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UNITED STATES DEPARTMENT OF AGRICULTURE AGRICULTURAL RESEARCH SERVICE

INTRODUCTION

In the first progress report and in the Memorandum of August 2, 1951, as well as in various conferences held in connection with this project, it has been emphasized that the available man-made laboratory facilities for some serious limitations on experimental work of this type. Accordingly, all results reported, as well as those to be reported herein, are of a qualitative nature only. It appears, however, that there was a misunderstanding with respect to the validity of the results obtained, since there seems to have been a belief that heat conductivity and strength tests were carried out with suitably small samples of the type used for the project on Fundamental Research of Microalga. This, however, was not the case. The samples we used were about 2" x 12" x 12", they were cut to 1" x 11 1/2" x 11 1/2" for the heat conductivity tests and to 1" x 2" x 11 1/2" for the modulus or rupture tests. It is believed that such samples are well suited for these tests and that the limitations mentioned at various times cover only the limited number of samples that could be prepared with the apparatus at hand.

the results given in the first progress report have also been subjected to critical analysis with respect to the fact that the evaluation of results and their plotting on the diagrams were not disregarding variations in density. This criticism is partially justified. However, an evaluation of the earlier tests based on this criticism rather confirmed our previous findings than disproved them. Further criticism was offered with respect to the program which was laid out on page 13, of the first progress report, namely, that the water to fine plus silt ratio rather than the water to total solids ratio was to be held constant. The actual results obtained in accordance with this program bear out this criticism and also bear out the fact that the limited size of the equipment makes it impossible to correct a mistake on short notice since it takes appreciable time to prepare a sufficient number of samples even for a rough evaluation of the results. Nevertheless, the results obtained in the series of tests run in accordance with the above-mentioned program offer certain definite, though qualitative, conclusions.

In addition to our experimental results, we report herewith, several pertinent findings in the literature, and we also give a brief outline of the experimental procedure used to prevent any further misunderstanding in this regard.



These findings, taken together, demonstrate both strength and
limitation of the current study. The strength of the study is that
the data were collected from a large, representative sample of
the population. The limitation of the study is that the data were
collected from a single source, which may have introduced some
bias. The study also did not include a control group, which
may have affected the results. The study was limited by the
availability of data, which may have affected the results.

As far as the application of strength and heat conductivity properties to construction, Asbestos gave the best results. The binding properties seem to be somewhat inferior. Possibly a mixture of half grade plus Cellvian and half partially beaten or other fine opened up Asbestos may be successful.

Such a mixture of fine Cellvian and Asbestos appears also promising from the economic point of view, since Asbestos at present is only twice as expensive as grade Chrysotile. Considering the cost of opaculating Chrysotile, it appears that a mixture of Asbestos and fine Cellvian could be an economical.

Our conclusions summarized in detail below, and our general findings as briefly summarized above, suggest, however, a development program which could be most satisfactorily carried out at the pilot plant in Berlin.

1. Samples containing 10, 15, and 20% opaculated Chrysotile.
2. Samples containing the optimum amount of opaculated asbestos found under 1 plus 10, 15, and 20% of grade Chrysotile to test strength.
3. Samples containing 10, 15, and 20% fine Cellvian.
4. Samples containing 10, 15, and 20% opened up (half beaten) fine Cellvian.

3. samples containing 10% waste and 10% ground-up blue collins.

6., 7., and 8., like 1., 2., and 3., with waste.

9. samples containing 10% waste plus collins and 10% ground up waste.

10. other types and ratios of waste should be suggested.

The conditions are as follows:

1. About 1% ground-up (half-ton) blue.

1. 10% waste or waste, or specified chrysotile gives the best combined strength and heat conductivity properties.

2. Under equal conditions waste gives the best combined strength and heat conductivity properties.

3. Substantial amounts of waste asbestos are necessary to obtain proper strength properties and the total amount of asbestos used should be much below 2%.

4. The difference between broken and waste was better for blue collins and waste than of a 2% waste, while for chrysotile high in the latter has substantially inferior.

5. In other cases to give equally good strength and heat conductivity properties, a relatively higher percentage than blue collins.

6. Separation of bentonite-polymer prior to the
incorporation into the latex appears to be un-
desirable.
7. Disintegration of emulsion by means of alkali
seems to be desirable.
8. Use of zinc sulfide with or without amine
appears to be both technically and economically
undesirable.
9. Further experiments of the type carried
out in this project should be discontinued
at our laboratories and transferred to the
Ist plant in Berlin.
10. A development research program as outlined
should be carried out at Berlin.
11. The "Mullany" process is commercially used
and gives products similar, though inferior,
to microgelite.
12. The authoritative literature describes the
"Mullany" process as a sodium hydroxide
catalyzed emulsion with a zinc compound.

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by the network, a few a full examination of the preparation
in the two before selected material, the following, the
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It is stated that this product is commercially prepared by the Eastman Organic Chemicals Company under the name of Duponit High Strength Cloth and Duponit High Strength Covering for glass pipes. According to this, the cloth is made and partially as follows: There are first prepared by weight of diatomaceous earth, 30 lbs and 100 lb well washed asbestos fibers, with sufficient water to give a paste of the consistency of moderately thin plaster of paris. The composition is then poured into shallow pans. The solids and contents are placed in an autoclave where the composition is set or bonded by the heat from live steam at a pressure of 125 lbs./sq. in., for about 24 hrs. The block now consists essentially of diatomaceous earth, asbestos, and the various fillers formed during autoclaving. The next steps are drying in a careful manner and trimming by saws to the exact dimensions desired."

The product is described as having a density of 2.1 lbs./cu. in. The heat conductivity is reported to be .004 lbs./sq. ft./°F./hr. for a temperature difference of 300°. It is said to stand temperatures up to 1400° F.

Although the data on the manufacture are quite unsatisfactory, it is reported that it is made from a composition of diatomaceous earth, asbestos, and various fillers. The composition is reported to be 30 lbs. diatomaceous earth, 100 lbs. asbestos, and 100 lbs. fillers. The ratio of diatomaceous earth to asbestos is reported to be 1:3, and the ratio of diatomaceous earth to fillers is reported to be 1:1. Obviously, the composition is not a simple mixture of these three materials, but a complex one.

In other words, the authoritative literature is of the opinion that the bulkhead product is a synthetic material which is superior to natural rubber.

High Resonance Insulation Products

The production of a high resonance insulation product is described in U.S. Patent 2,102,446, issued to General Electric, Inc. Although this product is not technically related to fiberglas, it is of interest inasmuch as it appears to be a highly competitive product and, inasmuch as it shows that a product made almost entirely from asbestos having a very low heat conductivity can be prepared. According to this patent this object is obtained by "the fibering" asbestos into its "maximum degree" and then mixing it with water and a binder. Subsequently the slurry is placed in a mold where it is slowly compressed and then permitted to settle and the surplus water to drain. Then the product is dried, for example, in an autoclave.

The favorable characteristics of this product are ascribed to the fact that the asbestos fibers which have been fibroscopically to the "maximum degree" and which are bonded by a small amount of resin, spread out over a large number of natural small voids. According to this patent the material is not through a battery of dielectric tests where they can determine the effect of heat

and which is produced by evaporation. According to this patent the treated material will develop 10 to 50 times in volume. The fibers are said to be too short for being satisfactory for use in a lining or covering.

A mixture of cement and cotton is used as a binder and large amounts of water are being used so as to induce the formation of a thin coating of the binder on the asbestos fibers. Insulation is carried out for about 48 hours at 120-125 lbs. saturated steam pressure. The product has a bulk density of about 11.3 lbs./cu. ft. and its heat conductivity, as measured by Professor H. N. Miles of M.I.T., is about .180 at a mean temperature of 200°F. The modulus of rupture is about 46 lbs. According to the patent specification rock wool, mineral wool, and slag like mineral fibers may be substituted for asbestos.

It is noticed that the strength of this product is rather low, but the heat conductivity on the other hand appears to me to be lower than anything we could obtain in our own experiments with chrysotile. As will be discussed later, however, we are now going to produce samples of an even better conductivity on the basis of product out of better strength, even under more exacting conditions, when proper care is taken in the selection of materials and in the selection of the process.

... a point of view this point is of interest because it dispenses the use of what is known as the "boulenger" substance for a heat insulation material. From our own experience with the material as rather suspect that as soon as a slight change in composition such as solubility or permeability.

1. Properties

Chiefly the procedure followed in preparing the material in connection with this project was as follows:

The raw material was calculated on the basis of the ratio of total water and total solids content. Accordingly, reference to percentages of asbestos refer to percentage of total solids. The 11.5-million ratios were determined as the ratio of diatomaceous earth to the dry lime raw material, disregarding the fact that diatomaceous earth is not pure silica and that the lime raw material is not pure lime.

Quantities were taken as much as 100 lbs. added to the material in the paper beater. The degree of disintegration was checked by means of the so-called "fines test". Actually, this test does not measure the fines in any direction, but merely a blow for rotation of the fines slurry is stirred on a fine mesh screen. The frequency that is used with a screen containing 100 mesh or more. The entire material is then stirred and taken to solution. It can be readily seen that the

fibers to a large extent after the action of different types of radiation with each other with respect to the character of the fiber. However, it offers a convenient point of comparison representative of the degree of integration of the fibers of different types of radiation. The following table is a list of the arbitrary R. G. numbers with the actual figures as found by experiment.

Table A

Label	Actual Figure	Actual Figure
R-1a	Chrysoth	11
R-1b	"	39
R-1c	"	61
R-1d	"	72
R-2a	Chrysoth	51
R-2b	"	60
R-2c	"	66
R-3a	Chrysoth	19
R-3b	"	50
R-3c	"	60

It is believed that the degree of the radiation of the fibers obtained at 100, 150, 200 and 250,000 rads is a reasonably good indication of the degree of integration of the fibers. The fibers of the R-1 series have been shown to be the most integrated and the R-3 series the least integrated.

Arthur W. Little, Inc.

ENGINEERS & ARCHITECTS



140 N. BROAD ST. NEW YORK 17, N. Y.

NY 100

AUGUST 16, 1944

General Electric Company
Attention: Mr. J. E. Smith
Schenectady, N. Y.

REPLY TO: NY 100

Gentlemen:

8-5716

We present herewith the first progress report
on the investigation of the effect of additions of
substance to the electrolyte solution.

Respectfully submitted,

John D. Little

carrying out of the test, a different designation can be used for convenience even in the discussion and tables of the present report. It is, however, necessary and proper to have been understood as to the use of the designations. It is, moreover, shown that it is believed that these details will be of the value of the material and the substance should be better prepared with the necessary and the nature of the material.

When the reaction was heated in a water slurry containing a small amount of water, it was necessary in many instances to dry the substance prior to introducing it into the reaction mixture to introduce to a small amount. It is not believed that this procedure is unfavorable for the best results, because it may well be that the dried substance will be better and then on drying with the reaction mixture is not entirely destroyed again. If we are rightly informed, the general procedure is to such cases is to mix the dried substance with the other reaction materials and then to dehydrate the entire mixture. It is believed that such a procedure should be very satisfactory since it will retain the substance in its original state of subdivision and not destroy it.

The weighed out raw material was placed with a 11 blading alloy, ground out into smaller which were about 20 x 12 x 12 and subjected for 12 hours in an autoclave at 1400 psi. The autoclave was back to normal pressure in about 6 hours at which time the door was opened. The samples were taken out about 2 hours after arrival. The samples were dried for 12 hours at about 100°C.

Two samples were made of each type and all samples were cut to about 12 x 11 1/2 x 11 1/2. One of each sample was sent to the laboratory at F.I.C., where it was tested for heat conductivity on the steam table apparatus, exactly in the same manner as used for samples sent from Berlin. Another sample was cut into rings of about 12 x 2 x 11 1/2 and tested for modulus of rupture on a support having a 10" span.

It is obvious that not too much importance should be attributed to the exact values reported for any given experiment. However, in the evaluation of the tests, it should be kept in mind that the prevailing conditions are unfavorable rather than favorable for the results obtained in that it naturally may be supposed that the high values obtained with samples made on a hot air oven would be rather higher than those obtained in the normal conditions. While it is believed that these values would not be seriously affected one way or the other, it is

noted that practically all "the volume of the nation's
with almost no change in output in spite of the threat of strike
and technical specifications, although in our opinion
national output values from a long different point of view
should not be below 50%.

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The results of the series prepared when the first nitrogen burner was used are given in Table II. All these samples were again run with a flame to oil ratio of 1:1.25, while the water to petrol ratio is given in the second column of the table. As explained in a preceding paragraph, the designation is indicated by a, b, c, and d, while the type of reactor is designated by 1, 2, and 3. According to, under 2a, 2b, etc. the results of samples reduced to a specific degree will be found. The percent 1.25 refers to nitrogen which has been directly added by adding a known quantity of nitrogen.

in order to be able to explain these results they were put in the 1976 program report, again reported in the form of diagrams and in fact when he explained the fact that the connection of some points in the diagram does not mean that such points were placed together in a way. In fact, the only comment of the diary was to point out that the connection between the different points was not to be taken literally, but could be interpreted as

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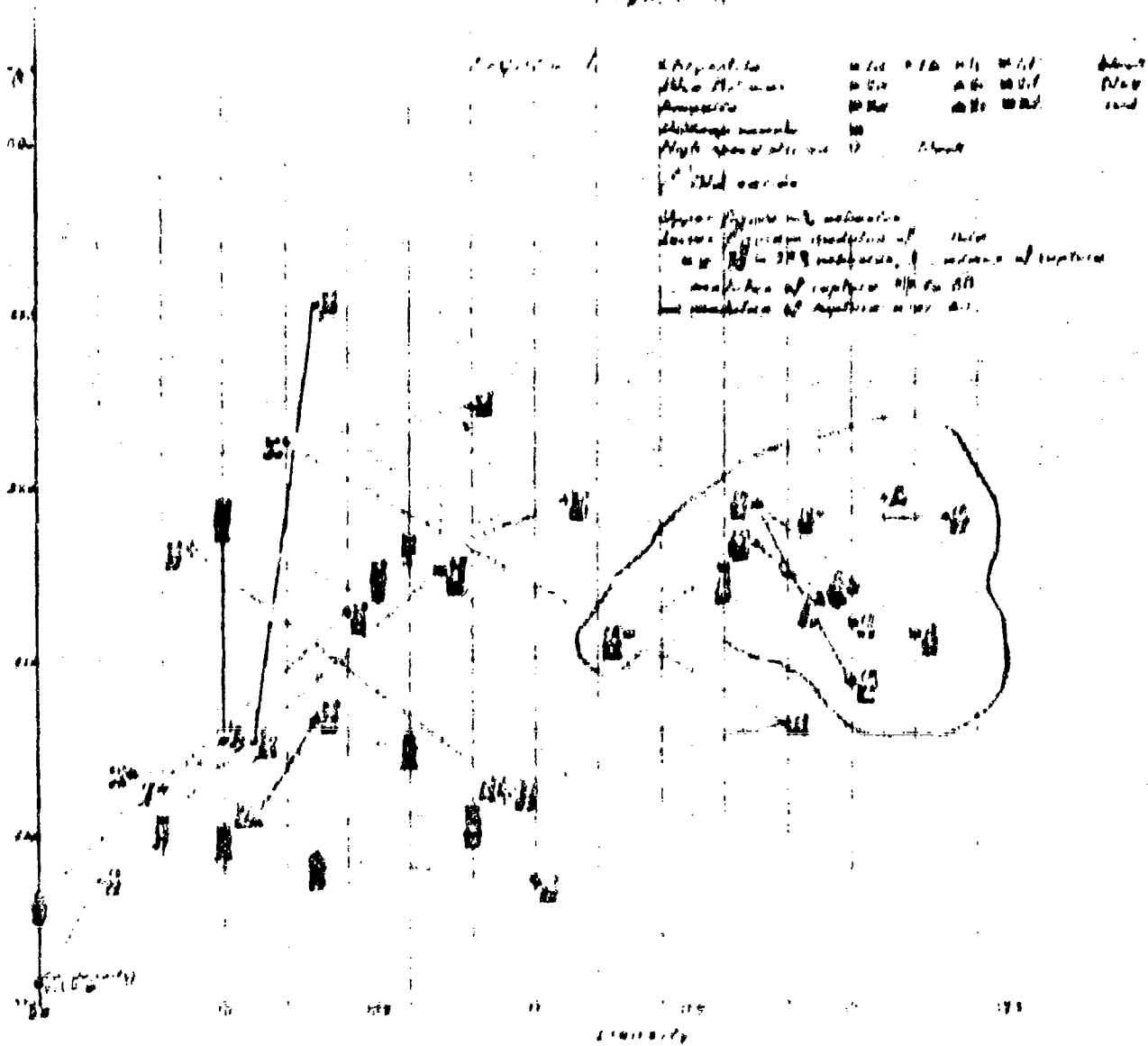
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conventional units, also those which reported in the First Progress Report have been included in the present report. In view of our difficulties, the data have been presented as plotted against density, which seems it necessary to correlate the other properties by means.

Figure 1 illustrates the results obtained by the addition of various types of mutation in various distributions in stages and varying quantities. At the same time, the method of procedure followed in the new series covers also a rather wide range of densities. In this diagram the density is plotted against "x" values. The Indians for each point give the amount of mutation and the modulus of rupture. Also underlined Indians have a modulus of rupture greater than 60, while underlined Indians have a modulus of rupture between 50 and 60, while plain Indians have a modulus of rupture less than 50. The group of experiments taken over from the old series was surrounded by a circle. This series should be regarded as a whole because the previous series was run by a different operator than the present one. In this connection it should be mentioned that the mutation of the new series were not as large as those of the old, so that the modulus of rupture values obtained in the earlier series are more reliable than those of the new one.

Figure 1



2. Investigations

At the request of the Berlin Research Laboratory the pH of acetone solution of different grades of acetone were investigated. In addition qualitative results as to the effect of chrysothide, blue holivian and caustic soda on the pH of these solutions was obtained with a laboratory stirrer and the pH of these solutions was then measured in the usual way. The pH values were as follows:

chrysothide	9
caustic	11.1
blue holivian	11.1

As to be expected chrysothide gave the highest

(1)

This test was run in view of the fact that the Berlin Research Laboratory discovered that magnesium is a possible source of weakness for chrysothide. It, therefore, was believed that acetone being a supposedly hydrophilic substance would be a source of trouble if it were appreciably hydrolyzable. Although the above tests indicate a certain solubility of chrysothide, we are not inclined to attribute too much stress to this fact. If the amount of calcium absorbed out of chrysothide were appreciable, this would have been observed with a solution of chrysothide in water. It would be surprising, however, if it were found that a solution of chrysothide should be such a weakly

Alcoholized than grade Chaparral. Nevertheless, simulated
Chaparral is very close to the strength of the real
material. The method of selection of the material is

to some extent arbitrary. The selection of the material is
based on the fact that this type of selection does
not have any, and is not, however, a type of
selection in a line, which is not similar to
a, and is not, it could be determined whether,
when mixed with suitable amounts of another type of se-
lection, it could not be used to advantage as a reinforcing
agent.

END

Again it has to be emphasized that evaluation of such a dispersion has to be done by statistical methods rather than by point to point evaluations. It is apparent at first sight that most points which have a low η' value and low density and are once or twice underlined are obtained with blue collins or white asbestos. It is further noticeable that extremely low η' values and satisfactory strength were obtained with Amosite of an intermediate beating degree. Possibly slightly less satisfactory results with respect to the η' value were obtained with completely splinted Amosite. It appears to be conclusive that non-splinted Amosite provides less satisfactory strength and η' values.

Dispersing blue Holliday asbestos with amosite, it might be concluded that also in this case an intermediate beating stage seems to be preferable. Furthermore, it seems to be indicated, although less conclusive, that an extremely low η' value can be only obtained at low densities whereby it must be remarked that the strength obtained for such low density appears to be reasonably good. We are inclined to believe that complete splinting of blue Holliday asbestos is disadvantageous rather than advantageous.

In the case of the chrysotile mine, it seems to be concluded that satisfactory mechanical strength and heat conductivity properties can be obtained with complete splintation. High speed stirred chrysotile seems to come closest to completely splintated chrysotile, although the data is too limited to draw any definite conclusions. The unsplintability of amphi chrysotile as a sole source of asbestos comes out quite clearly again.

In figure 2, the same results are plotted as density vs. modulus of rupture. The indices in this case represent the percent of asbestos and "K" value. "K" values below .400 are underlined 1 time; between .400 to .410 two times; between .410 to .420 three and between .420 to .430 with a wavy line. Higher values are not underlined at all. Values taken from the old series are again surrounded by a wavy line. A solid line is drawn at the modulus of rupture level which corresponds to heavy specification. Thus, this diagram illustrates the beneficial properties of value splintation and results obtained. Generally speaking, of course, since all indices are both with density and increased asbestos percent. The lack of a large amount of experiments does not allow conclusion as to which factor is the prevailing one under any given circumstances.

Figure 2

Figure 2

1. 1/2 inch
 2. 1/4 inch
 3. 1/8 inch
 4. 1/16 inch
 5. 1/32 inch
 6. 1/64 inch
 7. 1/128 inch
 8. 1/256 inch
 9. 1/512 inch
 10. 1/1024 inch
 11. 1/2048 inch
 12. 1/4096 inch
 13. 1/8192 inch
 14. 1/16384 inch
 15. 1/32768 inch
 16. 1/65536 inch
 17. 1/131072 inch
 18. 1/262144 inch
 19. 1/524288 inch
 20. 1/1048576 inch
 21. 1/2097152 inch
 22. 1/4194304 inch
 23. 1/8388608 inch
 24. 1/16777216 inch
 25. 1/33554432 inch
 26. 1/67108864 inch
 27. 1/134217728 inch
 28. 1/268435456 inch
 29. 1/536870912 inch
 30. 1/1073741824 inch
 31. 1/2147483648 inch
 32. 1/4294967296 inch
 33. 1/8589934592 inch
 34. 1/17179869184 inch
 35. 1/34359738368 inch
 36. 1/68719476736 inch
 37. 1/137438953472 inch
 38. 1/274877906944 inch
 39. 1/549755813888 inch
 40. 1/1099511627776 inch
 41. 1/2199023255552 inch
 42. 1/4398046511104 inch
 43. 1/8796093022208 inch
 44. 1/17592186044416 inch
 45. 1/35184372088832 inch
 46. 1/70368744177664 inch
 47. 1/140737488355328 inch
 48. 1/281474976710656 inch
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 52. 1/4503599627370496 inch
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 239. 1/883423532389192164791648750371459257913741948437809479060803100646309888 inch
 240. 1/1766847064778384329583297500742918515827483896875618958121606201292619776 inch
 241. 1/3533694129556768659166595001485837031654967793751237916243212402585239552 inch
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 244. 1/28269553036454149273332760011886696253239742350009903329945699220681916416 inch
 245. 1/56539106072908298546665520023773392506479484700019806659891398441363832832 inch

In Figure 1, the results obtained with mixtures of grade and completely oxidized acetone are illustrated. It must be readily admitted that these results are hardly open to any exclusive interpretation, with the exception of the fact that again best results were obtained particularly with Acetone but also with Methylol acetate. As far as Chrysotile is concerned, one can conclude that care is drawn in it as much as possible in possible study Chrysotile should be taken, since its only beneficial effect seems to be for binding, interaction with it seems to have a detrimental influence on other properties.

In a very cautious statement, it can be stated that an addition of around 15% of either a laminated chrysotile or of grade or disintegrated mica cellulose or vermiculite should constitute best results as to give the best combined strength and heat conductivity properties. In the case of Chrysotile this amount should be mixed with a suitable amount of substrate necessary to provide satisfactory binding values. At any rate, it appears to me to be worth while to make any large scale investigation of the influence of mixtures around this assumption. It is definitely believed that the amount which may be finally found satisfactory will likely be anywhere between 10 and 20% of the mixture as reported in the literature as a satisfactory mixture that good

Figure 3

Figure 3

Latitude	40° 45' N	41° 15' N
Blue Helix	41° 15' N	41° 15' N
Amplitude	41° 15' N	41° 15' N

1. 1944 series

Upper figure is a plot of the 1944 series

Lower figure is a plot of the 1945 series

2. 1945 series

3. 1946 series

4. 1947 series

5. 1948 series

6. 1949 series

Figure 3

highly uniform be obtained with less than about 15% asbestos
chrysotile, which carbon chamber would for an ideal solu-
tion with the use of chrysotile. In the case of the
straight-flamed asbestos types, the friction, strength and
heat conductivity properties can be obtained with the same
material as that all properties could be obtained with a
much less total amount of asbestos. Quite possibly mix-
tures of 1/2 benton or asbestos mixtures of these types
of asbestos could be satisfactorily used for all properties
with an addition of around 20% and possibly under improved
slipping conditions quite as economical as mixtures of
crude and totally agitated chrysotile.

It is believed that the experimental findings
discussed in the preceding paragraph are in agreement with
the microscopic findings reported in the preceding second
paragraph above. In this report it was pointed out that
both American and New Bolivian asbestos are similar to
completely agitated chrysotile. It was also stated that
high-speed-stirred chrysotile appeared to be somewhat more
agitated than the chrysotile in the case of beating
mixes.

Evaluation of the high speed action is rather
difficult. However, a few certain general conclusions
can be drawn. Certain definite the findings, comparative of
mixtures fully and apparently good findings can be drawn

valued only with products containing substantial amounts of grade substance.

If grade substance for introduction without the value of the substance, it appears that about a 20% addition will be satisfactory. New pictures of grade and splintered substance are used it is seen that the amount of grade can be decreased as long as the total amount of substance is not less than about 20%.

In comparing the different types of substance investigated with respect to their blinding effect, Acetate appears to be inferior to both Dinitro and Blue Cellulose substance.

It also should be of interest to compare the values of the different substance types. The prices are taken from our records and do not necessarily represent the actual present prices for large-scale consumption, also the constantly improved shipping situation may favorably influence the prices of imported substance.

Blue African Substance	20¢ per lb.
Blue Cellulose Substance	15¢ " "
Acetate	22¢ " "
Chloride	1 1/2¢ " "

We believe that the prices of Blue Cellulose substance are available. When shipping conditions are not so favorable as at present, the prices of the substance are higher and also than the Blue Cellulose.