.185/lb. This results in a savings per bag of Mono-Kote (i.e. AEA substitution) of $.025/bag.

Combining both of these changes, we now have a formulation using Cellufloc P-32 and Orvus A B which costs $.02147/lb., with a DMC of $1.3735 per 50 lb. bag. The DMC of standard Mono-Kote containing asbestos is $1.3860 per 50 lb. bag.

Strangely enough, because of a competitive situation on the West Coast which led Johns-Manville to provide freight equalized shipments to California, our Los Angeles plant pays less for asbestos than our South Carolina plant ($.02975/lb.). Again, using the new costs for asbestos and Orvus, the DMC of Mono-Kote out of Los Angeles is $1.27/50 lb. bag.

I believe since we are lower in cost (1¼ cents/bag) in Travelers Rest, (new formula vs. old) and since I don't have accurate aggregate costs out of Los Angeles, that we should ask Jim Zisson to cost out the new formula at several points in the U.S. An important consideration here is that the West Coast area should be able to buy Cellufloc at a lower cost than the Eastern U.S.

Ralph J. Bragg

R. J. Bragg

RJB:mlr

CAMBRIDGE

TO: O. F. Stewart

DATE: 30, 1970

FROM: R. J. Bragg

SUBJECT: Asbestos

CC: V. H. Dodson
H. A. Brown
K. R. Cranker
~~T. F. Egan~~
C. E. Parker
W. R. Wright

We are coming "down to the wire" on our Mono-Kote reformulation work, whose chief object is the elimination of asbestos from the product. At this point, our most promising formula utilizes an organic fiber.

Tom Egan, in preparation of promotion of the new product, has to be concerned about the emphasis which may be used on elimination of asbestos. Whether he calls Mono-Kote "asbestos-free" or some other adjective, he needs to be sure that it is in indeed free of asbestos. With the elimination of asbestos fiber which we have added in our blending plants, the remaining worry is the amount of asbestos that may be present in expended vermiculite.

I've advised that we use wet separation in both beneficiation mills and that it is highly improbable that detectable levels of asbestos could remain on the ore concentrate. I also expect that whatever minute quantities of asbestos remained on the ore, they would be eliminated by the actions of air separation and stoner activity in our expanding plants.

Please advise us of your opinions in this matter.

R. J. Bragg

RJB:mlr

09dd73

CAMBRIDGE

TO: [illegible] DATE: June 1?, 197?

FROM: R. J. Bragg SUBJECT: Status Report Mono-Kote

CC: D. G. Powell
J. K. Beveridge
W. E. Wright
K. R. Cranker
T. P. Feit
R. J. Anderson
J. K. Chapin, Jr./Travelers Rest

RECE[illegible]

CONSTRUCTION PRO[illegible]
H. A.

Attached find a copy of the status report presented June 15 at the Zonolite Research Committee meeting.

Ralph J. Bragg

RJB:mlr

Attachment

092336

EXHIBIT NO.

PROBLEM WITH MONO-KOTE

- CONTAINS ASBESTOS, ALLEGED TO BE CARCINOGENIC AND TO CAUSE ASBESTOSIS.

REFORMULATION OBJECTIVES

- ELIMINATE ASBESTOS.
- MAINTAIN PRESENT YIELD, RAW MATERIAL COST, AND PHYSICAL PROPERTIES.
- OBTAIN UNDERWRITERS LABORATORIES LABEL SERVICE ON NEW COMPOSITION IN REGARDS TO FORMULATION, APPLICATION, SURFACE FLAMMABILITY, THERMAL INSULATION AND BOND TO STEEL.

CONFIDENTIAL

770020

CAMBRIDGE

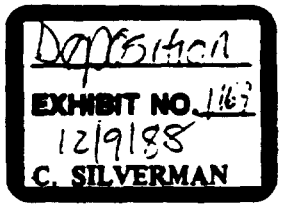
TO: T. Feit

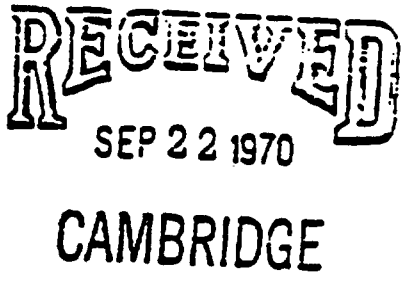
DATE: September 21, 1970

FROM: R. C. Ericson

SUBJECT: UL Procedures for MK 4

CC: N. Beveridge
R. Bragg
H. Brown
K. Cranker
T. Egan
D. Powell
W. Wright





We have discussed at length the importance of protecting the formulation flexibility required by manufacturing to permit us to produce a finished Mono Kote to proposed standard finished product characteristics. Basically this flexibility is required to handle the inherent variations in several of the raw materials used in Mono Kote and most especially to accommodate the range of Vermiculite aggregates we must use. At our last meeting I stated that the "nominal percentage by weight analysis" you presented to UL with a 2% tolerance on Gypsum and a ± 0.5% tolerance on P-20 fiber gave manufacturing a flexibility at least equal to the felxibility incorporated in the MK 3 procedure.

My testwork to date indicates that the MK 3 UL procedure can handle the variables I have encountered so far. However, I have no experience in the plant with the MK 4 formulation. This formulation is higher in the percentage of Vermiculite. Therefore, it seems reasonable that Vermiculite variations will be even more apparent in the formulated product properties. I am hoping that the degree of flexibility which was incorporated in the initial proposal to UL will be sufficient with MK 4. I feel that the research department should have this on their agenda as something that needs to be checked out.

We have discovered that our initial proposal to UL was in error to the extent that it had included the concept of a fixed 38% Vermiculite content. This is mathematically incompatable with the ± 2% Gypsum tolerance which we thought we had. I feel we must now spell it out that the resulting Vermiculite tolerance is ± 1.5 % by weight of the formulation. You are concerned about the UL acceptence of our initial proposal if we do spell this out. You asked me to draft a proposal for what would be Section I, Page 1A and 2 of a MK 4 UL procedure. A copy of this is attached.

I would like to point out that in drafting this procedure I attempted to make as few changes as possible in the layout and wording of these pages on the premise that fewer changes generate fewer questions. I would also like to point out that the new section headed "Proportioning of Ingredients" really tightens up the procedure significantly as compared to the latitude possible with the MK 3 format. I also

deliberately worded the sentence at the bottom of this section to say. "Each batch will contain ingredients within the percentage by weight proportions specified above." In other words, we are emphasizing that there is a new concept here, control by weight percentage. I would hope that this emphasis would more than balance the fact of disclosing a 1.5% tolerance in Vermiculite weight.

Finally, note the fact that the nominal formula is written for a Vermiculite density of 6.5 #/cu.ft., which is exactly at the midpoint of the recommended range, 5 to 8. This range is slightly tighter than the old Mk 3 range of 4.5 to 8.0.

R. C. Ericson

RCE/bhb

Attachment

770022

MANUFACTURING PROCESS:

The vermiculite ore is expanded in a furnace and is held in inventory (for later addition to the Mono Kote mixer) in bulk storage silo's or in 4 cu. ft. unmarked bags.

All ingredients are then added to a mixer and blended for approximately 5 minutes until the mixture is uniform throughout.

FORMULATION:

Ingredient Function	Name of Ingredient	Tolerances % by Weight of Batch
Aggregate	Expanded Vermiculite	± 1.5
Binder	Gypsum	± 2.0
Fiber	Cellulose Fiber (P-20)	± 0.5
Air Entraining Agent	Duponal WA Dry/ Duponal ME Dry/ Orvus AB	

Proportioning of Ingredients

Nominal Batch Size - 19 Bags (Approx. 61 Cu. Ft.)

	NOMINAL				TOLERANCE	
	Batching Quantity As Measured into Mixer		Analysis		Low Gypsum	High Gypsum
	Cu. Ft.	#	Vol.	% By Wt.	% By Wt.	% By Wt.
Vermiculite	50[1]		50	38.00	39.50	36.50
Gypsum		500.0	10	58.00	56.00	60.00
Fiber P-20		34.0	1	4.00	4.50	3.50
Duponal WA[2]		1.5	—	0.17	0.17	0.17
		863.5	61	100.17	100.17	100.17

1 Vermiculite @ 6.5 #/cu. ft. density
2 Alternate air entraining agents permitted

Duponal WA Dry	0.75 - 2.0
Duponal ME Dry	0.50 - 2.0
Orvus AB	2.00 - 3.0

The size of the batch may vary. However, each batch will contain ingredients within the % by weight proportions specified above.

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77002

INGREDIENT IDENTIFICATION:

Name of Ingredients	Description and Specifications
Vermiculite #3 or #4 Grade	Fine granules, uncoated and free from organic substances. Density 6.5 #/cu. ft. ± 1.5
Gypsum	A white Powder. Bags shall be marked for hand or machine application and/or ZOU
Cellulose	
Duponal	Fine white powder. Container shall identify ingredient as Duponal WA or ME, manufactured by E.I. Dupont Nemours Co. Inc.

FINISHED PRODUCT:

Net WT/Bag	Nominal ± 3#
Unit Weight	13 - 17 #/cu. ft.
Ash Content	Minimum 90%

098364

[redacted]

TO: K. R. Cranker

DATE: August 14, 19[redacted]

FROM: R. J. Bragg

SUBJECT: Trip Report
Aug. 4 to 7 inc.

CC: D. G. Powell

Purpose of Trip:

To assist W. R. Payment in implementing sample preparation of MK-3 and MK-4 as relates to our "Moderate Risk" Mono-Kote program.

Work Accomplished:

Thorough clean-up of fire test station, to permit more efficient operation.

Formulation, mixing and spraying of three batches each of MK-3 and MK-4 plus preparation of required test samples of each of these six batches.

Writing of "white paper" on Mono-Kote R&D.

Assistance to J. K. Chapin, Jr. in basic planning of proposed new R&D building at Travelers Rest.

Ralph J. Bragg

RJB:mlr

[redacted]
EXHIBIT NO. [redacted]
C. SILVERMAN

ZONOLITE DIVISION

FEB 4 1971

TO: R. Erickson, Cambridge - February 3, 1971

FROM: W. R. Payment, T.R.

cc: R.J.Bragg, Cambridge
J. Sawyer "
K.R.Cranker "
R.Rothfelder, L.A.
J.K.Chapin, Jr., T.R.

Dear Bob:

Attached is a graph representing my latest test work with two types of asbestos. These samples were provided by J. Sawyer, and I believe were the same as tested in January at T.R. and Cambridge (shown on the graph).

The 10 gram/250 cc. tests (Zonolite Method) are reasonably consistent but do not differentiate between the two. It is evident from the use of these materials in MK mixes that there is a substantial difference in MK handling and performance when JM7MQ72 is used in place of this particular National 7RS-2 asbestos.

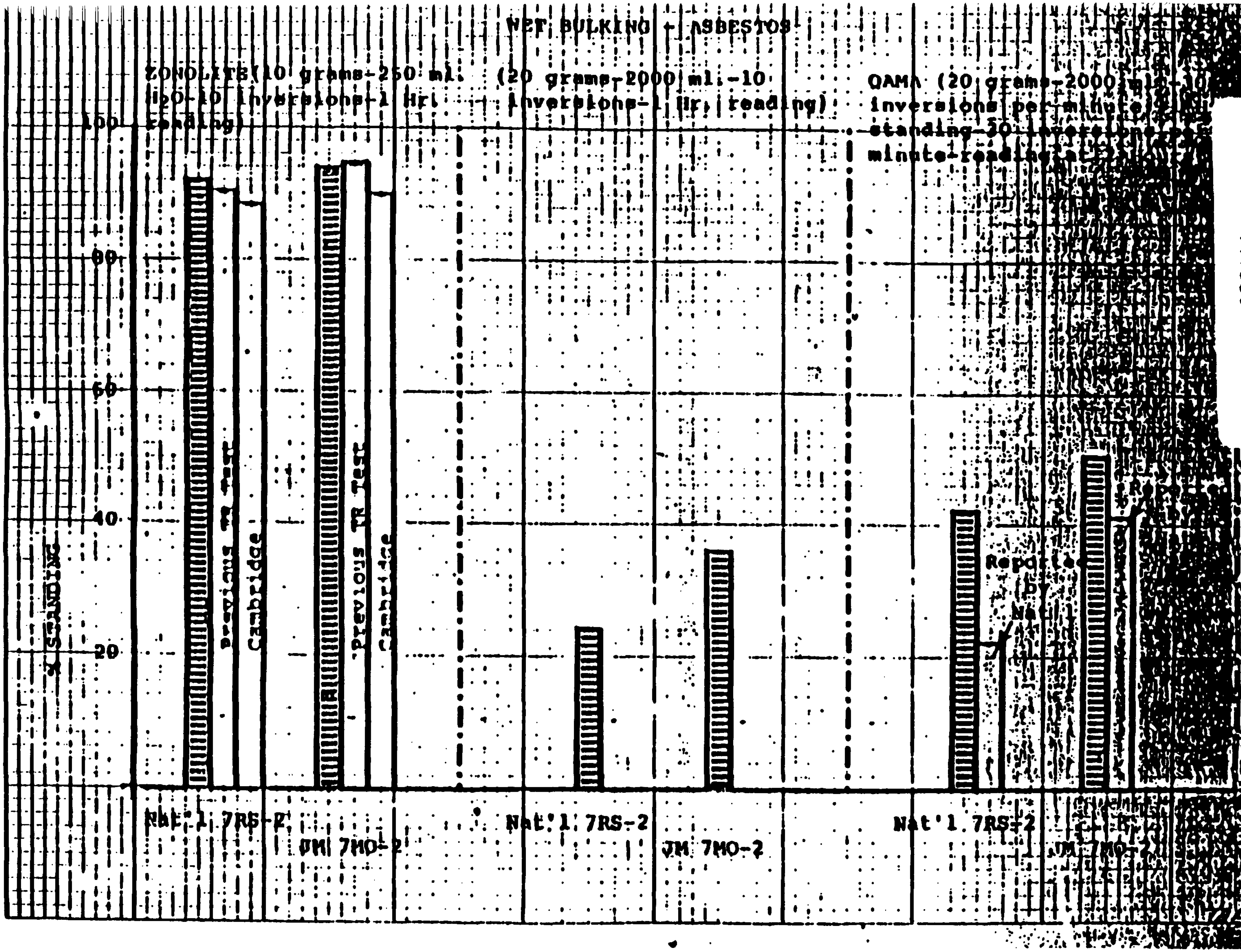
The California test (12.5 grams/500 cc.) was not conducted because of a lack of sample, and Janice could run such a test to plug the numbers into this graph. But having done so previously, I've found that while method puts asbestos settling in a more reasonable range (60-90%), it does not show the difference between the two that the finished MK mix does, in this particular case.

I tried a short-cut on the QAMA Test, running the proper ratios (20 grams/2000 cc.) and 10 inversions with a one hour reading. The results are quite low, but show a larger spread (11.5%) than the QAMA test. The QAMA test calls for 30 inversions per minute, one hour standing and 30 more inversions per minute, with a reading one hour later. The spread here was 8.5%.

I do not understand the difference shown by National Tests (19%). Were the samples actually the same as mine, or simply the same designation? National Asbestos has always varied substantially from shipment to shipment within the same grade. If they tested 2 differe samples I could understand the high results.

Very truly yours,

098443



WET BULKING - ASBESTOS
ZONOLITE (10 grams-250 ml. H2O-10 inversions-1 Hr. reading)
(20 grams-2000 ml.-10 inversions-1 Hr. reading)
QAMA (20 grams-2000 ml.-10 inversions per minute
standing-30 inversions per minute-reading)
% STANDING
100
80
60
40
20
Previous TR Test
Cambridge
Nat'l 7RS-2
JM 7MO-2
Reported by Nat'l

[illegible] Fletcher, Cambridge [illegible], 1 7.

[illegible] W. R. Pa[illegible] [illegible].

cc: R.J.Bragg, Cambridge
J. Sawyer
K.R.Cranker "
R.Rothfelder, L.A.
J.K.Chapin, Jr., T.R.

Dear Bob:

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The 10 gram/250 cc. tests (Zonolite Method) are reasonably consistent but do not differentiate between the two. It is evident from the use of these materials in MK mixes that there is a substantial difference in MK handling and performance when JM7MC-2 is used in place of this particular National 7RS-2 asbestos.

The California test (12.5 grams/500 cc.) was not conducted because of a lack of sample, and Janice could run such a test to plug the number into this graph. But having done so previously, I've found that while method puts asbestos settling in a more reasonable range (60-90%), it does not show the difference between the two that the finished MK mix does, in this particular case.

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Very truly yours,

WRP/tr

CAMBRIDGE

02015536

TO: E. C. Buecker

DATE: June 25, 1973

FROM: J. C. Yang

SUBJECT: The possible occurrence of asbestos in Monokote

CC: [redacted]
T. P. Feit
A. M. Rosenberg
B. R. Williams
J. L. Wright

FILE: 500 Asb. Dctn.

Expanded Vermiculite samples and Monokote products from various mining locations and plants have been analyzed since Dec. 1972, by quantitative X-ray diffraction method (developed by Arthur D. Little, Inc.). This is supplemented by optical microscopy (dispersion staining techniques developed by Arthur D. Little, Inc.), transmission electron microscopy (rub-out method, developed by Johns-Manville, but used ourselves at MRC) and scanning electron microscopy with X-ray fluorescence analysis attachments (Arthur D. Little, Inc.).

Based on the experimental results collected up to date, tentative conclusions and comments are summarized as follows:

1. Vermiculite contains a small amount of asbestos in the range of 0.5%. The only asbestos species detected is tremolite; it can be either in platy or fibrous morphology. The analyses are presented in Table 1.

2. Sampling technique for the analysis is extremely important - all the analytical techniques mentioned above require very small specimens. Because of the heterogeneous nature of mineral species present, difference in density and forms, segregation tends to occur. Representative analysis of a trace mineral in this material can be achieved only by collecting a large number of samples, perhaps 10 or more randomly and average the findings. Repetitious sampling (in Tables 1 and 2) show the variations in the determinations.

3. Monokote product contains approximately a maximum of 3% expanded vermiculite, 50-60% gypsum and a minor amount (4%) of organic materials. The only asbestos containing ingredient is vermiculite. Since the tremolite content of the expanded vermiculite is about 0.5%, Monokote products will have less than 0.2% tremolite by computation. Laboratory analysis shown in Table 2 confirms the computed results.

4. We are continuously improving the techniques for these analyses such as to determine the ratio of platy form vs. fibrous form of tremolite, to distinguish the fibrous tremolite vs. other fibrous-like minerals such as hornblende and contaminants which may lead to more accurate resolutions and identifications. In addition, we are trying to determine the number of samples required to give a statistically reliable analysis.

Julie C. Yang

Julie C. Yang

JCY:rb

Table 1 - Analysis of Expanded Vermiculite

No.	Identification No:	Description of Samples: Location of Ore	Location of Expanding	Tremolite Content (%) Analyzed By: ADL	JM
1	22203-2	South Carolina	Trenton	0.30	-
2	22209-9	Montana	East Hampton	0.20	0
3	22209-10	Montana	Denver	0.65	-
4	22209-11	South Carolina	Little Rock'	<0.2,0.45	-
5	22209-12	South Carolina	Enoree	<0.2	0
			Average: ADL	0.43	
			JM		0
			Total	0.33	

Table 2 - Analysis of Monokote Products

No.	Identification No.	Description of Samples: Location of Ore	Location of Manu.	Tremolite Content Analyzed By: ADL	JM
11	22203-9	Montana	Denver	0	-
12	22203-10	Montana	Los Angeles	0	-
13	22203-11	Montana	Midwick	0	-
14	22203-12	Montana	Oregon	0	-
15	22209-1	Montana	East Hampton	0.3	0
16	22209-3	Montana	Denver	<0.2	-
17	22209-3	South Carolina	Little Rock	0.3,<0.2	-
			Average - Total:	0.2	

Table 1 - Analysis of Expanded Vermiculite

No.	Identification No:	Description of Samples: Location of Ore	Location of Expanding	Tremolite Content (%) Analyzed By: ADL	JM
1	22203-2	South Carolina	Trenton	0.30	-
2	22209-9	Montana	East Hampton	0.30	0
3	22209-10	Montana	Denver	0.65	-
4	22209-11	South Carolina	Little Rock'	<0.2,0.45	-
5	22209-12	South Carolina	Enoree	<0.2	0
			Average: ADL	0.43	
			JM		0
			Total	0.33	

Table 2 - Analysis of Monokote Products

No.	Identification No.	Description of Samples: Location of Ore	Location of Manu.	Tremolite Content Analyzed By: ADL	JM
11	22203-9	Montana	Denver	0	-
12	22203-10	Montana	Los Angeles	0	-
13	22203-11	Montana	Midrick	0	-
14	22203-12	Montana	Oregon	0	-
15	22209-1	Montana	East Hampton	0.3	0
16	22209-2	Montana	Denver	<0.2	-
17	22209-3	South Carolina	Little Rock	0.3,<0.2	-
			Average - Total:	0.2	