FILED

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
BEAUMONT DIVISION

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James R. Cooney, Clerk, U. S. Court
By Virginia R. Lewis DEPUTY

CLAUDE J. TOMPLAIT

VS.

COMBUSTION ENGINEERING, INC., ET AL

CIVIL ACTION NO. 5402

ANSWERS OF THE DEFENDANT, OWENS-CORNING FIBERGLAS CORPORATION, TO INTERROGATORIES PROPOUNDED BY PLAINTIFF

TO THE PLAINTIFF, CLAUDE J. TOMPLAIT, AND MR. WARD STEPHENSON, STEPHENSON, THOMPSON & MORRIS, STEPHENSON BUILDING, ORANGE, TEXAS, HIS ATTORNEY OF RECORD:

Defendant, Owens-Corning Fiberglas Corporation, in response to interrogatories propounded under Rule 33, Federal Rules of Civil Procedure, served upon defendant's counsel on or about November 3, 1967, files this, its answers to such interrogatories, within the time required. Such answers to each interrogatory bears the same number and letter as the request:

INTERROGATORY NO. 1. From time to time since 1950 Owens-Corning has manufactured a variety of industrial insulating materials comprised principally of glass fibers and various types of binders. These materials are or have been identified as:

Heavy Density Sectional Pipe Insulation
One Piece Pipe Insulations
O-C Flexible Tubing Insulation
PF 610 Industrial Insulation
Industrial Insulation 700 Series
Intermediate Service Board
Metal Mesh Blankets

In addition, since 1958 Owens-Corning has manufactured an industrial insulating material comprised of calcium silicate, asbestos fibers and various types of binders. This product is known as Kaylo or Kaylo 20 Insulation.

INTERROGATORY NO. 2. Owens-Corning does not consider any of its industrial insulation materials to have a "dangerous nature" and such allegation or implication is specifically denied. However, the statements "This Product Contains Asbestos Fiber - If dust is created when this product is handled, avoid breathing the dust. If adequate ventilation control is not possible, wear respirator approved by U. S. Bureau of Mines" are set forth on the packaging container for Kaylo and Kaylo 20.

INTERROGATORY NO. 3. See Exhibits A - G.

INTERROGATORY NO. 4. See answer to No. 3.

INTERROGATORY NO. 5. Yes. Glass fiber and calcium silicate industrial insulating products have, in the past, been sold by Owens-Corning to distributors and applicators throughout the United States. These products are usually packaged in cardboard cartons.

INTERROGATORY NO. 6. See answer to No. 5.

INTERROGATORY NO. 7. Owens-Corning does not recognize that the result expressed in this question could occur and specifically denies that such could occur. Scientific investigation as reported in Exhibits A - G indicates that such a cause or contribution does not occur from the use of glass fiber materials.

INTERROGATORY NO. 8. No answer required.

DATED this 14th day of February, 1968.

KING, SHARFSTEIN & RIENSTRA

BY: John A. Rienstra

707 Beaumont Savings Bldg.
Beaumont, Texas
Attorneys for Defendant,
Owens-Corning Fiberglas
Corporation

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THE STATE OF TEXAS

COUNTY OF JEFFERSON

BEFORE ME, the undersigned authority, on this day personally appeared John D. Rienstra, known to me to be the person whose name is subscribed to the foregoing answers to interrogatories, and who being by me first duly sworn, did depose and say:

That the foregoing answers to interrogatories are true to the best of his knowledge, information and belief; that this verification is made by him because there is no officer of Owens-Corning Fiberglas Corporation within the jurisdiction of this Court or within the State of Texas; that the sources of his information used in answering such interrogatories are the files and records of Owens-Corning Fiberglas Corporation furnished to him for such purposes, and investigation heretofore made in this case.

John D. Rienstra

SUBSCRIBED AND SWORN TO before me, the undersigned authority, by the said John D. Rienstra, to certify which witness my hand and seal of office this the 14th day of February, A.D. 1968.

Louise Lancomb
Notary Public, Jefferson County, Texas.

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I certify that a true and correct copy of the foregoing answers to the interrogatories was served on Mr. Ward Stephenson, Stephenson, Thompson & Morris, Stephenson Building, Orange, Texas, by mailing a copy by certified mail on the 14th day of February, 1968.

A true and correct copy of the answers to these interrogatories was served on all other counsel of record by mailing by first class mail on the same date.

John D. Rienstra

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January 1960, Vol. 21, pp. 10-23
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Glass Dust: A Study of Its Biologic Effects

PAUL GROSS, M.D.; MARIAN L. WESTRICK, Ph.D., and JAMES M. McNERNEY, M.P.H., Pittsburgh

Introduction

Glass has been produced, used, and broken for many centuries, but because this material is not readily reduced to a fine particle size, it is only with the advent of new and mass production techniques that the problem of a possible health hazard from glass dust could have arisen.

Perhaps because every-day experience of civilized man has taught him that freshly broken fragments of glass possess remarkable and often treacherous potentialities for inflicting incisive skin trauma, the public-at-large seems to have acquired the impression that glass may be lethal when ground finely enough so as to be imperceptible when mixed with food. This impression is reinforced from time to time by sporadic reports in newspapers of attempted homicide by the admixture of ground glass with food.

Efforts have recently been made to clarify the potential pulmonary hazard of two types of glass dust. One of these was dust derived from a mixture of filamentous glass and a plastic.[1] In this investigation, no attempt was made to assess the possible role which glass itself may have played, independently of the plastic component, in the production of the results obtained. Neither was a determination made of the relative amount of glass present in the dust to which the animals had been exposed. Furthermore, although the dust was a rapidly settling one and dust counts had been performed, no indication was given as to the percentage of the dust which may have been sufficiently fine to be respirable. For these reasons, we believe that this published investigation adds little to our knowledge of the hazard of glass dust as such. The other study[2] was concerned with dust from glass wool. However, because of certain aspects to be dealt with later, some of the conclusions set forth in the latter study do not seem warranted to us.

We undertook the present investigation in order (1) to study the pulmonary response to a glass dust composed of very finely divided particles and to a glass dust composed of larger flake-like particles; (2) to document the effects of massive ingestion of ground glass so that some scientific information may be available on this subject, and (3) to study the potential of a glass dust with larger flake-like glass particles to irritate mucous membranes.

Received for publication June 24, 1959.

From the Industrial Hygiene Foundation, Mellon Institute.

This investigation was supported by a grant from the Owens-Corning Fiberglas Corporation, Toledo, Ohio.

Materials and Methods

The glass dust used in this investigation was prepared from flakes of glass* which were approximately 5μ thick. The glass contained, in addition to SiO_2, the oxides of Al, Ca, Mg, and B as major constituents. Also present, but in amounts less than 1% and usually more than trace, were the following elements: Na, K, Ti, Fe, and Zr. Fluorine was also present in traces to 0.3%.

A coarse dust was prepared by milling the glass flakes so that the resulting particles passed through a 325 mesh sieve.

In order to obtain a very fine glass dust, the milled flakes were suspended in water and atomized under a pressure of 90ψ. The jet of suspended glass fragments was made to impinge against a tool-steel baffle at near-sonic velocity. Thereby very small particles were produced. These particles, like those of kaolin and quartz which were produced in a similar manner as control dusts, became admixed with an appreciable amount of iron from the abraded tool-steel baffle. The

* Fiberglas Flake.

EXHIBIT A

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dusts were collected by means of electrostatic precipitators.

This investigation was composed of three parts:

1. Eye irritation study
2. Ingestion study
3. Pulmonary study

1. *Eye Irritation Study.*—Two experiments were performed, each using six eyes of albino rabbits. In the first, the lids were held open only long enough to dust the ocular conjunctiva thoroughly with the finely milled glass flakes (the largest particles around 400μ but the vast majority less than 50μ). In the second experiment, the lids were held open about one minute after the dusting. The eyes were examined 24 hours later with the aid of fluorescein.

2. *Ingestion Study.*—Young male white rats from Carworth Farms, approximately 28 days old, were divided into four groups of 10 each after a two-week observation period for acclimatization. These groups were given the following diets:

1. 10% finely milled glass flakes (by weight) incorporated in basic laboratory diet, *ad lib.* The basic laboratory diet consisted of pulverized Purina Laboratory Chow.
2. Pair-fed control; each rat fed only as much basic laboratory diet as its mate from the preceding group consumed on the previous day.
3. 50% finely milled glass flakes (by weight) incorporated in basic laboratory diet, *ad lib.*
4. Control; basic laboratory diet, *ad lib.*

The animals were kept on this regimen for a full year. During this time, weekly records were kept of the body weights and of the general appearance of the animals. Biweekly records were kept of the food consumption in all except the group receiving 50% glass in the diet. Due to much spillage and greater rate of consumption of the diet, the record of food consumption in the latter group was made more frequently.

At the end of the year, all surviving rats were weighed and then killed with ether. Autopsies were performed, and the liver and kidney weights were recorded. Sections were prepared from each of the following organs for microscopic examination: esophagus, forestomach, stomach, duodenum, jejunum, ileum, colon, liver, spleen, kidney, adrenal, testis, lungs, and heart.

3. *Pulmonary Studies.*—These studies consisted of one in which dusts were deposited by intratracheal injection and one in which the pulmonary deposition was accomplished by inhalation.

A. Intratracheal Injection: It was desired to test the pulmonary response to a relatively coarse glass dust and also to a very finely divided one. Because the coarse glass dust tended to settle very rapidly in an aqueous suspension it was found necessary to use corn oil (Mazola) as a suspending medium in order to accomplish the injections.

TABLE 1.—*Physical Data of Intratracheal Injections*

Dust	No. Rats	Particle Size	Amount Injected, Mg.	Suspending Medium, 1 Ml.
Glass	15	*	25	corn oil †
Glass	15	1.1μ ‡	25	water
Quartz	15	1.2μ ‡	25	water
Kaolin	15	0.7μ ‡	25	water
..	15	..	1 ml.	corn oil †

* This material passed through a No. 40 U.S. standard sieve. On microscopic examination it was found that, although a small number of particles was in the neighborhood of 400μ, the vast majority was in the region of 50μ or less.

† Mazola.

‡ Surface mean diameter ($\Sigma nd^3/\Sigma nd^2$): determined by optical sizing with oil immersion lens at a magnification of × 970

For the fine glass dust and the necessary control dusts (kaolin and quartz), water proved to be satisfactory. There were five groups of 15 rats each. Four of these groups were used for the two glass dusts and the two control dusts, whereas the fifth group was injected intratracheally with corn oil as an additional control. The physical data of these injections are given in Table 1.

The injections were administered under light ether anesthesia by means of a blunt-tipped No. 18 gauge spinal needle introduced between the vocal chords. This was accomplished under direct observation by means of a self-retaining, illuminated speculum.[3]

Three rats were killed from each group at 6 months and the survivors at 12 months. Autopsies were performed on these rats plus all that had died of spontaneous disease. Paraffin sections were cut of the lungs after formalin fixation. These were routinely stained with hematoxylin and eosin. Some were also stained with Van Gieson's stain and by the Gordon and Sweet method for reticulin fibers. Selected slides were subjected to incineration in order to study the topographic relationship of the dust.[4]

B. Inhalation Exposure: In this study, both rats and guinea pigs were used. In addition to exposures to glass dust, animals were exposed to quartz dust and to kaolin dust, respectively. Accordingly, there were three groups of 40 rats each and three groups of 15 guinea pigs each. Each group was housed in a separate inhalation chamber. The dust exposures were for six hours per day, five days per week, for one year.

The method of generating the dust cloud, its dispersal, and control were similar to that previously described.[5] The experimental conditions in the inhalation chambers and the particle size distribution of the various dusts are listed in Tables 2 and 3.

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TABLE 2.—*Experimental Conditions of Inhalation Exposure*

	Glass		Quartz		Kaolin	
	Rats	Guinea Pigs	Rats	Guinea Pigs	Rats	Guinea Pigs
Dust concentration, mg/cu. m.*	18.6	17.1	21.6	24.0	27.0	23.4
Average particle size, μ †						
Optical microscopy, × 970	1.1		1.2		0.7	
Electron microscopy, × 18,720	0.06		0.04		0.04	
Air flow, cu. m/hr.	4.0		4.0		4.0	

* The calculated numbers of particles per cubic foot in the different chambers vary as follows:
from 2.7×10^{8} to 1.6×10^{9} if based on optical microscope sizing;
from 1.7×10^{11} to 8.6×10^{11} if based on electron microscope sizing.
† Surface mean diameter ($\Sigma nd^3/\Sigma nd^2$).

In an attempt to minimize infections, all animals throughout the laboratory were given a saturated solution of sulfathiazole for eight hours once every week as drinking water.

Deaths caused by pneumonias made 13 replacements necessary among the guinea pigs during the first five months of exposure. After the conclusion of the 12-month exposure period, the animals were pastured for another year. After 6 months and again after 12 months of exposure, several animals from each group were killed for the purpose of sampling. All survivors were killed at the end of the second year. Autopsies were performed on all animals killed as well as on those that had died of intercurrent infections. Sections were prepared and stained as in the intratracheal injection series. Incineration studies were also performed on selected slides in this series.

TABLE 3.—*Particle Size Distribution of Inhalation Chamber Dusts* *

Particle Diameter, μ	Glass		Quartz		Kaolin	
	% by number	% by mass	% by number	% by mass	% by number	% by mass
<0.4	68.2	2.0	64.8	1.2	52.0	3.5
0.4	16.0	3.8	10.4	1.6	33.2	18.1
0.6	6.6	5.3	6.0	3.1	9.6	17.6
0.9	4.2	11.3	8.6	14.8	3.4	21.1
1.3	2.8	22.8	7.6	39.0	1.6	29.8
1.8	2.0	43.2	2.4	33.0	0.2	9.9
2.5	0.2	11.6	0.2	7.3	--	--

* Determined by optical sizing with oil immersion at a magnification of × 970.

Results

1. *Eye Irritation Study.*—The glass particles were very effectively cleared from the ocular conjunctiva by blinking. Careful search for corneal defects failed to reveal any abnormality.

2. *Ingestion Study.*—The significant data, including those of average food and glass consumption, mean body weights, and organ weights, are given in Table 4. A graphic representation of the gain in body weight is given in Figure 1.

Throughout the feeding period of one year, there was no appreciable difference

TABLE 4.—*Average Food Consumption, Body Weights, and Organ Weights of Male Rats Receiving Various Levels of Glass in Basic Laboratory Diet for One Year*

Level	Survival	Total Diet Consumed, Av/Rat/Day, Gm.	Food Consumed, Av/Rat/Day, Gm.	Glass Consumed, Av/Rat/Day, Gm.	Mean Wt., Gm.		Mean Gain, Gm.	Organ Wt., % of Body Wt.	
					Initial	Final		Liver	Kidney
10% glass	9/10	19.6	17.6	1.95	138	430	292	3.5	0.7
Pair-fed control	8/10	17.2	17.2	--	137	411	274	3.3	0.7
Ad lib control	9/10	19.1	19.1	--	141	480	339	3.3	0.7
50% glass	10/10	34.2	17.1	17.1	128	411	283	3.1	0.7

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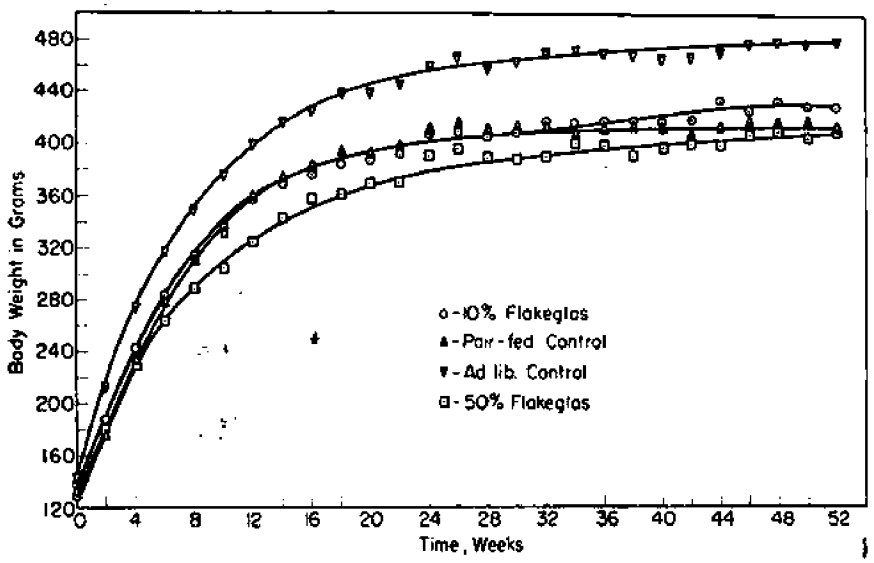


Fig. 1.—Growth curves of male rats fed normal diets and glass dust.

between the control groups and those receiving glass in their diet as judged by general appearance, behavior, growth (Fig. 1) and survival (Table 4). All of the rats on the 50% glass diet survived the experiment. The deaths in the other three groups appeared to have been caused by pneumonia and were associated with weight losses.

The average total diet consumed per rat per day on the 10% glass level (Table 4) approximated the amount eaten by the *ad libitum* controls. The rats on the 50% glass level compensated for the large amount of non-nutritive material in their diet by almost doubling their daily food intake so that the actual amount of food consumed each day approximated the corresponding values for the 10% glass and the pair-fed control groups. The growth curves of these three groups closely approximate each other.

The average weights of the liver and kidneys as listed in Table 4 indicate that there is no significant difference between the values obtained for the experimental groups and the corresponding values for the controls.

Microscopic examination of the various organs from all of these animals revealed no significant abnormality. There was no evidence of trauma, ulceration, or degeneration of the gastrointestinal mucous membrane.

3. *Pulmonary Studies.*—A. Inhalation of Glass Dust—Guinea Pigs: Grossly, no significant changes were noted. Microscopically, there were widely scattered, relatively small foci of clustered alveoli which contained massed dust cells. Proliferation of alveolar lining cells about the dust cells caused widening of some of the alveolar walls. The dust cells varied in color from tan to brown and gave a positive reaction for iron. The lung tissue between the dust foci was generally normal. No collagen formation attributable to the dust could be demonstrated.

The lymph nodes contained dust cells in the form of small foci and also loosely scattered.

Foci of spontaneous disease were fairly common and had to be differentiated from the experimentally induced lesions. The former included foci of interstitial eosinophilic pneumonia, focal adenomatosis, and a peculiar lipid pneumonia in which signet-ring type cells were a striking feature.

There were also four instances of an interesting disease of connective tissue characterized by focal interstitial pulmo-

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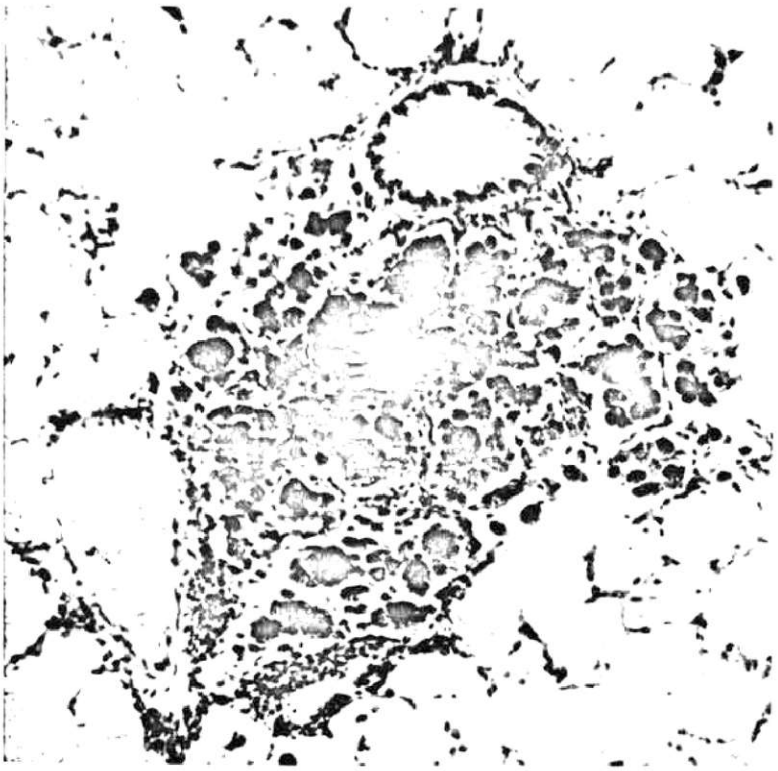


Fig. 2. — Guinea Pig 309, exposed to glass dust in inhalation chamber for 12 months and then pastured for another year. This is the characteristic glass dust depot. The dust deposits are small, widely separated, and few in number. A depot consists of clustered alveoli which contain aggregated, dust-filled macrophages. Alveolar walls show mild to moderate proliferation of alveolar cells. There is no fibrosis. Hematoxylin and eosin; × 197. Reduced 8% of the original.



Fig. 3. — Guinea Pig 304, exposed and pastured as animal in Figure 2. This is a portion of a paratracheal lymph node. In addition to lymphocytes, scattered dust-filled phagocytes are present. The latter are difficult to identify at this magnification. Hematoxylin and eosin; × 197. Reduced 8% of the original.

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nary fibrosis, associated with prominent basophilia of elastic tissue, and calcification. In addition to pulmonary involvement, as part of the syndrome there were lesions in the aorta, pulmonary artery, renal arteries, the heart, and kidneys. This pulmonary disease, which resembles a disease in human lungs recently described[6] will be the subject of a separate publication.

B. Inhalation of Glass Dust—Rats: No significant macroscopic lesion was noted. The microscopic indications of dust exposure were minimal and consisted of widely scattered small foci of clustered alveolar macrophages tan to brown in color. There were also the usual para- and perivascular collections of lymphocyte-like cells not unusual in the lungs of rats and guinea pigs. Some of these cellular foci contained a few dust cells. The alveolar walls often were thickened in the regions of the dust cells by a proliferation of lining cells. A rare alveolar giant cell was found. The intervening lung tissue was normal except for an occasional focus of spontaneous disease. There was less evidence of dust storage in animals killed near the end of the second year than immediately after the conclusion of the 12-month dust exposure.

The lungs of rats that had died, even after a full 12-month exposure, contained little or no evidence of such exposure in the presence of pneumonia or edema, in spite of the fact that the lymph nodes of these animals contained the usual dust-cell foci. Such dust-cell foci were also present in the lymph nodes of rats that had been killed. They consisted of small collections of tan-colored macrophages and were not associated with the formation of connective tissue.

C. Intratracheal Injection (Coarse Particle Size) of Glass Dust: The lungs showed no significant gross changes. Evidence of the injections could be seen microscopically in the form of scattered, small accumulations of transparent plates and spicules occupying a single alveolus or a small cluster of alveoli. These collections of glass fragments were associated with pronounced proliferation of alveolar-lining cells, and some became surrounded by a

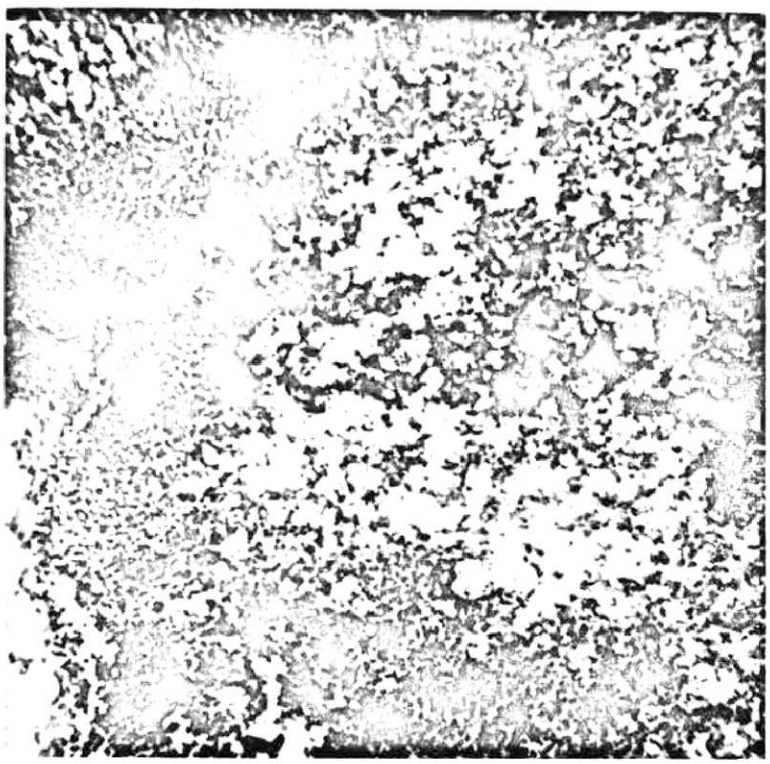


Fig. 4.—Same field as in Figure 3, with superimposed ash pattern showing a greater amount of dust present in the tissue than might be suspected from the appearance in Figure 3. × 197. Reduced 8% of the original.

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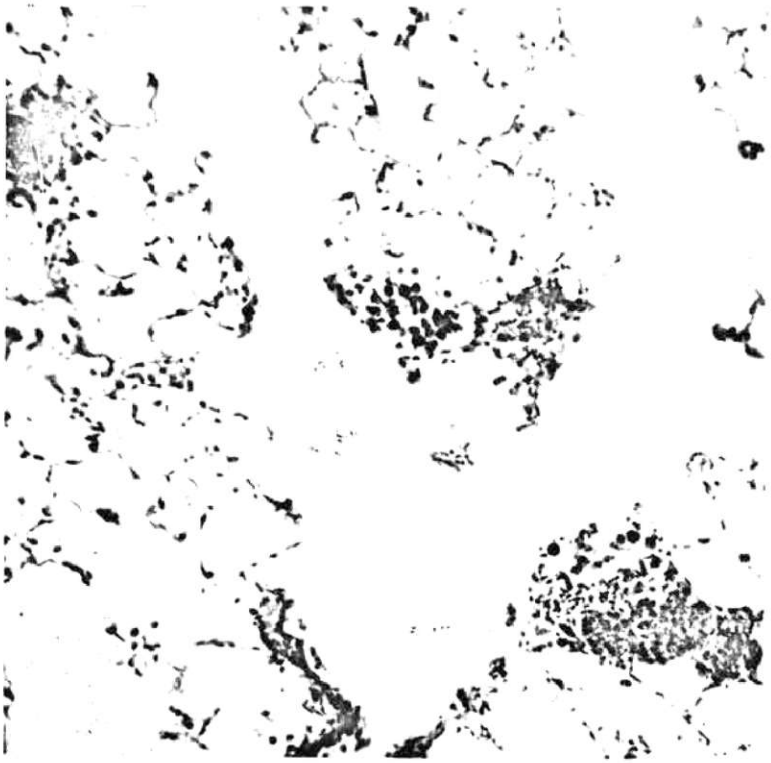


Fig. 5.—Rat 3173, exposed to glass dust in inhalation chamber for one year and then pastured another year. Dust deposits are widely separated, usually situated about vessels or bronchi and composed of few clustered alveoli which contain dust-filled macrophages. In this field, the dust-containing alveoli are near a bronchiole. Mild alveolar cell proliferation is present about the plugged air spaces. Hematoxylin and eosin; × 197. Reduced 8% of the original.

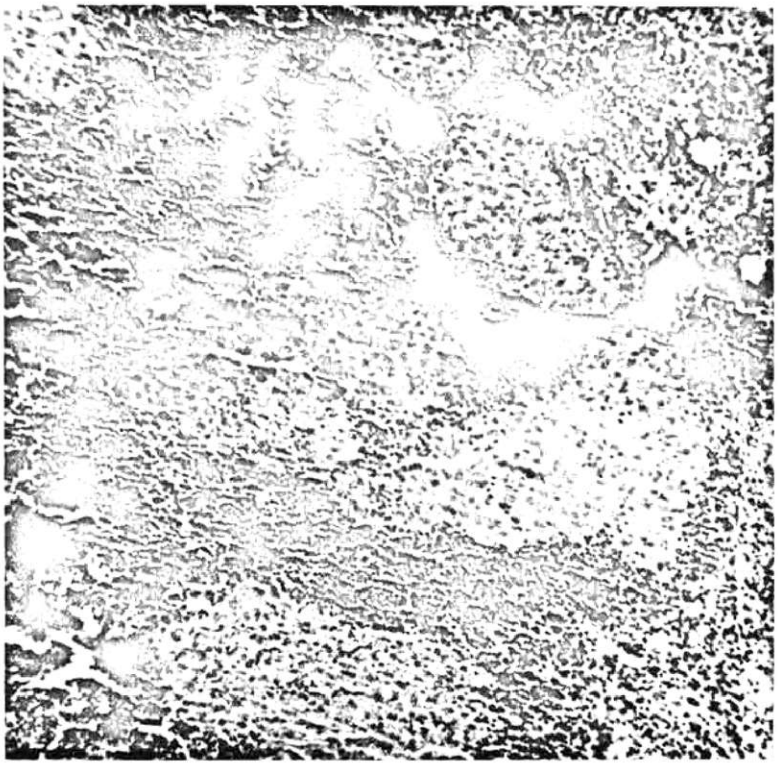


Fig. 6.—Tracheal lymph node from Rat 3173 showing well-defined foci of large, pale, reticuloendothelial cells which contain granules in the cytoplasm. No fibrosis is present. Hematoxylin and eosin; × 197. Reduced 8% of the original.

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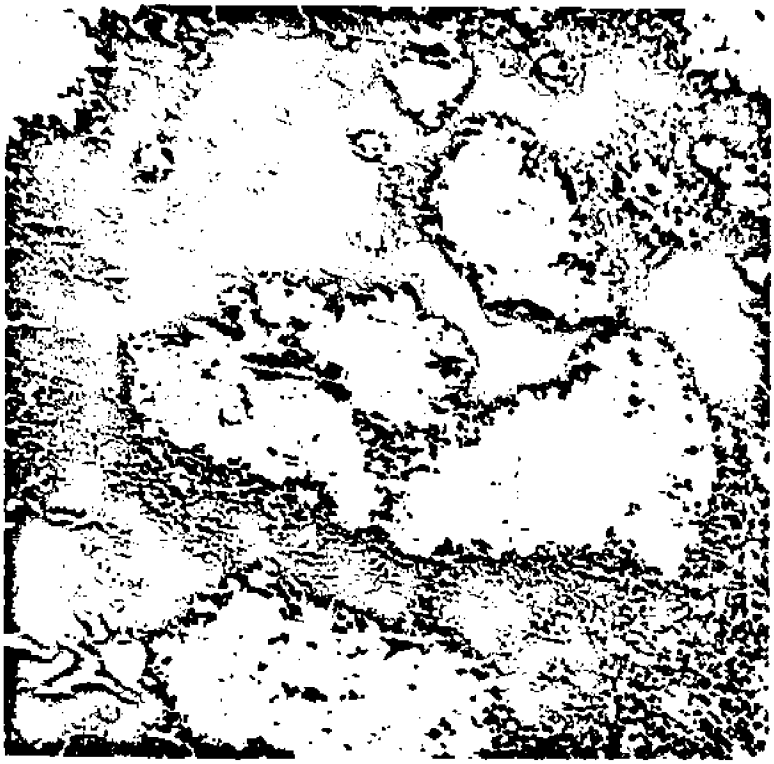


Fig. 7.—Same field as in Figure 6 but with superimposed ash pattern showing densely aggregated dust which is practically limited to the foci of large, pale cells. × 197. Reduced 8% of the original.

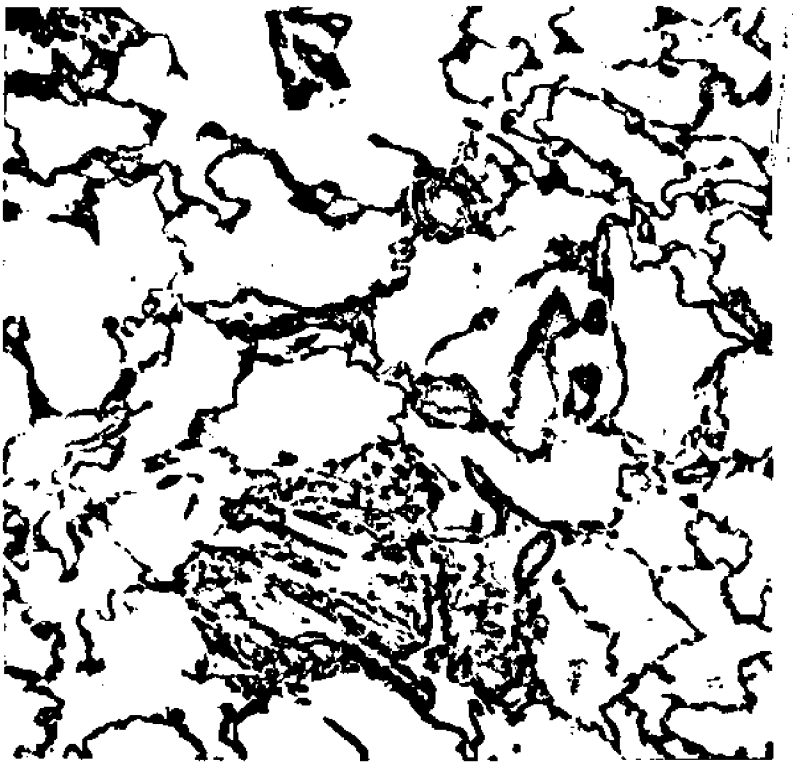


Fig. 8.—Rat 3080 treated intratracheally with 25 mg. coarse glass dust and killed one year later. One of the widely scattered, small depots of glass dust. The site of the glass plates is indicated by the clefts with parallel sides. These clefts are associated with proliferation of alveolar cells and an occasional giant cell. The depot is delimited by alveolar walls. Hematoxylin and eosin; × 197. Reduced 8% of the original.

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very thin, single layer of spindle cells. At the end of 12 months, only occasional thin collagen fibers were found associated with these foci. An occasional multinucleated giant cell was also noted. The intervening lung tissue was normal except for a few coarse scars representing pneumonic residua of the injection. The lymph nodes were uniformly without significant findings.

D. Intratracheal Injection (Fine Particle Size) of Glass Dust: Grossly, the lungs presented no significant change. Microscopically, a few widely scattered small alveolar dust foci were found in nearly every section. A few of the dust foci were also found interstitially, situated in the loose, edematous periadventitial stroma of vessels and bronchi. The foci were composed of tan, dust-filled macrophages some of which contained iron. In some of the foci a few collagen fibers were noted, and in some there was focal proliferation of alveolar-lining cells. Between the dust foci, the lung tissue was normal except for the occurrence, in a few animals, of spontaneous disease of infectious character. The lymph nodes were not enlarged but contained foci of dust cells without any connective tissue reaction.

Quartz: A. Inhalation—guinea pigs. Grossly, the lungs showed only slight tan pigmentation and a more fleshy consistency than normal. Silicotic nodules were absent. The lymph nodes were enlarged and firm but not hard.

Microscopically, the predominant feature was a severe diffuse proliferation of alveolar cells with plugging of the air spaces by desquamated, quartz-filled macrophages as well as giant cells. The cellular proliferation caused diffuse thickening of alveolar walls. In some regions, this thickening was irregular, fusiform, or nodular. However, silicotic nodules were absent. In general, collagen formation was absent, although there was focal collagen formation in the alveolar walls of some animals. No collagen was found in the lymph nodes which were enlarged and in which the lymphoid tissue had been replaced by masses of dust cells and multinucleated giant cells.

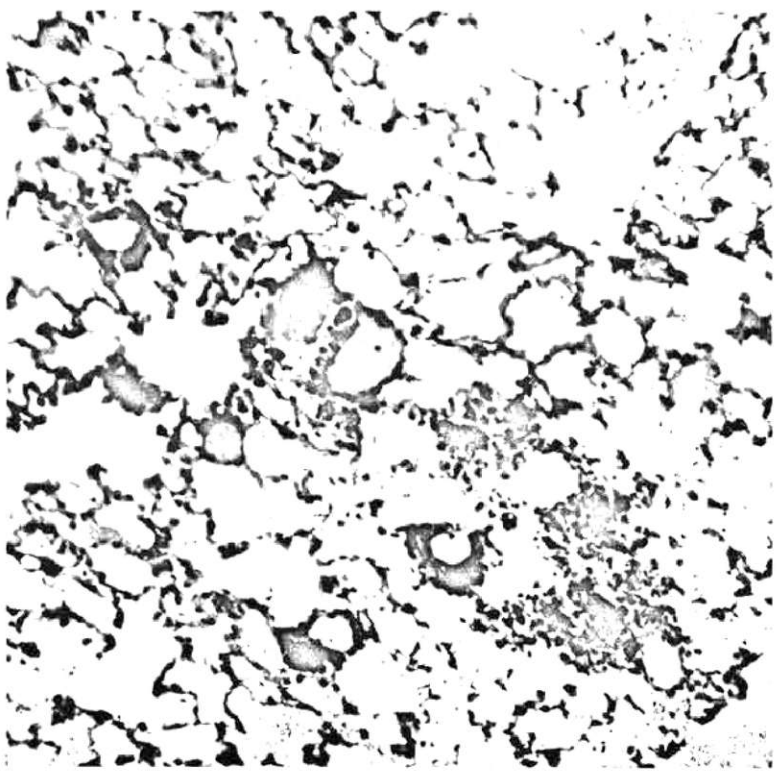


Fig. 9.—Rat 3087 treated intratracheally with 25 mg. fine glass dust and killed one year later. This dust depot, like those in the inhalation studies, consists of a few clustered alveoli which contain dust-filled macrophages. A moderate alveolar cell proliferation is present not only in the region of the macrophages but also in alveoli adjoining nearby vessels. Hematoxylin and eosin; × 197. Reduced 8% of the original.

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In addition to scattered, insignificant foci of spontaneous disease in surviving animals, there were 12 deaths from pneumonia. Some pneumonias were of the eosinophilic, interstitial type, others were frankly purulent, while still others had a lipidic component.

One instance of systemic connective tissue disease was found in which there was focal pulmonary fibrosis with basophilia and calcification of elastic tissue.

B. Inhalation—rats. Grossly, the lungs of this group of animals showed irregular consolidations of a fleshy character. The hard, gray-white, nodular, cartilage-like consolidation typical of silicosis was not seen. The lymph nodes were enlarged and firm-to-hard.

The microscopic examination revealed widespread formation of nodules typical of silicosis, except that no collagen was present at 6 months and relatively little at 12 months. After this time, there was increasingly greater collagenization of the silicotic nodules. In addition to the formation of nodules, there was widespread and increasingly severe alveolar stasis of lipidic debris and macrophages. This was associated with widening of alveolar walls, which developed collagen with the passage of time. The number of silicotic nodules and the amount of alveolar debris was usually sharply reduced in animals which had pneumonia or pulmonary edema.

The lymph nodes showed variable degrees of fibrosis and extensive replacement of lymphoid tissue by masses of reticuloendothelial cells.

C. Intratracheal injection—rats. As in the preceding group, the gray-white cartilage-like, nodular consolidation usually seen in well-developed experimental silicosis was not seen in the lungs of these rats. Instead, a more fleshy, irregularly distributed consolidation was found.

Microscopically, numerous silicotic nodules were present which were cellular and contained no collagen at six months. At the end of the year, the nodules in most animals demonstrated considerable amounts of collagen. However, there were a few rats in which collagenization of the nodules was still absent at this time. There was much alveolar stasis of lipidic debris and macrophages. In the regions of alveolar stasis, there were many cholesterol crystals with associated giant cells. The alveolar walls adjoining plugged air spaces were widened by proliferation of the lining cells, and, in the older animals, focal collagenization of the thickened walls was noted.

The lymph nodes were enlarged and showed varying amounts of fibrosis. Much of the lymphoid tissue was replaced by masses of dust-containing reticuloendothelial cells.

Kaolin: A. Inhalation—guinea pigs. Aside from slight pleural mottling of opaque tan, no significant gross change was noted in the lungs.

Microscopically, there were widely scattered relatively small foci of clustered alveoli plugged by massed dust cells similar to those of glass dust. Here, also, there was widening of adjoining alveolar walls by proliferated alveolar cells. No collagenization was found. The intervening lung tissue was normal except for occasional foci of spontaneous disease.

The lymph nodes contained large masses of dust cells but showed no connective tissue reaction to their presence.

A number of spontaneous deaths occurred. Many of these guinea pigs had a chronic pneumonia in which lipid-containing cells of signet-ring type were a striking feature. When pulmonary edema was demonstrable in the sections, the dust foci appeared disrupted and reduced in number. There were also three animals with the same type of systemic connective tissue disease as was noted in the other groups. This was associated with focal interstitial pulmonary fibrosis, elastic tissue basophilia, and calcification.

B. Inhalation—rats. Except for slight tan pleural mottling, no significant abnor-

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mality was noted grossly in the lungs of this group.

There were numerous relatively small, scattered dust foci composed of packed, large, dust-filled macrophages which plugged alveoli and were delimited by alveolar walls. Delicate collagen fibers could be seen coursing between the cells and were also occasionally noted about the periphery, in the alveolar walls. Some of the dust foci contained a sprinkling of small lymphocyte-like cells. The intervening lung tissue was unaffected by the dust.

In the presence of spontaneous disease, the dust foci were often disrupted, so that loose, clay-filled macrophages were found scattered in the air spaces over large areas and the number of discrete dust foci was reduced.

The lymph nodes contained large masses of dust-filled macrophages, but no collagen formation was demonstrable.

C. Intratracheal injection—rats. The gross findings were similar to those of the preceding group. The kaolin dust foci microscopically were generally small and widely scattered. Their structure was identical to that of the preceding group. The intervening lung tissue was unaffected by dust and essentially normal.

The lymph nodes were also very similar to those of the preceding group.

Mazola Control: Grossly, the lungs appeared normal. Microscopically, the lung sections showed only an occasional alveolus containing a group of unattached brown-pigmented macrophages. No collagen formation was noted, and the lymph nodes were normal throughout.

Comment

It is highly probable that the relatively large flat surface presented by the glass flakes caused them to become oriented parallel to the conjunctival surface due to surface attraction of the conjunctival fluid. This parallel orientation diminished the probability of injury from the sharp edges of the flakes.

It would seem that the effect of the glass in the diet was entirely that of a bulky, biologically inert material. The depression in the growth curve of the 10% glass group as compared to that of the *ad libitum* group can be accounted for by the fact that, although an appreciable amount of the dietary intake of the former group was non-nutritious, this dietary intake was approximately the same as that of the *ad libitum* group.

Inasmuch as there were no significant changes in general behavior, organ weight, or the microscopic appearance of the various organs, it is probable that the slight depression in the growth of the experimental groups is due to a less-than-optimum average daily food intake of adult rats (19-20 gm.). If the rats on 10% glass level had not been satisfied by the bulk of their diet but would have increased their daily intake by 10%, it is probable that there would have been no discernible difference between this group and the *ad libitum* control group.

The lack of irritating qualities to skin or mucous membranes of the flake-like glass dust particles is probably due to two important properties of this material. The first is the insolubility, and, hence, biologic inertness, of glass in general. The second is that because of the large, relatively flat surface of these dust flocculi in particular they tend to orient themselves parallel to the surface and to float upon the film of fluid present (on mucous membranes). The sharp edges of the particles thereby are given little opportunity to inflict tissue damage.

In view of the insolubility of glass, the absence of toxicity is not surprising, even from such massive dosage as is represented by the animals that ingested an amount of glass equivalent to the weight of their food, every day for one year. The significant difference in the weight curve of the above animals as compared to that of the control group can be explained on the basis that the former could not ingest sufficient food to equal the caloric intake of the controls

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because of the large bulk of their diet. Furthermore, the experimental rats obtained but little rest because they were eating practically continuously in an attempt to obtain their desired caloric intake.

However, one must concede the possibility of mechanical trauma from sharp-pointed or sharp-edged objects situated in a hollow organ which undergoes rhythmic vigorous contractions. Nevertheless, it is relatively difficult to create conditions whereby such sharp objects capable of producing trauma may be unwittingly swallowed. The present investigation establishes that finely ground glass is incapable of producing a traumatic effect. What the minimum dimensional requirements might be for crushed glass to produce a traumatic effect on the alimentary tract could very well be the subject for further research (in the field of forensic medicine!). In general, it would seem that glass fragments sufficiently coarse to be capable of producing trauma may be unwittingly ingested with food only by a person who swallows food without chewing it or who has lost, partially or completely, the ability to sense the presence of foreign nonfood material in his mouth. Certainly, glass in the form of dust can be exonerated from any suspicion that it can traumatize the alimentary tract.

The pulmonary response to coarse glass dust in the form of flakes or plates is minimal, consisting of alveolar-cell proliferations and of a thin investment of such glass fragments by a single layer of flattened cells and few delicate collagen fibers. In this laboratory, the reaction to equally coarse kaolin particles has been found more aggressive. Foreign-body giant cells were usually much more abundant and proliferation of alveolar cells upon nearby alveolar walls was more pronounced in relation to the kaolinite crystals.

The pulmonary reaction to the presence of the fine glass dust in both rats and guinea pigs is no more severe than the reaction to similarly fine kaolin dust and frequently less so. The reaction is nonfibrogenic and consists essentially of small collections of alveolar dust cells that become reduced in number with the lapse of time. Whereas most of the kaolin dust deposits are properly classified as interstitial, no significant interstitial deposition of fine glass dust occurs.

Glass dust deposits in lymph nodes are much less abundant than kaolin dust deposits and, similar to the latter, appear to be completely inert. No bronchial or bronchiolar disease attributable to glass dust could be demonstrated.

The experimental conditions under which the animals had been exposed to glass dust in no way duplicated the conditions of shop practice, inasmuch as the glass-dust content of the chamber air was astronomically high. Furthermore, whereas in industrial practice the glass-dust particles (from glass fibers) are so large as to be nonrespirable,[7] nearly all of the dust in the chambers was exceedingly fine and, therefore, respirable. Thus these conditions of optimal exposure serve only to emphasize the minimality of the glass-dust lesions produced in these animals.

In the study of dust from glass wool[2] mentioned earlier, the conclusions are drawn that this particular glass dust caused endobronchiolar and peribronchiolar lesions, a "tendency toward bronchial epithelial hyperplasia," and interstitial pneumonitis.

Although the critical reader may not be in a position to deny these conclusions, he may well question their justification. The findings upon which the above conclusions are based occur with sufficient frequency as spontaneous lesions in stock animals to make mandatory proof that they are not of spontaneous origin and that they are related to the dust exposure. Such proof was not furnished. Indeed, there was no mention in the published article that *any* controls had been used.

It may perhaps be superfluous to point to the necessity for adequate controls in bio-

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logical investigations. A case in point is the present investigation in which it was found that 4 out of 16 guinea pigs exposed to glass dust suffered from a striking, hitherto undescribed interstitial pulmonary fibrosis with calcification. Since, to our knowledge, no such lesion has previously been reported or seen in animals, it would follow that it was the glass dust that caused the pulmonary fibrosis. We were fortunately saved from falling into this error by the fact that it has been customary in this laboratory to run two additional series of animals as controls whenever an unknown dust is under investigation. These two additional series of animals are exposed to quartz and kaolin dusts, respectively, under conditions as nearly identical as possible to those of the experimental dust. As previously indicated, interstitial pulmonary fibrosis identical to that in the glass-dust group was also found in animals exposed to kaolin as well as to quartz dust. This seems to point not to the glass dust but to some as yet undetermined factor in the technique as a causative factor.

The failure of our quartz dust to produce silicotic nodulations in guinea pigs and the temporary inhibition of silicotic fibrosis in rats had not been anticipated. Investigation disclosed that the quartz dust contained considerable iron, and the latter modified and inhibited the silicotic manifestations.[8] At the same time, it was found that similar admixture had also occurred with the kaolin and glass dusts. It was this admixed iron which gave the alveolar dust cells in all groups the tan-to-brown pigmentation.

The question may be raised as to the extent to which admixed iron may have modified the pulmonary response to glass dust. A positive answer cannot be given. However, inasmuch as the inhibitory effect of iron is only of temporary character in the case of quartz dust in the rat, it would seem reasonable to anticipate no more than a temporary inhibitory effect, if any, in the case of glass dust in the rat. The fact that the effects of glass dust in rats which had been killed at two years were even more trivial than those killed at one year speaks against any inhibitory effect of iron. Furthermore, we have had abundant previous experience with the pulmonary effects of kaolin dust without iron contamination, and we do not see any significant difference in the histopathologic picture produced in the lung by kaolin dust whether contaminated by iron or not. In spite of the ameliorating effect of iron, the pulmonary involvement due to quartz was much more extensive and severe than that due to glass.

It has been inferred that glass dust in filamentous form may be biologically more active than glass dust in the form of, say, spherules because of the mechanical irritation of the sharp points.[2] This is, of course, pure conjecture and is based on a similar conjecture made in regard to the biologic activity of asbestos fibers. Unfortunately, there are at present no data which could serve either to support or to reject this assumption. However, a filamentous dust of glass-like material (aluminum silicate) has been shown recently to be biologically inert.[9] Besides, if the theory of mechanical irritation should apply to silicates like glass and asbestos, it should also apply to the sharp-edged crystals of quartz. Yet, the mechanical theory of the biological activity of silica has been discarded.[10] It is apparent that any difference between filamentous and flake glass of identical composition will tend to disappear if the glass is ground finely enough (as was done during this investigation).

Summary and Conclusions

A study was made of the biologic effects of glass dust upon the conjunctiva, the gastrointestinal tract, and the lungs of experimental animals.

No effect of glass dust and glass flakes was demonstrable upon the conjunctiva.

No toxic or traumatic effect was demonstrable upon the gastrointestinal tract. There was only slight depression of the growth rate when rats ingested a diet con-

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taining as much ground glass as food. This depression was due entirely to a lower food intake caused by the bulkiness of the glass diet.

The pulmonary changes in guinea pigs exposed to fine glass dust for one year and those of rats either exposed to the same dust or given injections intratracheally with it were minimal in character and consisted only of small focal alveolar dust cell collections without fibrosis. In the pulmonary lymph nodes there were also focal intracellular glass-dust deposits which were likewise not associated with reactive fibrosis. There was no bronchial disease attributable to the dust.

Compared to kaolin, the pulmonary effect of fine glass dust was even more benign, because the stored dust remained alveolar instead of occupying interstitial positions and therefore was more readily mobilized and cleared from the lung.

Coarse glass dust injected into the lungs of rats behaved like inert foreign material and was associated with minimal foreign body reaction without significant collagen formation.

Industrial Hygiene Foundation, Mellon Institute.

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Correlation Between the Character of the Chest Roentgenograms and Estimates of Intensity Plus Duration of Exposure to Fibrous Glass Coated with Phenolic Resin, as Studied by the Experience of Current Employees of the Newark, Ohio Plant of the Owens-Corning Fiberglas Corporation

Introduction

The Kettering Laboratory, Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, and George W. Wright, M.D., Head of the Medical Research Department, Saint Luke's Hospital, Cleveland, Ohio collaborated in the investigation of the health of 1400 employees of the Owens-Corning Fiberglas Corporation's Newark, Ohio manufacturing plant. The medical investigation, including the interpretation of serial X-ray plates and the analysis of medical and employment histories, was conducted and reported by Dr. Wright.

The investigation and report were completed in December, 1963.

Purpose of Study

The question at issue is whether or not prolonged exposure to a "working condition" environment containing airborne fibrous glass* is associated with any recognizable abnormality of the chest roentgenogram of persons thus exposed. The answer to this query can be expected to bear upon the larger question of whether or not the inhalation of fibers of this particular commercial type of fibrous glass is harmful to the respiratory system of man under what might be termed "working conditions".

Method of Study

Available for examination are the chest roentgenograms of all of the employees currently on the payroll at the Owens-Corning plant in Newark, Ohio, where fibrous glass is formed from raw materials; coated with a binder of phenolic resin; formed in "shapes" and packed for shipment.

A single PA chest film taken sometime in 1963, plus prior films extended over a period of five to twenty-five years are available for each man. The same individual (the author of this report) evaluated all of the films during a period of approximately six consecutive weeks, in an attempt to minimize "reader" variation. He brought to the task the usual formal training in the reading of chest roentgenograms, plus twenty-five years of experience with the day-to-day observation of roentgenograms of persons having various chest diseases of both occupational and non-occupational varieties. In addition, by virtue of many years of daily examination of pre-employment chest roentgenograms, he has an unusually broad experience in the observation of films from persons thought to be normal individuals.

* Coated with phenolic resin.

EXHIBIT B

Population Studied

Since we were interested in whatever chronic effects might have occurred, it was decided arbitrarily that no persons should be included in the study who had been employed fewer than ten years. This was done in order that the persons investigated should have sustained cumulative exposure, and also that sufficient time should have passed to permit changes to develop that might be recognized in the films. The chest roentgenograms of every employee who had worked, in what might be called the factory area, for more than ten years, including both men and women, were included in the study. In addition, salaried men, of clerical and non-factory experience, who had been employed for ten or more years, were included in the study and their X-rays examined. The total number of the group was 1401.

Results of the Study

After completing the observations of this entire set of films, it is apparent to the examiner that there was nothing peculiar or unusual which occurs in the films with sufficient frequency to suggest that a new or heretofore unknown type of lung disease, associated with exposure to fibrous glass, is present. In fact, no unusual shadows were seen that have not been observed in men whose lives have been spent in an environment thought to be free from any potential pulmonary hazard.

It can be concluded from these observations that none of the patterns known to occur in other types of pneumoconioses occur with any unusual frequency either in the entire population, or in any relationship to the intensity and duration of the exposure under investigation.

Conclusions of the Study

In view of the findings reported, it seems reasonable to conclude that, on the basis of an examination of chest roentgenograms, there is no evidence to support the contention that exposure, even of a prolonged nature, to an environment containing airborne fibrous glass, produces a unique shadow in the roentgenogram, nor does it seem to produce a preponderance of any other sort of roentgenographic characteristic.

Entire investigation and report by:

George W. Wright, M.D., Head
Medical Research Department
Saint Luke's Hospital
Cleveland, Ohio

Consultant (for this purpose) of Kettering Laboratory in the Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati, Cincinnati, Ohio.

Robert A. Kehoe, M.D., Director
Kettering Laboratory

Occupational Hazards of Pipe Insulators

WILLIAM T. KEANE, MS, AND MITCHELL R. ZAVON, MD, CINCINNATI

THE DEATH of a member of the International Association of Heat and Frost Insulators and Asbestos Workers, resulting from a *Bacillus anthracis* infection, focused attention on the potential occupational hazards of this trade. An investigation of the work which these men perform and the materials with which they come in contact was undertaken in order to determine the nature of the hazard, if any, of this trade. To initiate the study, all materials used by union members in the Cincinnati area were first reviewed and evaluated. These materials were divided into five major categories (A to E) according to their chemical composition. Each of these will be dealt with individually.

An analysis of the job indicated that the handling of fibrous glass, magnesium carbonate and calcium silicate materials containing asbestos fibers, adhesives, and cements occupies 80% to 90% of the average insulator's working time. Accordingly, these materials were of particular interest and have been reviewed in detail within the framework of the major category in which they reside.

Glass Insulating Materials

The term glass has traditionally been linked, in the minds of men, with lacerations and other forms of physical injury. In addition to such physical insults, there is reason to be concerned with the possible effects from the ingestion and inhalation of airborne particles of glass, since glass insulating materials are produced in forms that may give rise to airborne fibers and flakes of glass.

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From the Kettering Laboratory, University of Cincinnati College of Medicine, Cincinnati.
Reprint requests to Kettering Laboratory, College of Medicine, Eden and Bethesda Avenues, Cincinnati 45219 (Dr Zavon).

Review of Literature Concerning Glass Fibers.—Glass fiber materials were first developed by Owens-Corning Fiberglas Corporation in 1932, and in 1938 this company opened the first plant in the world for the production of fibrous glass.

Glass fibers are silicates and have the following general composition:

Silicon dioxide (SiO_2)	54-65%
Oxides of aluminum	1-15%
Calcium (Ca)	0-22%
Magnesium (Mg)	0- 6%
Boron	0-10%

Others additives: sodium (Na), phosphorus (P), iron (Fe), barium (Ba), titanium (Ti).

A phenol formaldehyde resin is applied to the glass fibers to bond and hold them in boards, mats, or wool-like masses. The resin is bonded securely to the glass fiber by heating to temperatures ranging from 450 F to 550 F, in order to prevent its removal from the glass and vice versa. Thus, the resin is not an airborne hazard in itself. Glass fiber insulating materials have the following properties: they are incombustible and resistant to high temperatures (600 to 700 C); they are nonhygroscopic, imputrescible, and do not deteriorate; they are stable, not attacked by oils, corrosive fumes and acids (except hydrofluric); they are not attacked, by parasites, mites, termites, or rodents; they are resistant to traction, but are not elastic and have little resistance to friction and impact. Glass fibers commercially serve as thermal, electrical, and acoustical insulators.

Under the influence of sufficient friction or impact, the insulating material shatters into small glass fibers of varying lengths with jagged ends. Some of these fibers are of sufficiently small size to remain airborne for appreciable periods of time, thus

EXHIBIT C

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Malignancy as the Cause of Death From Jan 1, 1939 to Jan 1, 1964

Insulator	Cause of Death	Years in Trade
1.	Bronchiogenic carcinoma	28
2.	Bronchiogenic carcinoma	17
3.	Carcinoma of lung	38
4.	Metastatic carcinoma of brain	42
5.	Generalized carcinomatosis	29
6.	Carcinoma of tongue	41
7.	Carcinoma of caecum	24
8.	Carcinoma of sigmoid	42

providing a possible source of particles for ingestion and inhalation.

Glass fibers in various insulating materials will have the following average diameters:

Insulating Material	Diameter (μ)
Building insulation	7.11
Pipe insulation	10.7
Duct insulation	5.84
Acoustical products	13.21

The fibers listed above range from approximately 5μ to 14μ in diameter, and under normal conditions their minimal lengths will range from 8μ-12μ to 60μ-90μ. Most fractured fibers do not reach these minimal lengths, and in numerous atmospheric surveys of fiberglass manufacturing plants in areas involving the production and handling of various products made from finished glass fibers, only 6% of all airborne fibers were less than 20μ in length and only 40% were less than 100μ in length.[1]

Airborne glass fibers are too large to enter the alveoli. Their tendency, unlike the fibers of asbestos, is to form felt-like masses on any object with which they come in contact, and this probably aids in preventing their inhalation. Thus, it is the concensus of opinion of many investigators that airborne glass fibers present no lower respiratory hazard.[1-5]

As stated previously, glass fibers are silicates, but contain no free silica (SiO_2) or free sodium silicate, thus do not give rise to silicosis. No harmful vapors or fumes can be given off, since no substances are present which might volatilize within the range of temperature recommended for service.[5]

There have been numerous investigations of plants and of employees engaged in producing and handling glass fibers. The majority of investigators agree that glass fibers give rise to a moderate amount of irritation to the upper respiratory system, but have no adverse effects on the lower respiratory system.[3,11,12] One of the most recent and thorough studies took place in 1963 at the world's oldest production plant for glass fibers, located in Newark, Ohio, in which active commercial production began in 1938. In 1963 this plant produced 250,000,000 pounds of glass fibers and employed 1,352 men and 113 women with more than ten years of company service. Clinical surveillance of these workmen throughout the period in which the manufacturing processes have been in operation, in conjunction with the examination of serial x-ray films of these workmen, have failed to reveal the existence of any form of respiratory disease which can be related to glass fibers.[1]

It appears from the data thus far assembled that the airborne spicules of glass fiber to which insulators would be exposed in their work present no pulmonic hazard.

A workman's initial exposure to glass fibers gives rise to a temporary cutaneous irritation and pruritus, but does not induce sensitivity. Punctiform erythema appears promptly after contact with glass fibers, and usually disappears after the workmen discontinue such exposure. Occasionally the erythema persists after the itching has ceased, and may not disappear completely until several days later.[13] Many experiments with animal and human subjects have revealed that these microtraumatisms are due to mechanical irritation and are very superficial, localized strictly in the corneal layer of the skin.[3,4,12-18] In biopsies taken from irritated sites, examinations with both incandescent and polarized light have not enabled the investigators to locate glass spicules or foreign body reactions in the epidermis or dermis.[16] The pruritus increases with perspiring and rubbing. Pruritus appears primarily on wrists, ankles, neck, and at other areas where clothing fits closely to the body and enables the little glass fibers to accumulate. They penetrate the fabric of clothing and irritate the skin causing slightly painful stimuli which are interpreted as an itching sensation. Further experimentation has revealed that the severity of this super-

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ficial cutaneous reaction varies directly with the size (diameter) of the glass fibers being handled. This finding has been confirmed in all interviews conducted with insulators on plant visits.[16] The reactions of workmen to glass fibers are highly variable; the degree of reaction may vary from day to day with changes in temperature, humidity, type of clothing worn, and other preexisting abnormalities of the skin.[10,19]

Apparently, insulators may undergo superficial, transitory cutaneous irritation and pruritus, but do not develop a true dermatitis.

One additional testimony to the benign composition of glass fibers is the large number of medical and related uses of the material in intimate contact with both normal and severely damaged tissue. Glass fiber materials are used as bandages, skin graft material, wound dressings, tracer threads for surgical sponges, prosthetic appliances, blood plasma filters, extra-pleural packing, American Medical Association approved glass fiber filled pillows, and in dental work.[1,20-24]

Review of the Toxicity of Glass Flakes.—The second type of airborne, particulate glass, is that which occurs in the form of flakes and arises from the handling of an insulating material known as foam glass. These flakes may be ingested, inhaled, and deposited on the skin and in the external ocular space. An experiment with animals was conducted to determine the effect of glass flakes, less than 50μ in size, on any organ with which they might come in contact by one of the above mentioned means.[10] It was found that these flakes were removed effectively from the eye by blinking and did not give rise to corneal injury. After the animals had ingested a diet containing 50% (by weight) of glass flakes, all of their organs were examined grossly and microscopically. No abnormalities were observed. There was no evidence of trauma, ulceration, or degeneration of the gastrointestinal mucous membrane. Both intratracheal injection and inhalation of flakes gave rise to a cellular reaction in the alveoli which was no more severe than that of finely divided kaolin which was being used as a control.

Not all glass flakes encountered by insulators will have such small dimensions as to be respirable. However, the above experimental evidence is cited for completeness and to account for any unforseen situation in which particles of such small dimensions may be generated.

It seems evident that glass insulating materials present no major health hazard to the members of the insulating trades in the normal performance of their occupation.

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Fiberglas Health Hazard Investigation

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St. Louis, Missouri

THE development and use of a new basic material frequently gives rise to a question as to the possible health hazards for workers handling the material. Glass fiber products, now widely used for thermal and electrical insulation, are still of such comparatively recent origin that the question of a possible health hazard is not unnaturally associated with them.

This association, while it is to be expected because of the newness of the products, is due in part to a special circumstance. The word glass is surrounded by connotations which suggest a hard, shatterable, transparent material. Although Fiberglas is glass in a new physical form, and with physical properties which make it unrecognizable as glass by persons who are familiar only with glass in its more conventional forms, the old connotations may cling to the new products.

Purpose of the Investigation

THIS article summarizes an investigation which was carried out by the author during the month of June, 1941, at the request of WILLIAM H. BARTLEY, of the law firm of Bartley and Mayfield, St. Louis. MR. BARTLEY is attorney for the International Association of Heat and Frost Insulators and Asbestos Workers, Local Union No. 1, of St. Louis, Missouri.

The purpose of the investigation was to determine the existence or non-existence of health hazards in connection with Fiberglas thermal insulating materials which are used or may be used by members of the union. The investigation was conducted by the author as an unbiased, independent consultant, in no way, other than in carrying out the assignment, associated either with the union or with Owens-Corning Fiberglas Corporation, manufacturers of Fiberglas.

Throughout the course of the investigation the author was given complete cooperation by Owens-Corning Fiberglas Corporation, and untrammeled access to all its pertinent records. The author, however, accepted no statements made by the corporation's officials as valid unless supported by his objective examination of the records, and by objective evidence adduced from disinterested sources and his own research.

The investigation covered the following specific phases:

1. Pulmonary disorders, diseases of the upper or lower respiratory system, and gastro-intestinal diseases,
2. Eye, ear, nose and throat infections,
3. Dermatitis.

Fiberglas a Form of Mineral Wool

FIBERGLAS is true glass, but, chemically, it is substantially identical with mineral wool. It can properly be classified as a new, refined form of mineral wool. The fact that mineral wool has been used for many years without causing any known industrial diseases, while by no means conclusive, in itself suggests that there is nothing in the inherent physical characteristics of Fiberglas that is likely to introduce any serious occupational hazard.

The chemical and physical characteristics of binders used in manufacturing and processing Fiberglas, like the chemical and physical characteristics of the glass fibers, are not of a kind from which serious industrial health problems would theoretically arise. This conclusion is based upon examination of formulas used in the manufacture and processing of Fiberglas products.

1. No free silica is present in the material known as Fiberglas.
2. No carcinogenic hydrocarbons or other hydrocarbons could be present in Fiberglas because of the extremely high temperatures employed in fusing the batch during the manufacturing process.
3. No harmful fumes could be given off, since no substances are present in the Fiberglas which would volatilize within the recommended service ranges.
4. Absent from Fiberglas is any free sodium silicate.
5. Only three binder substances are present in glass wool products used for industrial insulation. These are bakelite, a refined mineral oil, and bentonite.
6. Bentonite is a refractory clay that is employed as an ingredient of candy with the cognizance of the United States Food and Drug Administration. There is no evidence from factory experience that either bakelite or the mineral oil used for binding substances is the cause of a health hazard.

Medical Literature Searched

AN important phase of the investigation was an exhaustive search of world medical literature for references to possible health hazards in the handling of Fiberglas. This search failed to reveal references to any new or unusual occupational hazards in the handling of these products.

In view of the continually expanding market for Fiberglas products since 1932, and in view of the promotion and advertising campaigns directed toward increasing their sale, the scarcity of references to the subject in the literature of science and medicine, and the lack of controversy or interest in the subject on the part of persons usually alert to possible industrial hazards, cannot be attributed to a lack of familiarity with the existence and use of the products. On the contrary, it warrants the conclusion that the handling of the products is attended by no unusual occupational hazard.

Fiberglas Free of Dusting Characteristics

ON the basis of his own careful observation, and dust counts made in Owens-Corning's Newark, Ohio, plant, the author finds that Fiberglas is remarkably free of the dust which characterizes certain products. Because of the length of the fibers and the "pack strength" of Fiberglas, there is negligible dusting of the material during handling. The glass fibers break, rather than shatter, along clean edges at points where they are abraded by sawing, chopping or cutting during production line or fabricating operations.

[NOTE: DR. SIEBERT, formerly assistant professor of pathology, Washington University School of Medicine, is Pathologist and Director of Laboratories of DePaul Hospital, Lutheran Hospital, St. Louis; St. Joseph's Hospital, Alton, Illinois, and St. Mary's Hospital, Cairo, Illinois. He is a member of the American Board of Pathology, American Association of Pathologists and Bacteriologists, American Association of Experimental Pathology, and the Society of Experimental Biology and Medicine.]

EXHIBIT D

The following extract is from "Researches of Mellon Institute 1940-41"[1]:

"L. U. GARDNER, Director, Saranac Laboratory, has reported on the researches which the Foundation supports at his institution, saying in part. . . . 'We have been studying the effect of inhaled glass wool. Apparently even the finest textile glass set up as an atmospheric dust is not inhaled in appreciable concentrations and does not produce any dangerous effects upon the lung.' "

A further report on DR. GARDNER'S work appears in the Annual Report of the Saranac Laboratory for the Study of Tuberculosis of the Edward L. Trudeau Foundation for the Year 1940. The following statement is made on page 11 of the report:

"The apparent lack of pulmonary damage from exposure to glass wool dust is being demonstrated by an inhalation experiment. For over a year animals have now been exposed to as high a concentration of this material as could be maintained, with no serious effect upon their lungs. The dust has been produced by breaking into short lengths the finest textile glass that is made but none of the fibers that are floating in the air can be found in the lungs of the exposed animals. Their tendency, unlike that of asbestos, to form felt-like masses upon any object with which they come in contact, probably prevents their inhalation. Slight amounts of chronic inflammation similar to those observed with other harmless dusts, have resulted from accumulated particulate debris. These very fine, non-fibrous particles are the by-product of the violent beating used to break up the material."

X-ray Plates of Employees

THE author examined several hundred stereoscopic x-ray plates of the chests of employees of Owens-Corning Fiberglas Corporation. These were selected at random by the author from the files of some 1500 plates taken since the company, in 1939, instituted the policy of making x-ray plates of the chests of all Newark employees. Among the plates selected for special inspection were those of employees working in the batch house where the raw materials for Fiberglas are handled, and the plates of employees with records of silicosis.

Beginning in May, 1939, serial stereoscopic chest films were made of the 15 men who are now working, or who have worked, in the batch house. A repeat examination of all of the men was made in June, 1941. In no case was there any radiographic evidence of pulmonary disease.

Three cases of silicosis were discovered by the company. None of these men had ever been employed in the batch house, but their employment does require the handling of Fiberglas products. It is the policy of the company neither to refuse employment to, nor discharge, any man for whom safe employment can be found. The following covers the occupational histories of these three workers:

1. CASE NO. 1 worked for another company as a molder from 1924 to 1929, and roentgenograms of the chest were made in 1929 because of the presence of tuberculosis in his family. Chest plates were again made in 1936 because of suspicion of silicosis. He was first employed by Owens-Corning Fiberglas Corporation on June 6, 1940.

2. CASE NO. 2 was employed as a bottle blower and machine operator from 1901 to 1930. He was first employed by Owens-Corning Fiberglas Corporation on March 26, 1941. Silicosis was diagnosed following an x-ray examination of the chest made on May 12, 1941.

3. CASE NO. 3 worked for 12 years as a molder before entering the employ of Owens-Corning Fiberglas Corporation on October 25, 1939. Silicosis was diagnosed following an x-ray examination of the chest on November 1, 1940.

In each of these silicosis cases there is a sufficient causative factor in the man's previous employment history or other circumstances, and the evidence is entirely inadequate to indicate that the condition of any one of these three men should be attributed to any silicosis hazard encountered in handling Fiberglas, even assuming such a hazard to exist.

Physicians Give Fiberglas Clean Bill

EXAMINATION of the records of disability and absenteeism in the office of the plant physician of the Owens-Corning Newark plant reveals that there is no unusual incidence of respiratory infections among Owens-Corning employees. Statements furnished directly to the author by Newark physicians whose practices are limited to eye, ear, nose and throat diseases, and who are in no way affiliated or associated with the company, indicate that these specialists notice no unusual incidence of respiratory disturbances among their private patients employed by the company, as compared with their private patients who are not employees.

The following letter, dated June 17, 1941, written to the author by JOHN E. HENDRICKS, M.D., of Newark, is typical of letters received from Newark eye, ear, nose and throat specialists:

> "I am one of five E.N.T. [ear, nose and throat] specialists located in this city. I have practiced my specialty in Newark for three years following a four-year residency in an Eastern hospital. During these three years I have treated my share of Owens-Corning employees. I can safely say that I have noticed no unusual preponderance of head or throat infections among these people as compared to my other patients who are not employed there.
>
> "If I ever make a table showing percentages of different diseases that I have treated, I feel sure that there would be only a normal proportion of Owens-Corning employees in each classification."

On the basis of the evidence, the author finds that workers handling Fiberglas products are subjected to no special occupational hazards that manifest themselves in eye, ear, nose or throat disorders, pulmonary disorders, diseases of the upper or lower respiratory system, or diseases of the gastro-intestinal tract.

Temporary Skin Irritation

NEW employees of Owens-Corning Fiberglas Corporation engaged in handling Fiberglas products occasionally suffer a mechanical irritation of the skin for a few days at the start of the job. Except for extremely rare cases of workers who may be allergic to an ingredient of binders or lubricants used in processing glass fibers, the irritation disappears within a few days. The new workers apparently become immunized against the action of the fibers, and they suffer no further discomfort.

The company recommends that workers wear clothing loose at the neck and wrists, and that they use plenty of warm water and soap when the day's work is done. Soap and water has proved most effective in removing particles of fibers, whether of glass or any other material, from the skin. The company has found that there is seldom, if ever, need of gloves, armlets or other protective clothing. In the absence of gloves or similar protective clothing there is less tendency for fiber particles to be rubbed into the skin.

1. Appearing in *News Edition, American Chemical Society*, Vol. XII, page 402, April 10, 1941.

Two Hundred Employees Examined

ON June 3, 1941, the author made an examination of the wrists, arms, ankles, necks, eyes, shoulders and waists of approximately 200 production employees engaged in handling Fiberglas products in Owens-Corning's Newark plant. These workers were employed on production lines and at fabricating operations, cutting, sawing, shaping, transporting and packaging glass thermal insulating wool, both bonded and unbonded.

The author did not see a single case of eye irritation or conjunctivitis during this inspection. Only one worker who had begun to work in the plant four days before on a fabricating job showed evidence of significant skin irritation. One 22-year-old employee who told the author he had worked in the plant for two and a half years said that, although he had become accustomed to handling Fiberglas and suffered no discomfort while continually on the job, he had noticed a mild skin irritation that lasted a few days after returning to the job following his two-week vacation.

"As long as I am working right along," he told the author, "I stay toughened up to it. But if I haven't been handling it for a while, like when I'm on my vacation, then it takes a few days to get over the itch when I start in again."

Many of the workers who were examined said the temporary irritation was similar to blisters on the hands that are the result of unaccustomed manual work while the hands are getting toughened to a job. "It don't bother me none," was the reply repeatedly heard by the author in response to his question as to whether the handling of Fiberglas products caused irritation.

Biopsy Specimens Taken

AT THE request of the author, DR. H. A. CAMPBELL, the Newark plant physician, removed two biopsy specimens of skin from the arm of the newly-employed worker who showed a moderate degree of skin irritation. Serial microscopic sections of this tissue showed a mild degree of capillary dilatation in the corium of the skin. In addition, there were a few scattered lymphocytes around several of the dilated capillaries. The epidermis was entirely normal. No glass particles were found. There was no evidence of fibrosis, bacterial infection, allergy or hyperkeratosis.

Several of the serial sections revealed a small amount of a brownish pigment in the corium which showed no inflammatory reaction around it. It is assumed that this pigment is bakelite, one of the substances used as a binder for the glass fibers. The fact that there was no foreign body reaction around this indicates that this material is an inert substance, and that it does not produce either a foreign body reaction or a fibrosis. The extremely mild inflammatory reaction in the corium of the skin would result from any slight mechanical irritation.

Report of Louisville Dermatologist

DR. ADOLPH B. LOVEMAN, Louisville dermatologist, reporting on an examination of 10 workers who handled Fiberglas, writes, "I did not find any evidence of a definite contact dermatitis in any of the employees although some complained of a mild itching when handling the product. The dermatitis produced was unquestionably of a very mild and transient nature.

"I did examine one patient who complained a great deal of a skin eruption and who felt certain it was due to the Fiberglas. He presented, however, a toxic eruption, and upon questioning him I learned it had been present at times prior to working with Fiberglas. Nevertheless, we removed him from this work for a period of two or three weeks, after which I again examined him and he presented the same type of eruption. In this particular case, it is my opinion that his teeth were probably the foci of infection."

The author believes that the following generalization is warranted by the evidence:

Contact with glass wool may cause ephemeral discomfort among workers inexperienced in handling the material. The skin irritation, however, cannot be regarded as a progressive dermatitis, for it is non-toxic and usually disappears in a few days. In extremely rare instances, where a worker may be predisposed to secondary effects of mechanical skin irritation because of idiosyncrasy, allergy, or the presence of foci of infection elsewhere in his body and otherwise dissociated from the effects of mechanical irritation, lesions may persist. But these cases are encountered with such rarity that they do not justify incriminating glass fiber as a causative factor.

No Claims for Workers' Compensation Validated

FIBERGLAS products have been produced in the Newark, Ohio, plant of Owens-Corning Fiberglas Corporation over a period of nine years. The number of employees has ranged from approximately 20 when production was started in 1933 to more than 1800 in 1941. During this nine-year period no claims for workers' compensation, on the basis of an industrial disease arising out of employment in the manufacture and handling of Fiberglas, have been validated in the State of Ohio.

A letter dated June 17, 1941, from MR. J. A. SHAW, Claims Referee of the Industrial Commission of Ohio, Legal Section, addressed to the author reads, in part, as follows:

> "For your information, we recognize diseases of the respiratory tract as compensable occupational diseases, such as silicosis, asbestosis, anthracosis, and siderosis. As a matter of fact, there is a provision under the law to recognize any disease of this type which is caused by the inhalation of any injurious dusts.
>
> "We endeavor to keep a complete statistical record in the Department of Safety and Hygiene of all cases of this type. I have made a thorough check with this department, and to date we have never had a claim filed for a disease of the upper respiratory tract caused by the alleged inhalation of Fiberglas particles."

Health Better Than Average

THE health of Fiberglas workers is regarded as better than average by the Aetna Life Insurance Company, which underwrites group insurance (life, disability, sickness and hospitalization) for employees of Owens-Corning Fiberglas Corporation. In a letter to an executive of the corporation dated June 11, 1941, JOHN A. HILL, Toledo General Agent of the Aetna Life Insurance Company, wrote, in part, as follows:

> "The health of your employees has been better than average. This is evidenced by the fact that we now have in effect a 35% reduction in rate (from standard) on both the sickness and hopitalization insurance carried by your employees. This is the result of nearly four full years' exposure, and develops a rate lower than any similar industry that we have insured. . . .
>
> "There is in effect a permanent and total disability feature in connection with your life insurance, and as yet there has been only one claim from an employee, and this was due to a non-occupational

accident, far removed from the course of his occupation or from any health hazard in his occupation."

The author regards as particularly significant the following paragraph from Mr. Hill's letter:

". . . our Casualty Company carries what is known as products liability at an extremely low rate, and no claim has ever been presented, indicating, of course, that there is no hazard in the use of Fiberglas or any of its products."

In submitting his best judgment, based on his professional interpretation of all facts assembled in the course of the investigation, the author finds that there is no silicosis, fibrosis or dust hazard connected with working with Fiberglas, and that the manufacture, fabrication and application of Fiberglas products is attended by no unusual occupational hazards.

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The Effects of Fiberglas on Animal and Human Skin

—Experimental Investigation—

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RUDOLF L. BAER, M.D.,
With the Technical Assistance of
CLARE LOWENBERG, M.S., *and* HILDEGARD MENZEL, B.S.

FINE, flexible glass fibers which can be woven into fabrics, or fabricated into bats, blankets and rigid or semi-rigid sheets, were first produced on a commercial scale in 1932. Known as Fiberglas, this new type of glass is produced and fabricated by Owens-Corning Fiberglas Corporation, and in its various forms is widely used for electrical and thermal insulation purposes.

From time to time during the past 10 years, newly employed workers unaccustomed to handling Fiberglas material, have experienced skin discomfort which disappeared, apparently, when they became hardened to the action of the fibers. The period of initial discomfort seldom exceeded a few days.

Although experience indicated that the irritation was of a purely transitory and superficial nature, Owens-Corning Fiberglas Corporation, manufacturers of Fiberglas, desired to obtain authoritative medical evidence that would support or disprove the evidence of experience. The authors of this report were requested to conduct an investigation to determine the nature and effect of the irritation.

Laboratory animals and human beings were employed as subjects for experimentation.

Animal Experiments

SIXTEEN rabbits were first rubbed, over a period of a month, with two Fiberglas materials in the wool-like form, and with two competitive materials (materials made from substances other than those from which Fiberglas is made, but employed for some of the purposes for which Fiberglas is used).

Each animal was rubbed on six sites. One site was rubbed with each of the materials mentioned. In addition, two sites on each animal were rubbed with absorbent cotton as control sites.

Depilation was performed 24 hours preceding the first rubbing, and then as often as required, with barium sulphide paste. The treated areas were on the belly, and each area rubbed was 4.5 cm. in diameter. A standard time of two minutes for each rubbing was established and maintained. Rubbings were performed almost daily except Sundays and several Saturdays, or when individual sites were too irritated to permit rubbing.

From the Department of Medicine, New York University College of Medicine and the Third (New York University) Medical Division, Welfare Hospital, Welfare Island, New York.

Twenty-six guinea pigs were rubbed in the same manner, for an equal period, with the same materials; but in addition each animal was rubbed on additional sites with two Fiberglas textile materials (continuous filament and staple fiber) in fabric form. Twelve guinea pigs were then rubbed with the wool-like form, and with one of the competitive materials. The rubbing period varied from animal to animal and from site to site, ranging from three to nine days.

The reactions observed, both in rabbits and guinea pigs, were all based on the mechanical action of the different materials. The reactions on the rabbits, when they appeared after repeated rubbings, usually consisted of faint redness, scaling and superficial yellowish crusting. In general, the reactions of the guinea pigs' skins were somewhat more intense than those of the rabbits' with more erythema and crusting.

Human Experiments

TEN human subjects—six male and four female—were rubbed, over periods ranging from seven to 19 days, with the two Fiberglas materials in the wool-like form, one of the competitive materials, the two Fiberglas textile materials in fabric form, and with absorbent cotton as a control.

The normal skin of the flexor surface of the forearm was used. Three sites on each forearm, each about 4.5 cm. in diameter were rubbed. Each site was rubbed daily, except Sunday, for two minutes.

On the same subject, the same material was always rubbed in at the same site; but on different subjects, differently situated sites were chosen for the different materials. This was done in order to avoid any possible error which might occur due to the potential differences of sensitivity of different parts of the skin.

In addition to the sensory disturbances at the time of rubbing, there was some pain and discomfort for some time after the application, particularly when clothing pressed against rubbed site. This discomfort after each rubbing usually lasted no more than a few hours.

Astonishingly enough, even when the objective signs of skin irritation increased with each rubbing, subjective manifestations were not intensified. On the contrary, the subjective manifestations of the second, third or fourth times of rubbing were generally less than those of the first rubbing.

The objective reactions consisted of erythema, swell-

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ing, pin-head-sized papules soon after the rubbing, followed within a few hours by erythema, scaling and varying degrees of crusting. Later, after several rubbings, there were persistent papules, lichenification, scaling, thickening and roughness of the skin surface, and varying degrees of hyperpigmentation.

Sensitization Experiments

IN EXPERIMENTS designed to determine whether any specific sensitizations of skin were produced, eight of the original rabbits, 29 of the original guinea pigs, and all of the original human subjects were subjected to a test exposure of each of the materials that had been used originally. In order to allow for a possible incubation period of sensitization, at least two weeks were allowed to elapse between the last rubbing and the test rubbing.

The responses elicited from the animals were essentially identical to those produced by the first rubbings in animals never exposed to the materials. There were no signs of accelerated response, intensification of reaction, lessening of reaction, delay of response, or any other evidence of difference when compared with the results of the original application of the material. There was no evidence of sensitization or desensitization of the skin.

In the case of the human subjects, no marked degree of sensitization was produced to any of the materials, even under the severe conditions of the original exposures. It is very questionable whether, even in several instances of mild evanescent reaction, specific sensitization played a role. If sensitization did exist, it must have been practically negligible.

Histological Examinations

HISTOLOGICAL examination of the reaction sites in animals and human subjects showed evidence of a superficial inflammatory process. Although the clinical examination of the sites rubbed with the different materials revealed marked changes in the degree of reaction, the histologic changes in all sites, including the sites rubbed with absorbent cotton, were of approximately the same type.

The histologic sections did not show any evidence of permanent damage, and the epidermis was generally found to be intact and undisturbed in its continuity. Special methods of fixation which were designed to retain clinically visible glass spicules sticking into the skin, were used in the attempt to demonstrate these spicules in the histologic section. However, in none of the many slides examined could the glass spicules be seen.

This, together with the fact that no disturbance in the continuity of the horny layer of the epidermis was seen, suggests that the spicules which were seen clinically after the rubbings, were only very superficially embedded. No foreign-body reaction was seen in any of the sections examined, thus demonstrating that no fragments of the various materials used in these experiments had penetrated into the deeper layers of the skin.

Conclusion

ALL OF the reactions observed were of a transitory and superficial nature. The only parts of the reactions which persisted for more than a few days were slight thickening and brownish pigmentation of the skin. The latter were sometimes apparent for several weeks. No reactions or symptoms outside the rubbed skin areas were observed at any time during the experiment.

The minute pieces of material which were seen sticking into the skin after rubbings with Fiberglas in its wool-like form appeared to be very superficially embedded. This observation was borne out by the fact that ordinary washing with water easily removed a large part of the spicules remaining in the skin after rubbing.

No definite sensitization to any of the materials could be demonstrated. In a few subjects there were a few mild and evanescent reactions to several of the materials, but it appeared very questionable whether these reactions were based on specific sensitization.

The biopsies of all specimens taken from various sites in animals and humans showed a superficial inflammatory process. Sites on human subjects which had been rubbed with the Fiberglas continuous filament and staple fiber presented such mild clinical reactions that it appeared unnecessary to take biopsies.

There were no significant differences in the types of histologic reaction produced by the other materials. No spicules or pieces of materials, and no foreign reactions, could be demonstrated in any of the histologic sections.

Cutaneous Reaction to Fiberglas

ELDRED B. HEISEL, M.D., Associate Professor of Medicine
and Chief, Division of Dermatology
JOHN H. MITCHELL, M.D., Clinical Professor
and Head of the Division of Allergy
Ohio State University, Columbus

GLASS is an organic compound of fusion which has cooled to a rigid condition without crystallizing. It is generally thought of as a hard, transparent, shatterable material. Fiberglas is produced by the Owens-Corning Fiberglas Corporation and is molten glass drawn into fine filaments or fibers. These glass fibers of different diameters are formed into glass wool, glass fiber mats, or yarns, from which they are fashioned into a myriad of different substances varying from fine decorative fabrics (for curtains and draperies) and insulating materials to Fiberglas reinforced plastics for many uses.

Sulzberger and Baer[1] in 1942 investigated the effects of Fiberglas insulating wool and textiles on human skin and in 1943 Schwartz[2] studied the skin hazards in the manufacture of glass fiber thread and wool. Since these early studies, glass fiber products have been used much more extensively, and are, therefore, possible cutaneous irritants in numberless more instances in the manufacture of the basic products, in the fabrication of various glass fiber materials, and in the hands of those using finished glass fiber products.

From our experience in handling Fiberglas and from our observation of persons working with the product, it was felt that any dermatitis from glass fibers was probably due to mechanical irritation rather than to specific sensitivity. It was further felt that the degree of irritation might vary with the coarseness of the fibers contacted. It was toward proving or disproving these hypotheses that this study was directed; first by patch testing human subjects, and second by rubbing experiments in animal and human subjects.

Patch Tests

THE FIRST group of subjects consisted of 50 white women varying in ages from 22 to 73 years who had never, as far as we were able to ascertain, had any contact with Fiberglas. Each was patch tested one to three times. The patches were applied to the backs of the subjects, and allowed to remain in place for 48 hours, at which time readings were taken. Observations were also made at 96 hours, one week, and one month.

The glass fibers* used in the entire experiment contained the same chemical substances. Since most Fiberglas used commercially has a starch-base sizing (#630) bound to it, we patch tested both with plain glass fibers and fibers to which sizing #630 had been bound. Fiberglas fibers of three different diameters were used. That designated #37 varied in diameter from .00070 to .00075 inches; #150 from .00035 to .00040 inches in diameter, and #333 was composed of fibers under .00003 inches in diameter.

The selection of fibers was made because they represent the coarsest, middle range, and finest sizes encountered in most of the manufactured products, such as heat insulations, textile yarns and fabrics, and sound-absorbing materials.

On one half of the back, fibers cut three to five millimeters in length were used. On the other half, fibers two centimeters in length, attached to a small piece of cardboard, the ends covered with tape so as to allow direct contact of unbroken fibers with the skin in an area of 0.75 square centimeter, were used. In this way the same fiber, in approximately the same mass, was applied to the skin. The only variation was that on one half of the back, the tests were made with cut, sharp particles, and on the other half with smooth, unbroken fibers.

The second group of subjects patch tested was composed of 92 persons employed at the Fiberglas Corporation plant in Ashton, Rhode Island, where basic materials are produced, woven into glass yarn, and wound onto large spools. The employees tested were from every operation in the plant, and were selected specifically only with relation to their length of employment. In order to test groups having short, medium, and long periods of employment, 30 subjects who had been employed less than one year, 30 subjects em-

*All materials used were furnished by Owens-Corning Fiberglas Corporation.

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ployed one to six years, and 32 subjects employed six to 15 years were patch tested. Each subject was tested with two patches of smooth, unbroken glass fibers, one with and one without sizing #630 bound to the glass.

Rubbing Experiment

BECAUSE in the patch testing we were unable to note any difference between reactions to Fiberglas with or without sizing, all of the rubbing experiments were done with fibers to which sizing #630 had been bound.

In the first five subjects, one half cubic centimeter of finely cut fibers #37, #150, and #333 was rubbed vigorously for 60 to 90 seconds into areas of skin five centimeters in diameter on one half of the back. On the opposite side of the back, unbroken fibers two inches long which had been stretched over a curved piece of celluloid and the cut ends covered with adhesive tape were used. This allowed for vigorous rubbing of unbroken fibers into the skin. In that there were no reactions with either cut or unbroken fibers on the backs of four of the first five subjects, the tests thereafter were done on the forearms. Since we had been unable, either by extensive patch testing or by the early rubbing tests to produce any reaction to the finest fiber #333, a fiber designated fiber #12 having filaments with a diameter of .0015 inches was used in the remaining rubbing experiments. Fiber #12 was the coarsest fiber used in any of the experiments. These glass fibers are used only in impingement type air filters.

Thirty of the 50 human subjects who had been patch tested one to three times, four weeks previously, were used in the forearm rubbing experiment. In these 30 subjects one half cubic centimeter of cut particles of Fiberglas #12, #37, and #150 was rubbed vigorously into areas five centimeters in diameter on the upper, middle, and lower thirds of the volar aspect of the right forearm. This was done for 60 seconds daily for five consecutive days. Unbroken fibers stretched over a piece of curved celluloid were rubbed into the corresponding areas of the left forearm. Observations were made and recorded at the end of each period of rubbing, at 48 and 96 hours, and at one week and one month after the rubbing was done.

One month after the patch testing and the rubbing experiments were finished, five of the subjects were again rubbed daily for five days with cut particles of fiber #12, the only one with which we were able consistently to obtain irritation of the skin. Biopsies were then taken on the first, tenth, seventeenth, and thirtieth days after the rubbing was done.

The epilated backs of four rabbits were subjected to rubbing experiments similar to those described on the human subjects. The rabbits had not been previously exposed to the materials by patch testing nor were patch tests done after the rubbing experiments.

Results

PATCH TESTS — The patch test reactions consisted only of small isolated, erythematous papules, some of which were capped with a tiny pustule. These we interpreted as being due to mechanical irritation from a sliver of glass penetrating the epidermis.

In Table I an attempt to grade the reactions from the 708 patch tests done on the group of 50 female subjects was made, the grading being from no reaction through one plus (1 to 3 papules), two plus (4 to 6 papules), three plus (7 to 10 papules) to four plus (over 10 papules). We noted no reactions to the unbroken glass fibers, either with or without sizing, and there was essentially no reaction to the very fine fibers numbered #333. There were fewer and less severe reactions to the #150 than to the #37 glass fibers, the coarsest used in the patch testing experiment.

Some of the subjects complained of itching at the sites where the cut particles were in contact with the skin. In general, the degree of subjective symptoms corresponded with the degree of reaction. A few persons complained of itch-

TABLE I.
FIBERGLAS PATCH TESTS — CUT VS UNBROKEN FIBERS

	CUT SHORT FIBERS												UNBROKEN LONG FIBERS											
	#37*				#150*				#333*				#37				#150				#333			
Reaction	Sized	Unsized	No.	% Total	Sized	Unsized	No.	% Total	Sized	Unsized	No.	% Total	Sized	Unsized	No.	% Total	Sized	Unsized	No.	% Total	Sized	Unsized	No.	% Total
None	8	10	18	15	32	27	59	50	59	58	117	99	59	59	118	100	59	59	118	100	59	59	118	100
+	20	20	40	34	22	25	47	40	0	1	1	1	0	0	0	—	0	0	0	—	0	0	0	—
++	24	20	44	37	5	7	12	10	0	0	0	—	0	0	0	—	0	0	0	—	0	0	0	—
+++	7	7	14	12	0	0	0	0	0	0	0	—	0	0	0	—	0	0	0	—	0	0	0	—
++++	0	2	2	2	0	0	0	0	0	0	0	—	0	0	0	—	0	0	0	—	0	0	0	—
Total	59	59	118	—	59	59	118	—	59	59	118	—	59	59	118	—	59	59	118	—	59	59	118	—

*Diameters: #37, 0.00070"-0.00075"; #150, 0.00035"-0.00040"; #333, 0.0-0.00003"; #12, 0.0015"

ing at the sites of all of the patch tests. In these subjects there was mild miliaria from the tape used. Other than these, however, no itching was noted at the sites where unbroken fibers were in contact with the skin.

In the group of the 92 employees of the Fiberglas Corporation who were tested, one had two tiny papules under each patch and three had one or two papules under one of the two patches used. Eighty-eight subjects showed no reaction at all. In no case was erythema, edema, or vesiculation noted. The few tiny papules seen were interpreted as being a foreign body reaction to spicules of glass which had penetrated the epidermis.

In addition to the patch testing, these employees were asked if they had ever had any skin trouble which they felt possibly might be associated with their occupation. Seventy of the 92 had no complaints, 10 complained of mild itching which disappeared after bathing, and two complained of itching only while working on the hammermill, a machine which hammers the glass into fine particles. Ten had objective cutaneous signs. Three of these had a few small papules on the forearms, and two, a few papules on the ankles. Three had glass slivers in their hands, and one had miliaria on the buttocks. Only one employee complained of severe itching. He had generalized itching and a generalized eruption, both of which he stated disappeared soon after bathing and changing clothing. This disturbance had been present for 10 months, the entire length of his employment. Examination revealed him to have a generalized eruption which was most severe on the trunk and consisted of many small papular and large longitudinal areas of urticaria. The longitudinal areas were at the sites of excoriations. He exhibited a marked degree of dermographism.

RUBBING TESTS — Table II is a comparison of 48-hour observations of areas on the forearms of 30 subjects which had been rubbed for 60 seconds on five successive days, using moderate pressure. Grading was done in the following manner: A one-plus reaction indicated minimal erythema; a two-plus reaction, definite erythema without eczematization; a three-plus reaction, erythema plus low grade eczematization, and a four-plus reaction indicated erythema, edema, and marked eczematization.

There were no reactions in the areas rubbed with long unbroken, glass fibers. Immediately following the first rubbing with finely cut fibers (#12), we noted a few tiny excoriations, some tiny spicules of glass in the skin, and there were many tiny petechial hemorrhages in the area. By the next day, after simple cleansing with soap and water, no spicules were noted, the excoriations were crusted, and no hemorrhages could be seen. Rubbing with cut particles of Fiberglas #12, the coarsest fiber tested gave positive reactions in all instances and severe reactions in 43% of the subjects rubbed. In the rubbing tests with a finer fiber (#37), 23% showed no reaction at all and the others showed less severe reactions than those produced by the coarse #12 fiber. Cut fiber #150, the finest fiber tested, produced no reaction in 73%, and there was only a one plus reaction in the rest of the subjects. After two weeks, all eczematization had disappeared, and after one month only various degrees of pigmentation could be seen.

The patients offered no complaints when rubbed with fibers #37 and #150, but with fiber #12 most complained of a burning, sticking sensation at the time of rubbing. The subjective symptoms were more severe at the time of the first rubbing than after eczematization began.

During the rubbing experiments one subject developed severe urticaria over her entire back about 10 minutes after the rubbing was done. She was later found to have marked dermographism.

The rubbing experiments in the four rabbits produced results comparable to those found in the humans.

Sensitization Tests

AT THREE-WEEK intervals, 50 subjects were patch tested once, 20 were patch tested twice, and 10 three times, with cut and unbroken fibers. In reapplications, patches were applied as nearly as possible to the sites of the previous patches. Thirty of the 50 were then put through the rubbing experiment and six weeks later, when all reactions had disappeared except for mild pigmentation, all 30 subjects were patch tested again with unbroken glass fibers at the exact sites where cut fibers had been rubbed into the forearms for five successive days. In no case did we

TABLE II.
RUBBING EXPERIMENT — CUT VS UNBROKEN FIBERS

	CUT SHORT FIBERS						UNBROKEN LONG FIBERS					
	#12*		#37		#150		#12		#37		#150	
Reaction	Sized	% Total	Sized	% Total	Sized	% Total	Sized	% Total	Sized	% Total	Sized	% Total
None	0	0	7	23	22	73	30	100	30	100	30	100
+	0	0	13	43	8	27	0	0	0	0	0	0
++	2	7	8	27	0	0	0	0	0	0	0	0
+++	15	50	2	7	0	0	0	0	0	0	0	0
++++	13	43	0	0	0	0	0	0	0	0	0	0
Total	30	—	30	—	30	—	30	—	30	—	30	—

see patches of erythema, edema, and vesiculation as are commonly seen in sensitization reactions. No delayed reactions were observed.

Comment and Conclusion

AN INTENSE effort was made to sensitize some of the 50 white women used in the study, either to the glass fibers or to sizing #630 which is one very commonly used. A total of 708 patch tests was applied to the 50 subjects. After one month, 30 of these were rubbed with glass fibers in six areas daily for five days for a total of 900 applications, and this group finally was patch tested again at the three sites on the forearm, a total of 90 patch tests. In all, the glass fibers were applied either by patch testing or rubbing a total of 1,698 times over a period of four months. It was felt that the applications were intense enough and the time elapsed long enough to allow for the development of sensitization. In 92 employees examined there was no evidence of sensitivity to glass fibers or to sizing #630, although they had had intimate contact with both substances for a period of one month to 15 years. On the basis of these observations, we felt it was logical to conclude that it is most difficult to sensitize humans to the Fiberglas fibers or to sizing #630.

In no case were we able to cause any trauma with unbroken, long glass fibers, either by patch tests or by rubbing the material vigorously onto the skin. In only one instance, and that very minimal, was there any reaction at all to the very fine wool-like fiber #333. As the size of the fiber tested was increased, there was a corresponding increase in the degree and number of reactions. The immediate reaction to the rubbing of finely cut coarse fibers into the skin consisted of tiny lacerations and hemorrhages in the epidermis, and with repeated rubbing, eczematization occurred. In biopsies taken from rubbing sites we were unable with either incandescent or polaroid light to see glass spicules or foreign body reactions in the epidermis or dermis.

We concluded, therefore, that cutaneous reactions to Fiberglas (a) vary directly with the size of the fiber being handled, (b) are due largely to mechanical irritation from sharp, broken ends, and (c) are transitory in nature.

One of the subjects in the rubbing experiment and one of the employees examined developed urticaria on contact with shredded fibers of Fiberglas. Both exhibited marked dermographism. This observation, we believe, further corroborates our conclusion that cutaneous reactions to glass fibers are largely mechanical in nature. Since it is practically impossible for workers in the Fiberglas factory to completely avoid some contact with fine filaments of glass, we believe a simple test for dermographism might be a worthwhile pre-employment test for Fiberglas workers.

Practically, it seems we can further deduce that cutaneous reactions to finished Fiberglas products containing unbroken, long fibers as used in fabrics, bandage, tape, and electrical insulating materials are very remote; and that reactions to products such as air filters and insulating materials are due to mechanical irritation, transitory in nature, and are largely preventable by adequate skin hygiene.

Summary

FIFTY white women who had never knowingly been previously in contact with Fiberglas were exposed repeatedly by means of patch testing and rubbing experiments with finely cut and long, unbroken glass fibers. Ninety-two employees who had been in constant contact with Fiberglas for from one month to 15 years were also patch tested with unbroken glass fibers. We were unable to induce sensitivity in the first group and no sensitization reactions were noted in the second group. Reactions were observed when finely cut fibers were applied to the skin. These varied directly with the size of fiber used and were interpreted as being due to mechanical irritation. Two persons were observed to have severe urticarial reactions when exposed to broken fibers of glass. Both exhibited severe dermographism.

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— 1941 —

THE FIFTY-SEVENTH
ANNUAL MEDICAL REPORT
OF THE
Trudeau Sanatorium
AND THE
THIRTY-SEVENTH
MEDICAL SUPPLEMENT
FOR THE YEAR ENDING SEPTEMBER 30, 1941

TOGETHER WITH THE
TWENTY-FIFTH COLLECTION
OF THE STUDIES
OF THE
Edward L. Trudeau Foundation
FOR RESEARCH AND TEACHING
IN TUBERCULOSIS

REPORT OF THE DIRECTOR
OF
THE TRUDEAU FOUNDATION
— 1941 —

LEROY U. GARDNER, M.D.

whether the same results will be obtained elsewhere owing to variation in composition of rock. While none of the available evidence even suggests that established silicotic nodules can be made to disappear from the lungs, many miners have experienced symptomatic relief and there is reason to believe that their disease will cease to progress. This new endeavor should clarify prevailing views on disability in various stages of silicosis and demonstrate whether aluminum therapy has general application.

The Saranac Laboratory is still devoting its major effort to the study of industrial disease due to dust and associated tuberculosis.

The year's work has demonstrated the following points of general interest: Exposure to dust of glass wool, a material used commonly to insulate buildings, involves no hazard for the lungs because this fibrous material is not inhalable. A report is nearly completed upon the protective action of aluminum hydroxide against quartz and the conditions under which prevention and therapy may be effective. An experiment upon the influence of fumes generated in electric arc welding upon normal and tuberculous animals is demonstating that even excessive exposures fail to alter the usual course of benign infections. A joint pathological and roentgenological study with Dr. Sampson indicates the probable hazard from exposure to dust of a special variety of talc. With the aid of a grant from Merck and Company, Dr. Vorwald is studying therapeutic effects of certain new chemical compounds upon tuberculous animals. The Laboratory continues to maintain an active consultation service on problems of industrial disease. Mr. Cummings, the Field Director, still has supervision of the industrial health program of the Lake Superior Iron Ore Association. This involves not only iron mines but coal mines and limestone quarries. Dr. Sampson collaborates in the interpretation of approximately 10,000 annual x-ray films. They are assisted by Mr. Urb resident engineer, Mr. Downs, roentgenological supervisor, and three t nicians.

The Director appreciates the loyal support of all members of the dif departments, the financial assistance of those who are making this p possible and the interest and sympathetic understanding of his B Trustees and takes this opportunity to express his gratitude to all earnest hope that the work of the Foundation is of such be found to continue it through the perio by two contributions of $5,000 each f that these may be contin

EXHIBIT G

CIVIL ACTION NO. 5402

CLAUDE J. TOMPLAIT

VS.

COMBUSTION ENGINEERING, INC., ET AL

ANSWERS OF THE DEFENDANT, OWENS-CORNING FIBERGLAS CORPORATION, TO INTERROGATORIES PROPOUNDED BY PLAINTIFF

KING, SHARFSTEIN & RIENSTRA
ATTORNEYS AT LAW
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The Tomplait v. Combustion Engineering Case File (1962-1969), Response to plaintiff's interrogatories with exhibit...
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