DC-42-2

OWENS-CORNING
FIBERGLAS
INTRA-COMPANY CORRESPONDENCE

PLAINTIFF'S EXHIBIT
K-907

To Mr. R. F. Shannon, Granville

From O. W. Pfeifer, Granville

Date May 16, 1967

cc: Mr. M. Hardwick, Berlin

Subject ASBESTOS
AMOSITE AND CHRYSOTILE

There has been a need to have some basic information available on asbestos, both amosite and chrysotile, in the general knowledge area. Specifics as to specifications, etc. are in other detailed sources. This study had as its beginning the information concerning amosite asbestos, in its various grades, as obtained from North American Asbestos Corporation. This was followed by its milling, preparatory to its inclusion as a reinforcement and an aid to thermal conductivity in Kaylo slurry for the characteristics of the final product. As we continued, we added other sections, which we thought were pertinent and these were included to the volume of the present project makeup.

O. W. Pfeifer

OWP/ris

01 040 1174

B E S T O S ,., AMOSITE AND CHRYSOTILE

OCF
Keyws

01 040 1171

R.F.SHANNON

ASBESTOS

AMOSITE & CHRYSOTILE

01 040 1172

TABLE OF CONTENTS

01 040 1173

PART I

AMOSITE ASBESTOS

A S B E S T O S

A M O S I T E   A N D   C H R Y S O T I L E

TABLE OF CONTENTS

SECTION – 1

CORRESPONDENCE

01 040 1177

PART I -- AMOSITE ASBESTOS

SECTION 1 -- CORRESPONDENCE

A. DR. GAZE'S REPLY TO PALLMAN MILL PROCESSING OF AMOSITE

Page 7 -- The outstanding fact is that the amosite asbestos is milled dry. It has been obvious for years that by wet milling to open amosite fibers, we have been destructive to the fiber length and have further shortened the already short fiber length.

Page 8 -- Here are listed the factors determining the set up of the mill for best results. This will be most helpful information for us.

The Pallman Mill people in North Jersey can supply us with information on chrysotile asbestos.

B. LD3 AMOSITE

Page 13 -- We can explore the availability and cost of LD3 amosite fibers when we get along with the Pallman Mill trials. By using this longer fiber as a percentage in a blend with shorter amosite fibers, we may increase impact strength in the final Kaylo product and effect a lower asbestos cost at the same time. As anxious as everyone is to eliminate asbestos from Kaylo the arrival at this state of reinforcement is a few years away, so the work on amosite reinforcement for product strength, as well as cost improvement, should go forward at full speed.

C. PALLMAN PULVERIZERS, INCORPORATED

Page 15 -- We shall immediately contact these people in Hoboken and secure cost of processing different grades of amosite for fiber opening at various recommended settings of the Pallman Mill. Several tons of each grade should be sent to them, opened and then processed in regular production at Berlin. Also, several experimental batches should be undertaken at Kaylo Research on blends of amosite Pallman opened fiber, so as to 'bulls-eye' the target runs in the plant for the optimum results.

D. PALLMAN MILL

Page 19 -- The picture here shows the rotor and the swinging, stationary, mounted head. At first glance it is to be noted that the design is considerably different than the Bauer Mill and the shearing action to open the fiber is less direct and abrasive than the Bauer. On the following pages are descriptions of the mill and its operations. Of particular note is the inclusion of a magnetic separator for trapping of 'tramp iron', which is most important for other Kaylo equipment protection, particularly pumps. We shall secure quotations from them on costs on suggested mills for Berlin's capacity per hour, feeding and discharging methods and equipment, etc.

E. DR. GAZE'S VISIT TO GRANVILLE

Page 26 -- Dr. Jerome, of North American Asbestos, brought Dr. Gaze, of Cape Asbestos, to Granville and talked with Dr. Kalousek and, evidently, Marsh Armstrong as well, in October 1961, regarding the milling of asbestos. Unfortunately, Messrs. Kalousek and Armstrong are no longer available for comment. However, Kalousek's memo is important in that it states rather emphatically Dr. Gaze's reaction to Berlin's wet asbestos opening process compared to Cape's dry method and their poor results from similar wet milling experiments. You will note that Dr. Gaze was dubious about using the hydrapulper in the mixing of the asbestos into the slurry. He was likewise very definite in his disapproval of the use of centrifugal pumps, because of shortening the fiber length, due to the shearing action of the impellers. We recall several visits of Dr. Jerome to Berlin, both with and without Bob Cryor of NAAC, and he was familiar with the Kaylo operation, particularly the mixing area, and constantly urged the elimination of the wet Bauer milling for an improvement in fiber length. The arguments pro and con of wet vs dry milling have gone on in Kaylo for years and prior to 1958 there was a definite position of Kaylo's technical people in support of wet milling. Strength, until extenders to the batch were introduced for various reasons, were adequate and better than competition, with the exception of J-M. This debate has since continued intermittantly without any direct action being taken. It is significant to note that all of the other calcium silicate manufacturers use dry milling to open their asbestos. J-M has their own design of picker for their first opening of fiber, patterned after such equipment at their Thetford mine. Baldwin-Ehret-Hill uses a Sprout-Waldron attrition mill for coarse grinding amosite and finer shredding of chrysotile for suspension purposes.

F. SPROUT-WALDRON EQUIPMENT FOR OPENING ASBESTOS FIBERS

Page 26A -- A description of the equipment manufactured by Sprout-Waldron for opening asbestos fibers for Baldwin-Ehret-Hill is self-explanatory on the above numbered page. To our knowledge this calcium silicate manufacturer is the only other one that uses a hydrapulper for mixing purposes. There is a definite reason for this for they bought much of the Sayreville Kaylo equipment when it was dismantled and their Director of Research was then, and still is, Jack McAllister, who was Production Manager for us at Sayreville until late 1952. The B-E-H process is the Pabco vertical machine, which is under a license agreement to them. The experimental vertical casting machine at Berlin several years ago was a take off from this patent. R. F. Shannon made some experiments in 1961-1962 with W3 asbestos opened by Sprout-Waldron equipment, with results that were better than wet milled Bauer opened amosite.

G. PROCTOR AND SCHWARTZ EQUIPMENT FOR OPENING AMOSITE ASBESTOS

R. F. Shannon, in early 1962, contacted Proctor and Schwartz, Philadelphia, who manufacture various types of equipment used in the textile processing, such as feeders, shredders, pickers and carders. W3 amosite was taken to their laboratory and opened on a feeder, shredder, carding machine and in a combination of feeder-picker and feeder-shredder. When dry opened amosite was milled through the wet process at Berlin, namely hydrapulper, centrifugal pumps, etc., a much lower result in drop test strength was obtained than when the same opened W3 amosite was mixed and poured in the Research Laboratory at Granville. This very definitely pointed out the attrition to fiber length, after being dry opened that was occurring at these points in the Berlin mixing and slurry transport system. The laboratory results gave best strength from the feeder-picker combination. All of Proctor and Schwartz opened W3 amosite gave higher strength results than dry opened W3 amosite with Devil Tooth Bauer Mill or Sprout-Waldron fiberizer.

H. AMOSITE GRADE FIBRE CANADIAN BOX TEST

Pages 27 and 28 --

CANADIAN BOX TEST SAMPLING AND SIEVE SIZES				
Amosite Grade	½" Mesh	¼" Mesh	10 Mesh	Pan
LD3	15½	0	½	0
W3	12½	1½	1½	½
S33	0	10	3	3

01 040 1180

H. AMOSITE GRADE FIBRE CANADIAN BOX TEST (Cont.)

The three sizes listed here point out the big difference in fiber length between LD3 and S33, as well as between W3 and S33. If LD3 is still available at the same price as W3, a blend may be devised of LD3 and S33 that will give longer fiber for higher strengths at a lower cost than for W3. Also, W3 and S33, when Pallman Mill opened, may give a lower cost with increased strengths than present W3, wet Bauer Mill opened, and certainly better results than present W3-S33 combination, wet Bauer milled. A careful and studied observance of longer fiber effect on clogging of 3/8 inch pouring spout openings will have to be made and not an opinion accepted prior to testing of what the result will be. It may be necessary to redesign the pouring nozzle and good results are a possibility from this investigation as well. It may be something to consider for instance, to try to eliminate the 180° direction travel of the slurry from the input side of the nozzle to the discharge slot. An overhead mounting with a vertical charge and discharge style nozzle may be a revolutionary breakthrough, affecting not only strength, but surface finish as well. It would be well worth a trial! Such a beginning with an 8 inch length pouring nozzle could well develop into the 36 inch length pouring spout, with all of its advantages.

amosite
asbestos news
crocidolite

PUBLISHED BY NORTH AMERICAN ASBESTOS CORPORATION
141 West Jackson Blvd. / Chicago, Illinois 60604 / Phone (312) 922-7435 / Cable Address: NORAMCO, CHICAGO

Vol. I - No. 1 - July 1966

NEWSLETTER? -- WHY? The NAAC monthly Newsletter is intended to provide an additional information service for those interested in Amosite and Crocidolite Asbestos. The Newsletter is an effort to extend and to increase the effectiveness of NAAC communications, as a means of keeping in touch with customers and friends in addition to telephone contact, correspondence and personal visits.

The Newsletter will regularly include general information about Amosite and Crocidolite (Blue) Asbestos, news of technical developments, fibre availability, shipping and transportation as related to these fibres, and other items of interest. We will keep it brief.

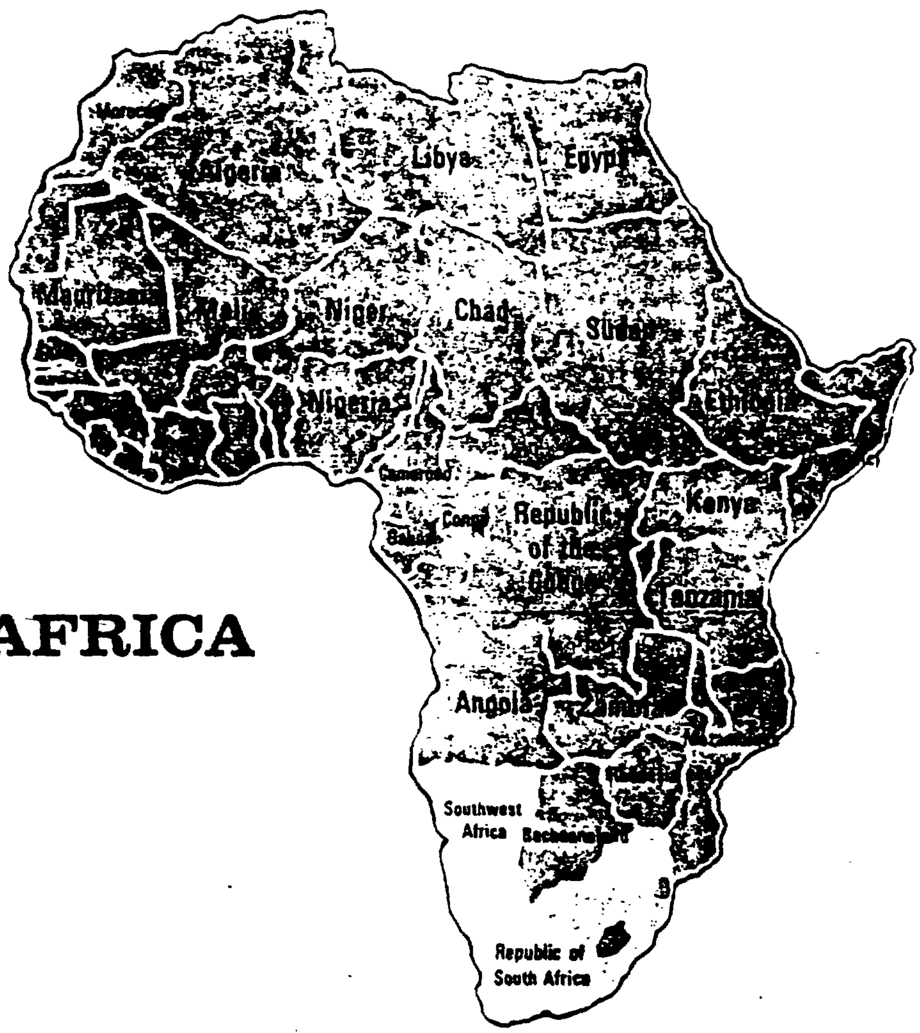
We hope the Newsletter will become a useful extension of NAAC services. If there are others in your company who should be on the mailing list, please have them write or simply complete the enclosed reply card.

NAAC? -- WHO? WHAT? WHERE? North American Asbestos Corporation, a part of the Cape Asbestos Group, is engaged exclusively in the marketing of Amosite and Crocidolite Asbestos, both mined in South Africa. We do not mine or market Chrysotile Asbestos. Amosite and Blue Fibres are frequently used in conjunction with Chrysotile, but ordinarily do not compete with Chrysotile -- end uses are usually different.

The NAAC marketing territory is the United States, Canada, Mexico, Central America, and the Caribbean area. We regularly bring Amosite and Crocidolite into all major ports in North America, including Montreal, Boston, Philadelphia, New York, Baltimore, Norfolk, New Orleans, Mobile, Galveston/Houston, Tampico, Vera Cruz, Los Angeles, San Francisco, Seattle/Tacoma, and Vancouver. Inventories of certain grades of Amosite and Crocidolite are regularly warehoused in Philadelphia, and occasionally in New Orleans, and Los Angeles. We strive to provide continuous and up-to-date information on Amosite and Crocidolite availability in respect to supplies at the mines, in transit, and in warehouses. We can frequently adjust or divert inbound shipments to meet emergency requirements.

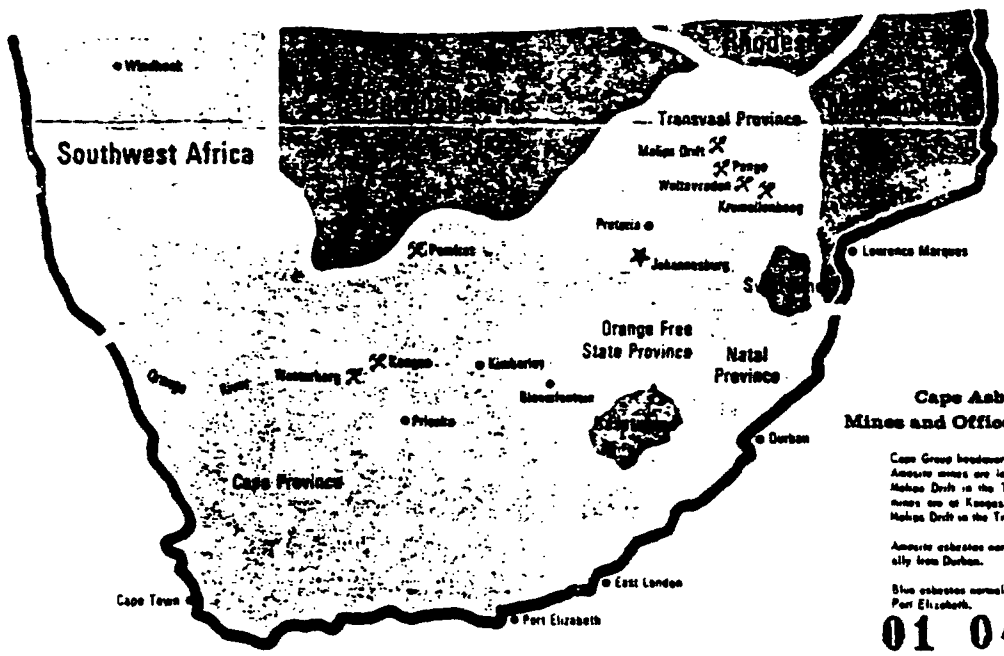
Our parent company, The Cape Asbestos Company Limited/London, through extensive mining operations in South Africa, is the largest producer of Amosite and Blue Asbestos. NAAC is the largest importer/marketer of these fibres in the Americas.

01 040 1182



AFRICA

Republic of South Africa



Cape Asbestos Group of Companies
Mines and Offices in the Republic of South Africa

Cape Group headquarters are located at Johannesburg [illegible]. Principal Amosite mines are located at Penge, Weltevreden, Kromellenboog, and Malips Drift in the Transvaal Province. Principal Crocidolite (Blue) mines are at Koegas, Westerberg, and Pomfret in Cape Province, and Malips Drift in the Transvaal.

Amosite asbestos normally shipped from Laurence Marques or occasionally from Durban.

Blue asbestos normally shipped from Cape Town or occasionally through Port Elizabeth.

01 040 1183

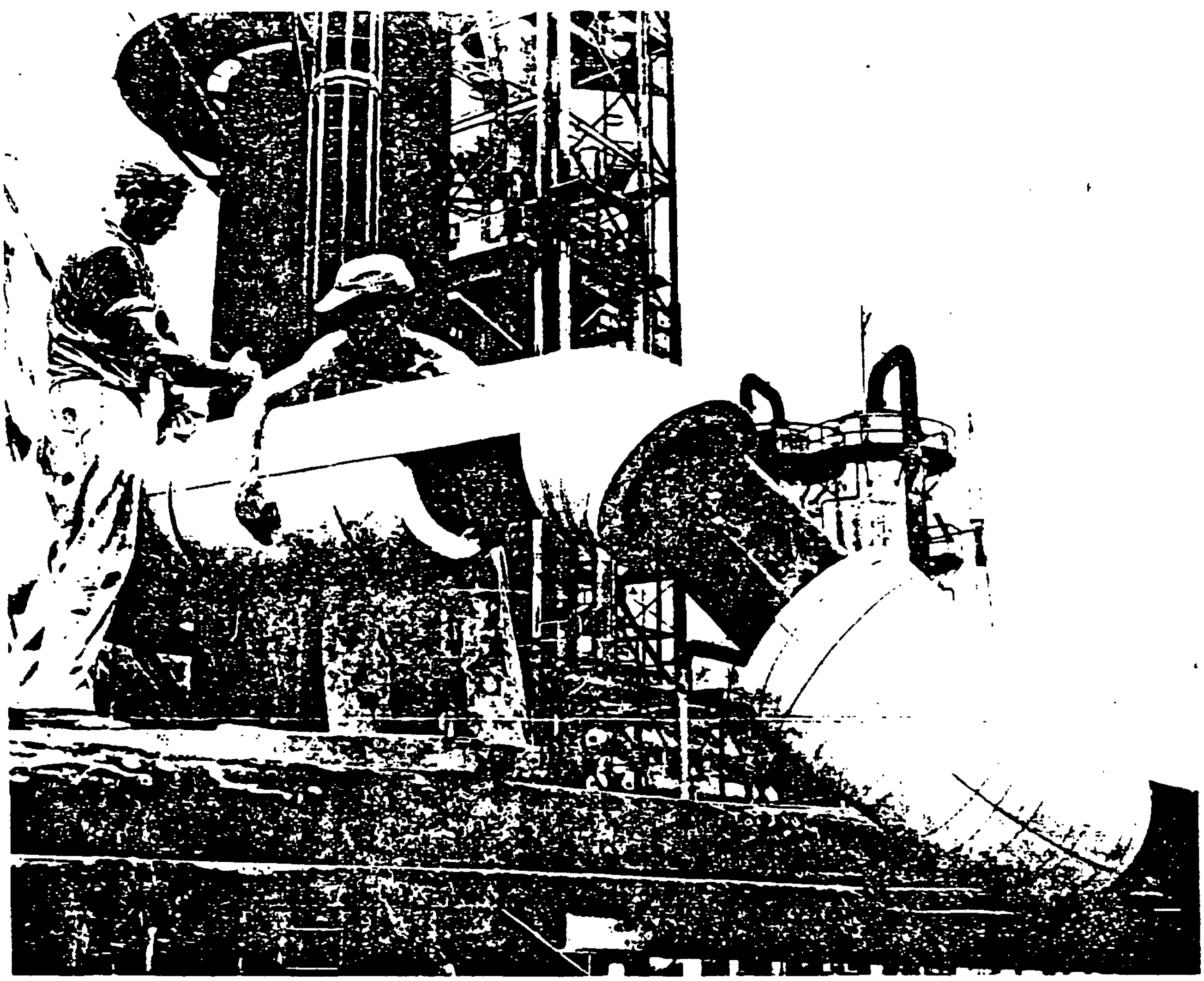
Country Boundaries   Provincial Boundaries   Railways   Rivers   Company Mining Towns

AMOSITE IN THERMAL INSULATION APPLICATIONS A large percentage of the world's Amosite production is used in manufacturing thermal insulation. These insulations take many forms, the most important of which is rigid molded pipe and block insulation for high temperature service.

Such insulation must have high thermal efficiency, relatively high strength, low density, heat stability up to 1,200 degrees or more, and durability over the long service life of the insulation.

There are two principal types of rigid molded insulation in which Amosite is either an essential or a predominant component. One type is calcium silicate insulation composed of asbestos, diatomaceous earth, silica and lime. This product results from chemical conversion of the basic components into calcium silicate, followed by wet molding with subsequent autoclaving before drying and finishing. Calcium silicate insulation is notable for high insulating efficiency, and for its smooth finish and dimensional accuracy.

The other important type is molded Amosite insulation, which is produced by a process of accumulating Amosite fibre combined with inorganic binders on mandrels of suitable size, using a semi-wet forming process. Produced in many different countries, molded Amosite insulation is well known for its high insulating values, rugged strength and durability.



Amosite is a major component of these high quality insulations primarily because of its heat resistance and reinforcing characteristics, but also due to its great bulkiness. No other mineral fibre provides the same combination of strength, heat resistance, stability and durability at economical cost.

01 040 1184

Amosite's unusual performance characteristics also make it an ideal material for use in flexible and wrap-around types of thermal insulation. It also is used in combination with mineral wool, vermicu-

2A

NEW TESTING MANUAL FOR AMPHIBOLE FIBRES Cape Asbestos Fibres Limited/London, part of our parent group, and responsible for world marketing of Amosite and Blue Fibres, has recently published an authoritative manual, "Test Methods for Blue and Amosite Asbestos Fibre". This publication is intended for distribution primarily to scientific and technical personnel, particularly those engaged in the testing and laboratory evaluation of asbestos fibres. Let us know the names of those in your organization who should have a copy. The new manual should prove to be a valuable companion publication to the volume, "Testing Procedures for Chrysotile Asbestos Fibres", a widely recognized manual issued jointly by Asbestos Textile Institute, Mineral Fibre Products Bureau, and Quebec Asbestos Mining Association.

U.S. GOVERNMENT STOCKPILE DISPOSAL The U.S. Government, through General Services Administration, has authorized the disposal of a substantial tonnage of both Amosite and Crocidolite now considered to be in excess of emergency stockpile requirements. The Amosite and Blue Asbestos is being released along with excess tonnage of some fifty other strategic minerals in the Government Stockpile. NAAC is cooperating with GSA to establish a means of moving the surplus tonnage into industry channels with minimum disruption of normal commercial relationships, and with due attention to the age and condition of the surplus stocks. Part of this has been in stockpile since 1951, during which time standard gradings, through improved milling techniques, have changed and improved considerably.

It is possible GSA may wish to rely on NAAC as a principal agency in the disposal program, but as yet no decision has been reached. Discussions are continuing. Meanwhile GSA will, from time to time, offer portions of the surplus material on public bid. More on this later.

FIBRE SUPPLY The tight supply position on certain grades of Amosite, particularly grades DX, D11, W3, K3, S33, GK, A10, continues. For the long and medium-long grades -- DX,D11,W3,K3 -- the position is expected to ease during the next ninety days due to increased production and availability of stockpile material. The shorter grades -- S33,GK,A10 -- will continue to be difficult until the early part of 1967 when additional production becomes available.

Blue Asbestos is in fairly good balance in supply and demand for most gradings. Inventories are relatively low, but mine shipments are keeping up well with current requirements. Long Blue gradings for spinning purposes are in tight supply.

LET US HEAR FROM YOU. Call or write NAAC if you have questions or need assistance on any problem relating to Amosite or Blue Asbestos.

****

01 040 1185

NORTH AMERICAN ASBESTOS CORPORATION

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

December 21, 1965

Mr. O. W. Pfeifer
Owens-Corning Fiberglas Corp.
Technical Center
Granville, Ohio

Dear Mr. Pfeifer:

Referring to your letter of December 7, I now have further word from Dr. Gaze in London concerning the questions you raised about the Pallmann Mill.

I enclose copy of his letter of December 16, and, after you study this, if you find that there is further information you think we can supply please let me know.

With kind regards and very best wishes for the Holidays.

Very truly yours,

NORTH AMERICAN ASBESTOS CORPORATION

President

RECryor/jc
encl.

01 040 1186

December 7, 1965

Mr. R.E.Cryor, President
North American Asbestos Corporation
Board of Trade Building
Chicago, Illinois 60604

Dear Mr. Cryor:

We have your letter of December 1, 1965. We have studied the brochure on the Pallman Mill. We have several questions for you to secure answers, if you will:

1. We would deduce from Dr. Gaze's letter that Cape Asbestos uses a Pallman Mill to open their amosite fibers, in the manufacture of CAPOSIL Insulation? Is this done by the dry or wet method?

2. Has Dr. Gaze had any experience in opening chrysotile asbestos with a Pallman Mill? Perhaps CAPOSIL uses only amosite asbestos fibers? As you know we use both amosite and chrysotile and in our case, could we use the Pallman Mill for opening both types? If both types of asbestos fibers are to be opened, could Dr. Gaze secure mill settings for the various gradings of both types?

3. Is a picker or any other type of fiber opening equipment used in conjunction with the Pallman Mill?

4. Could we propose to Dr. Gaze that he have Mr. McFarlane write concerning details of speeds and adjustments?

5. Does the Pallman Mill have any percentage of fiber length attrition loss, and if so does this vary between chrysotile and amosite types because of differences of original stiffness of the fibers?

6. We are having our Purchasing Agent get in touch with Pallman, in Hoboken, for further information.

We talked with Dorsey McRae regarding LD3 substitution for a possible shortage in W3 grading in 1966, and had him call the Plant for their approval to secure from you about 10 tons for trials, for any processing or mixing problem occurrence. We also wrote to Mr. Hardwick, at Berlin, suggesting he make these trials, in order to determine the adaptability [illegible] research.

[illegible] appreciate your securing some further answers for us, [illegible] in the Cape organization.

Sincerely,

Owens-Corning FIBERGLAS Corporation

C. W. Pfeifer

CWP/md

01 040 1188

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 PARK STREET · LONDON W.1.

TELEGRAMS: INCORRUPT LONDON TELEX

TELEPHONE: GROSVENOR 6022

TELEX Nº 23759.

16th December, 1965 DEC 20 1965

Dear Bob,

The answers to the questions from Owens Corning which you enclose with your letter of 9th December are as follows :

Pallmann Mill

i. We are, in fact, using the Pallmann Mill to open Amosite fibre for the production of Caposite but we are satisfied, from our pilot scale trials, that the mill is equally suitable for the preparation of Amosite for Caposil and indeed for any other process that we know of for which Amosite is used (with the possible exception of the very long textile fibres with which Owens Corning are not concerned).

We are already replacing our existing mills for other processes by Pallmann's and I believe it is only a matter of time and convenience before a complete substitution is made.

The Pallmann opening is carried out entirely dry.

ii. We have carried out experiments with Chrysotile using the mill and all our results were favourable. We have little doubt that the mill will be equally satisfactory for processing Chrysotile although we have not pursued this to any great extent since the processing of Chrysotile is not a large activity in any of our plants.

So far as the mill settings are concerned, Mr. McFarlane has provided the following information :

The three variables which influence the degree of fibre opening are :-

01 040 1189

(a) The rotor diameter

(b) The rotor speed

(c) The diameter of the confining ring

(d) The type and grade of crude fibre

For all grades of Amosite we have found that a rotor diameter of 720 mm and a speed of 2,600 r.p.m. produce the best results. The bore of the confining ring needs to be related to the resistance of the system through which the fibre is discharged from the mill. For any one installation, a few experimental runs will quickly determine the most suitable size of ring to be used for any particular grade of fibre. For example, our Pallmann Mill is connected to a system of ducting which terminates in a cyclone, the whole producing a resistance of about 3½ inches water gauge. Under these circumstances, we have determined that for the opening of DX, D11 and LD3 fibres, the best results are achieved with a confining ring of 450 mm diameter.

iii. No other opening equipment is used in conjunction with the Pallmann Mill, nor indeed should it be necessary.

iv. We hope that the comments given under paragraph ii will answer this question.

v. One of the major virtues of the mill is that it will open fibres to a consistent degree and without the production of fluffy material.

One of our reasons for choosing this mill, after an extensive search, is that it damages fibre less than any other mill that we have encountered. We would expect similar results with processing Chrysotile Asbestos.

vi. We have been given to understand that the Pallmann organisation in Hoboken have had considerable experience in the opening of Chrysotile Asbestos, but are unlikely to have much knowledge of the application of their mills to Amosite fibres. If, therefore, it is felt that we can provide further information on the subject, we shall be pleased to do so.

01 040 1190

Yours sincerely,

Dick

Mr. R.E. Cryor,
North American Asbestos Corporation,
Board of Trade Building, Chicago.

NORTH AMERICAN ASBESTOS CORPORATION

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

December 9, 1965

Mr. O. W. Pfeifer
Owens-Corning Fiberglas Corp.
Technical Center
Granville, Ohio

Dear Mr. Pfeifer:

Thank you for your letter of December 7, in which you raised several questions with reference to the Pallmann Mill.

As we are not in position to answer these questions I am taking the liberty of passing a copy of your letter on to Dr. Gaze, in London, and I am sure the answers will be forthcoming promptly.

I do know that Cape is using a Pallmann Mill to open Amosite Fibres, and this is done by the dry method.

I am grateful for the fact that your people at Berlin are studying the possible substitution of Grade LD3 Amosite in view of the particularly tight supply of Grade W3 for 1966. In accordance with your note, I am arranging to send you, under separate cover, three pounds each of Grade LD3, Grade DX and Grade W3. I do not believe I previously sent you a sample of DX, but we did arrange to send a sample of this to Berlin along with the LD3. Grade DX is somewhat closer to W3 in fibre length than is LD3, and either LD3 or DX gradings are in better supply than W3.

Will write you again as soon as I hear from Dr. Gaze.

Sincerely,

NORTH AMERICAN ASBESTOS CORPORATION

R G

President

RECryor/jc

01 040 1191

9.

V :

021 BE PL FG

1 BE TO PL

3 BE TO FG

G W PFEIFER PL

CC H V SMITH FG

R J MCEVOY PL

R S GRANT FG

W K SIDWELL FG

RE LONG FIBER ASBESTOS - I REPEAT BERLIN NOT ACCEPTING BOTTLENECKS AND WILL ON SMALL SCALE BASIS ATTEMPT USE OF THIS FIBER. WE DO NOT, HOWEVER INTEND MAJOR CHANGOVER AND/OR MASS PURCHASING UNTIL RESULTS FROM TRIALS ARE EVALUATED. PLS BE ASSURED THAT THE BERLIN PLANT IS MOST INTERESTED AND HV DEMONSTRATED THIS INTEREST IN EVER IMPROVING KAYLO PRODUCTS.

WLD U PREPARE UR SPECIFIC IDEAS OF CORRECTIVE ACTION SHOULD DIFFICULTIES BE ENCOUNTERED THANK

H HARDWICK BERLIN 300 12/8 CG

03/05 BE 032

03/07

01 040 1192

V

NO21 PL BE FG

1 PL TO BE

4 PL TO FG

M HARDWICK BE .

CC R S GRANT FG

H V SMITH FG

XCC R J MCEVOY PL

W K SIDWELL NR

RE USE LDS AMOSITE ASBESTOS... THERE ARE SEVERAL MAJOR ADVANTAGES ACCRUING TO UR OPERATION AND PRODUCT IF YOU CAN USE LONGER FIBER AMOSITE AND PARTICULARLY IF IT CAN BE MORE EFFICIENTLY OPENED, OTHER THAN WITH THE WET PROCESS THRU THE BAUER MILL. IF U DO ENCOUNTER PLUGGING AND BALLING IN THE POURING NOZZLES THEN PERHAPS WE SHLD COLLECTIVELY GIVE YOU ASSISTANCE IN REDESIGN OF POURING NOZZLES AND SLURRY TRANSPORT, TO ELIMINATE BALLING OF LONG FIBER AMOSITE PRIOR TO ENTRY TO NOZZLE AND ENTERTAIN IDEAS OF STRAIGHT PLANE INTRODUCTION OF SLURRY INTO POURING NOZZLE AS WELL AS MOLD. WE KNOW U HV A SMALL CLEARANCE DISTANCE BETWEEN EDGE OF CORE AND SIDEWALL OF SHELL ON SMALL SIZES OF ONE INCH WALL THICKNESS. IMPROVEMENT HERE CAN BE INVESTIGATED AS WELL. AT THIS STAGE DO NOT BELIEVE WE SHLD ACCEPT ANY BOTTLENECKS OF PRESENT EQUIP AS BEING FINAL TO IMPROVEMENT TO END PRODUCT, SINCE MARKETING IS PLACING SO MUCH EMPHASIS ON FIRST FOUR CATEGORIES OF THE NINE IMPROVEMENTS DESIRED

G W PFEIFER 1125 12/3 MS

01 040 1193

11.

V

001 BE PL FG

2 BE TO PL

19 BE TO FG

C W PFEIFER PL

W C TAYLOR FG

J B RHOADS BE

CC R S GRANT FG

H L HAYS FG

R J MCEVOY PL

DORSEY MCRAE FG

W K SIDWELL FG

H V SMITH FG

THANKS FOR UR MEMO OF 12/6 CONCERNING LD-3 GRADE AMOSITE AS POSSIBLE SUBSTITUTE FOR W-3 WHICH IS IN SHORT SUPPLY. WE HV 500 LB SAMPLES BEING DELIVERED FOR TRIALS. OUR CONCERN AT THE MOMENT RELATES TO "PLUGGAGE & BALLING" OF BATCH IN POURING NOZZLES WITH FIBER LONGER THAN W-3 AS WAS EXPERIENCED WITH HIGH PCT SUBSTITUTION OF "LOW COST" M-D ASBESTOS EARLY IN 65.

WE WILL TRY HOWEVER AND APPRECIATE UR ATTENTION.

MIKE HARDWICK BERLIN 330 12/7 CG

00/40 BE 002

06/50

01 040 1194

Owens-Corning
F I B E R G L A S

To Mr. M. Hardwick - Berlin

December 3, 1965

From O. W. Pfeifer - Granville

Subject LONG FIBRE AMOSITE - LD3

cc: Mr. R.S.Grant - Toledo
Mr. H.L.Hays - Toledo
Mr. R.J.McEvoy - Granville
Mr. Dorsey McRae - Toledo
Mr. W.K.Sidwell - Newark
Mr. H.V.Smith - Toledo

Dear Mike:

We were talking with Bob Cryor, of NAAC in Chicago, a few weeks ago and he later covered us on a letter he wrote to Drosey McRae, on a shortage of Amosite Gradings in asbestos for 1966.

Cryor wrote: "We still anticipate quite a little difficulty in meeting your requirements in the grades you prefer."

"I call to your attention a grade that has not heretofore been tried by your associates at the Berlin Plant. This is Grade LD3, which is a grading considerably longer in fiber length than Grade W3, which has been more or less standard with you for several years. Grade LD3 is normally priced considerably higher than W3, but in view of the shortage that we anticipate in the medium grades, we are prepared to supply you Grade LD3 at the same price as Grade W3. Provided there would be no serious technical problems in introducing the longer grading into your operations, the LD3 would represent a very good value in terms of fiber for reinforcement."

We were discussing this situation with Dorsey the other day and we suggested that he call you and have your permission to order 10 ton or so, for Plant trials. There may be LD3 in this country that Cryor can have shipped to you. The longer LD3 fiber in pipe insulation should increase the number of drops in the tests as well as increase overall impact strength. When this fiber is opened the longer length should be more advantageous yet. Even with the length attrition in the wet Bauer Mill it should give better results than W3. This also would be a distinct advantage to receive it at no price increase.

Several years ago, when Dr. Gaze of Cape Asbestos, Limited, was here from London, he spoke of LD3 grade of amosite being used, in CAPOSIL, where unusual high flexural strength was obtained, which was attributed to the fullest utilization of long amosite fibers. When Harry Cohen, Managing Director of Fibreglas South Africa, was here about a month ago, he spoke of the high strength of Cape's CAPOSIL, having just seen some of it in London. We are having Dr. Gaze give us up-to-date information on opening equipment for long fiber amosite, which we will cover you with when we receive it.

You may be somewhat concerned about the fuzzy appearance of Kaylo Block with the longer fibers but doubt if there will be much difference between LD3 and present W3. There may be quite a few batches made in a day that can be pumped directly to #1 and #3 holding mixers, for #1 flatware line, from the batch floor, if so scheduled, using W3 rather than LD3. Certainly there should not be any protruding surface fiber on block, as might be expected with the longer and

01 040 1195

stiffer "sticks" as in "Blue." When the longer LD3 is opened more efficiently with other equipment, than the wet Bauer Mill, the finer opened fiber may have less surface protrusion than is now present with W3.

This could be a lucky break of having this longer fiber fit into John Vyverberg's #3 IMPROVED BREAKAGE quality item. Regardless of opinions, we suggest you secure some LD3 and then check the results and from the specimens make the decisions. LD3 several years ago, before at least one price increase since, sold for $260 per ton. It probably is $275 or $285 now. Getting it for the same price as W3 is a favorable cost break too.

We are sending samples of LD3, in case you do not have them, along with W3 for length comparison.

O. W. Pfeifer

OWP/md

01 040 1984

14

Mr. G. H. Hamer - Granville

O. W. Pfeifer - Granville

December 6, 1965

<u>Opening Amosite Fibers</u>

Dear Glenn:

There is a piece of equipment for opening amosite asbestos fibers called a Pallman Mill. It is of English manufacture but there is an American distributor, namely,

Pallman Pulverizers Inc.
315 New Art Street
Hoboken, New Jersey

We would like for you to secure literature regarding this mill and also arrange for one of their representatives to call on us, to discuss the efficiencies of this mill over their American competitor, Bauer Brothers, of Springfield, Ohio.

Thanks for your help.

O. W. Pfeifer

OWP/md

01 040 1197

15

NORTH AMERICAN ASBESTOS CORPORATION

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

December 1, 1965

Mr. O. M. Pfeifer
Owens-Corning Fiberglas
Technical Center
Granville, Ohio

Dear Mr. Pfeifer:

Further to your letter of November 10 and my letter of November 12, I now have had a letter back from Dr. Gaze in London in which he gives some information on the Pallmann Mill, which I know is used effectively in Europe for processing Amosite.

I am enclosing herewith a copy of Dr. Gaze's letter to me, and a brochure on the Pallmann Mill, which explains the operation in some detail.

After you have looked this over, if there is any additional information you would like us to try to obtain please let us know.

With kind regards and best wishes.

Sincerely,

NORTH AMERICAN ASBESTOS CORPORATION

President

RECryor/jc
encl.

01 040 1198

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 PARK STREET · LONDON W.1.

TELEPHONE: GROSVENOR 6022

TELEX Nº 23759.

NOV 22 1965

17th November, 1965

Dear Bob,

Thank you for writing to me on 11th November regarding Owens Corning and their interest in methods of opening Amosite. I well remember the visit you mention though I confess I have no recollection of undertaking to provide Dr. Kalousek with this particular information.

We do agree that there should be more information available regarding the methods of treating our fibres and Dr. Hodgson is at present engaged on the first draft of a brochure on this very subject.

So far as Mr. O.M. Pfeifer's problem is concerned, our experiments have clearly indicated that the Pallmann Mill is the best equipment available in Europe for opening Amosite of the type in which he is interested. The High Speed Cobra is also an excellent machine and works on a very similar principle; this is used extensively in South Africa and I only suggest that the Pallmann is the more interesting alternative since the High Speed Cobra is essentially a piece of South African equipment whereas Pallmann have agents and service in Europe and the United States. Their American address is :

Pallmann Pulverizers Inc.,
315 New Art Street,
Hoboken,
New Jersey.

I am enclosing a brochure and would suggest that they are contacted but if further information is required, I will ask Mr. McFarlane to write separately giving details of the speeds and adjustments which would be suitable for Mr. Pfeifer's particular application.

Yours sincerely,

Dick

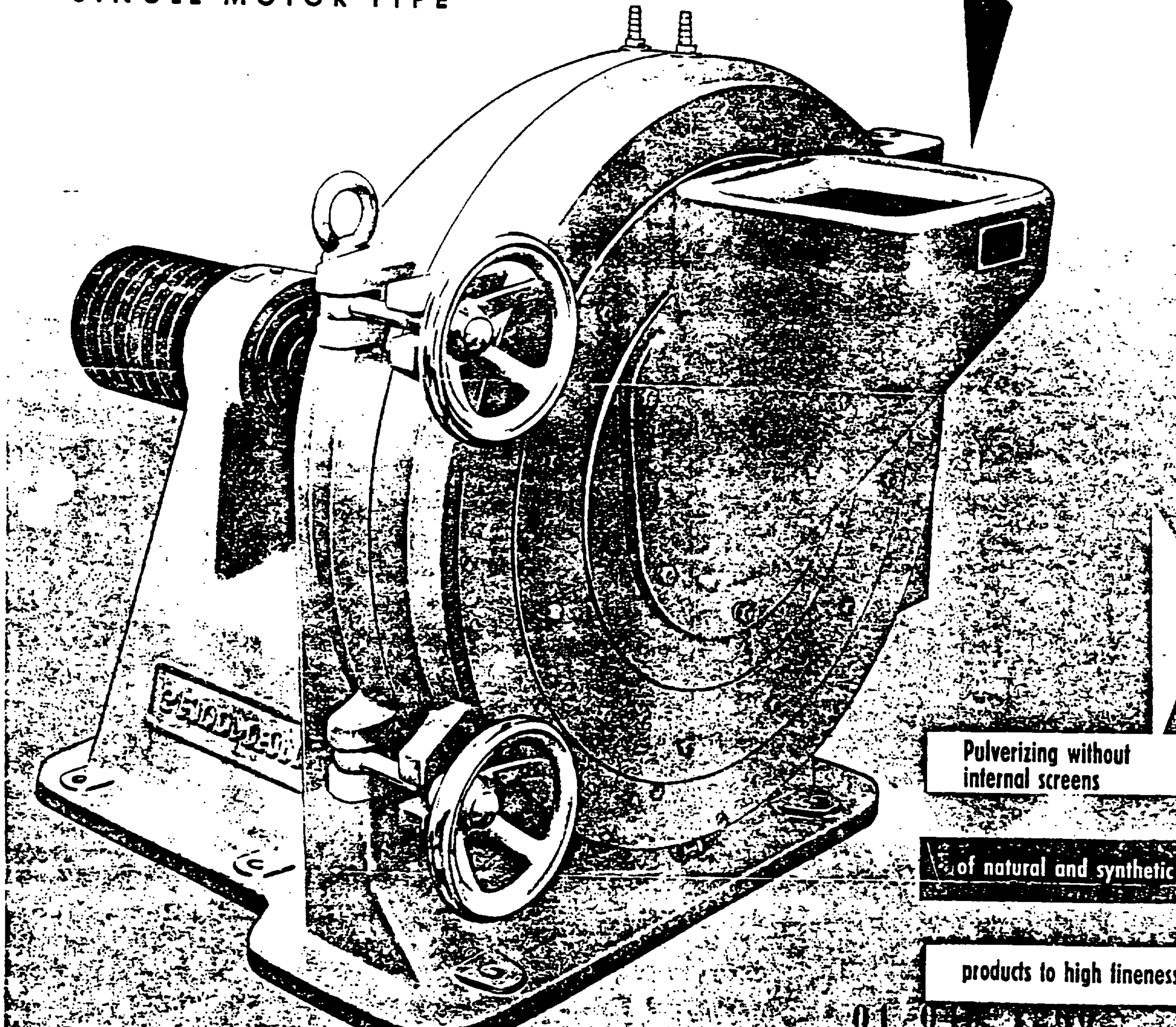
01 040 1199

Mr. R.E. Cryor,
North American Asbestos Corporation,
Chicago,
Illinois 60604.

17.

TURBO PULVERIZER

SINGLE MOTOR TYPE



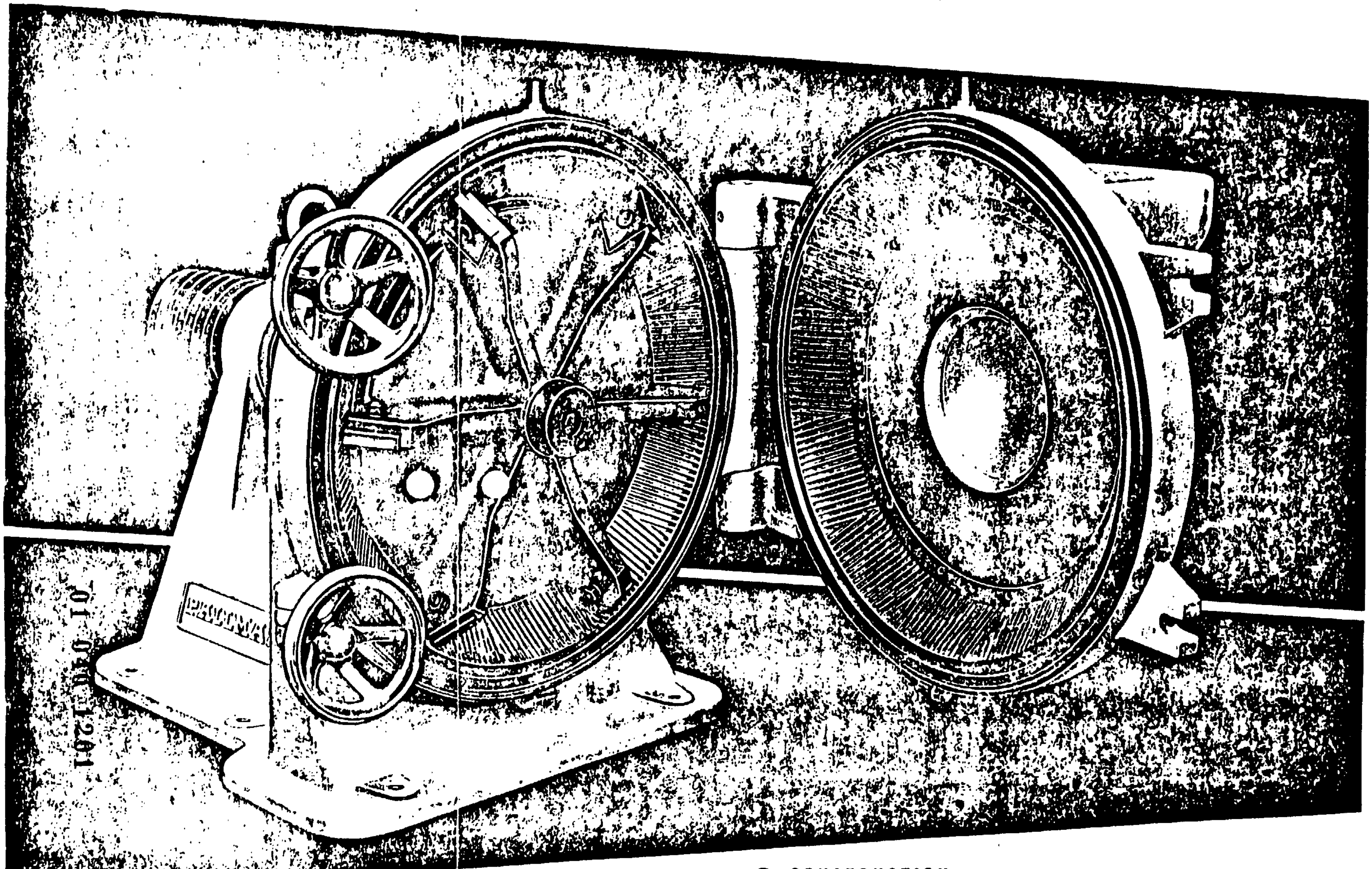
Pulverizing without internal screens

of natural and synthetic

products to high fineness

PALLMANN PATENTS IN MAJOR COUNTRIES THROUGHOUT WORLD

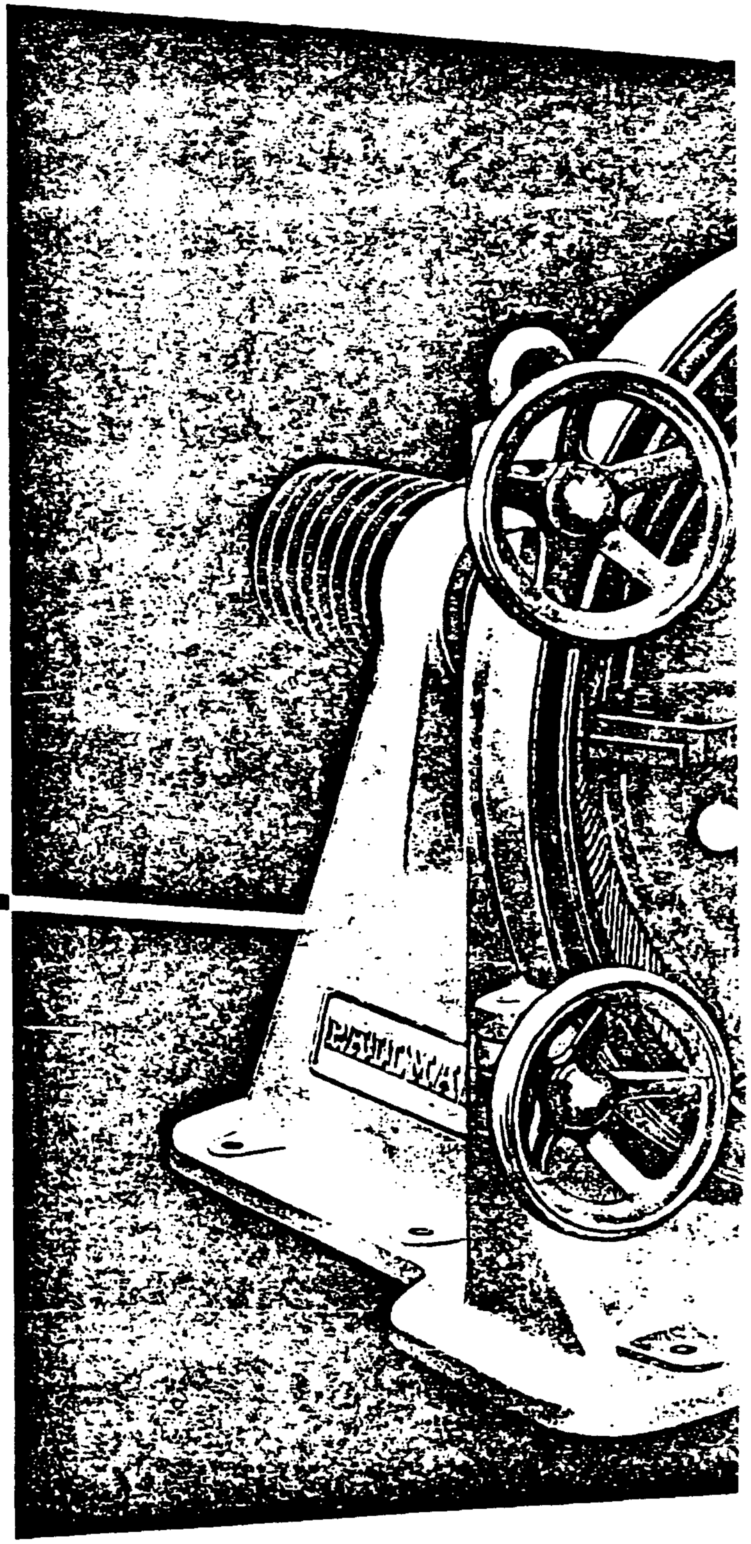
Original PALLMANN



CONSTRUCTION DRIVE

PALLMANN - PULVERIZERS

The economy of the PALLMANN Pulverizer - Single - Motor type - is proven in continuous operation owing to its sturdy construction along simple lines. The grinding surfaces are of a high chrome vanadium - nickel steel construction.



● METHOD OF REDUCTION

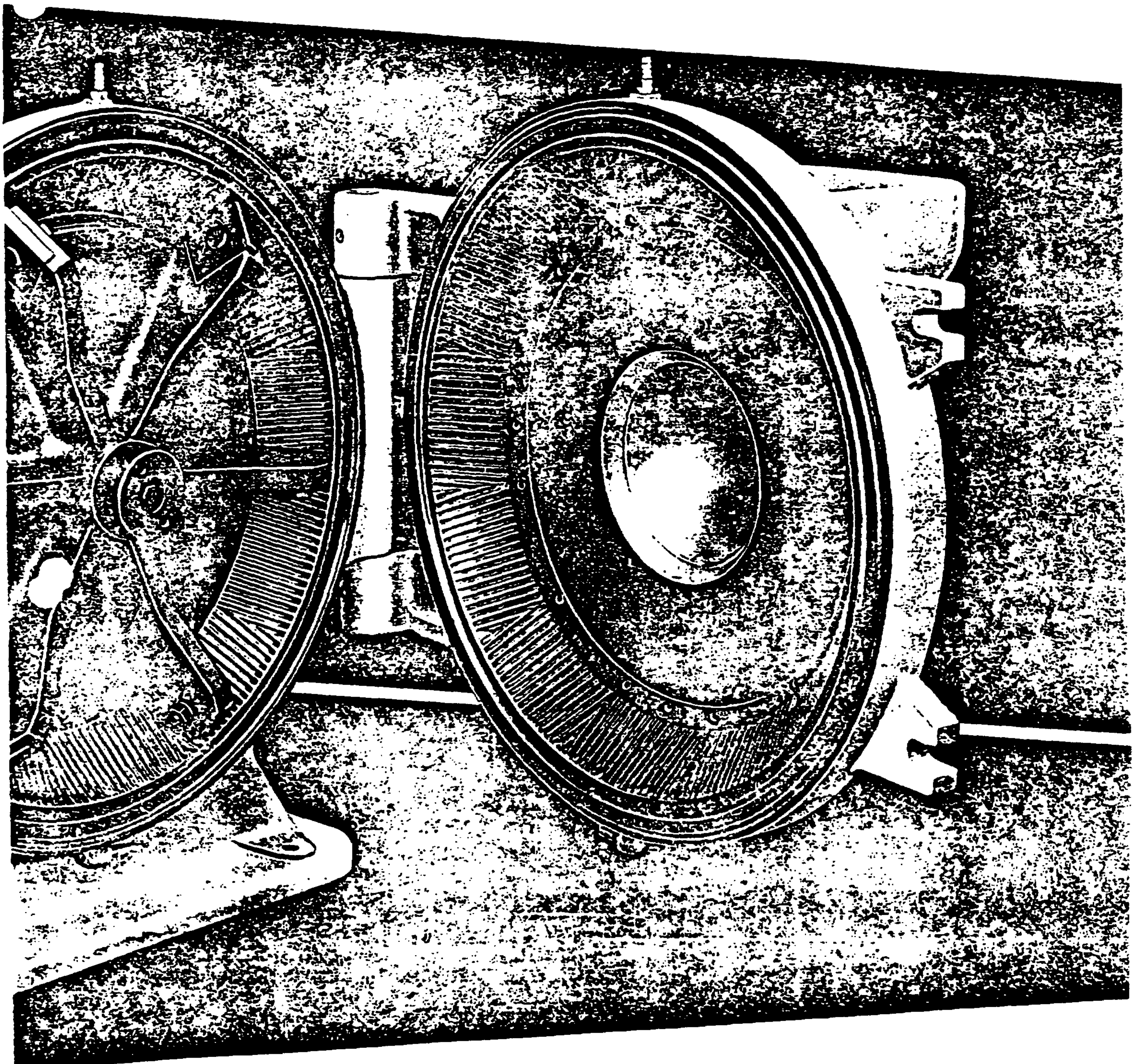
The method of reduction of the Pallmann differs from those in common use. Material entering through the feed chute is thrown by an impeller rotating at high speed against the grinding liners of a chamber formed by two oposing cones The liners are divided into replaceable sections.
There are three principles of reduction employed in a single action dependent on selection of liner design:

1. Turbo (Jet) 2. Impact 3. Shear.

The air suction in a second, collecting chamber located behind the grinding chamber draws the ground particles through an annular gap between the two chambers. Particle fineness is controlled by inserting confining rings of different sizes in the annular gap. The fineness of the material is determined by how long it remains in the grinding chamber before removal by air suction. The impeller and a fan located behind the impeller on the shaft create the high velocity of air.

01 040 1202

. . for economic reduction



● CONSTRUCTION

The mills are heavily constructed and designed for tough operations. The housing is a heavy, cast iron. The castings are properly aged before machining. The impeller and liners are a steel construction while the shafting is especially compounded to withstand high torque.

● DRIVE

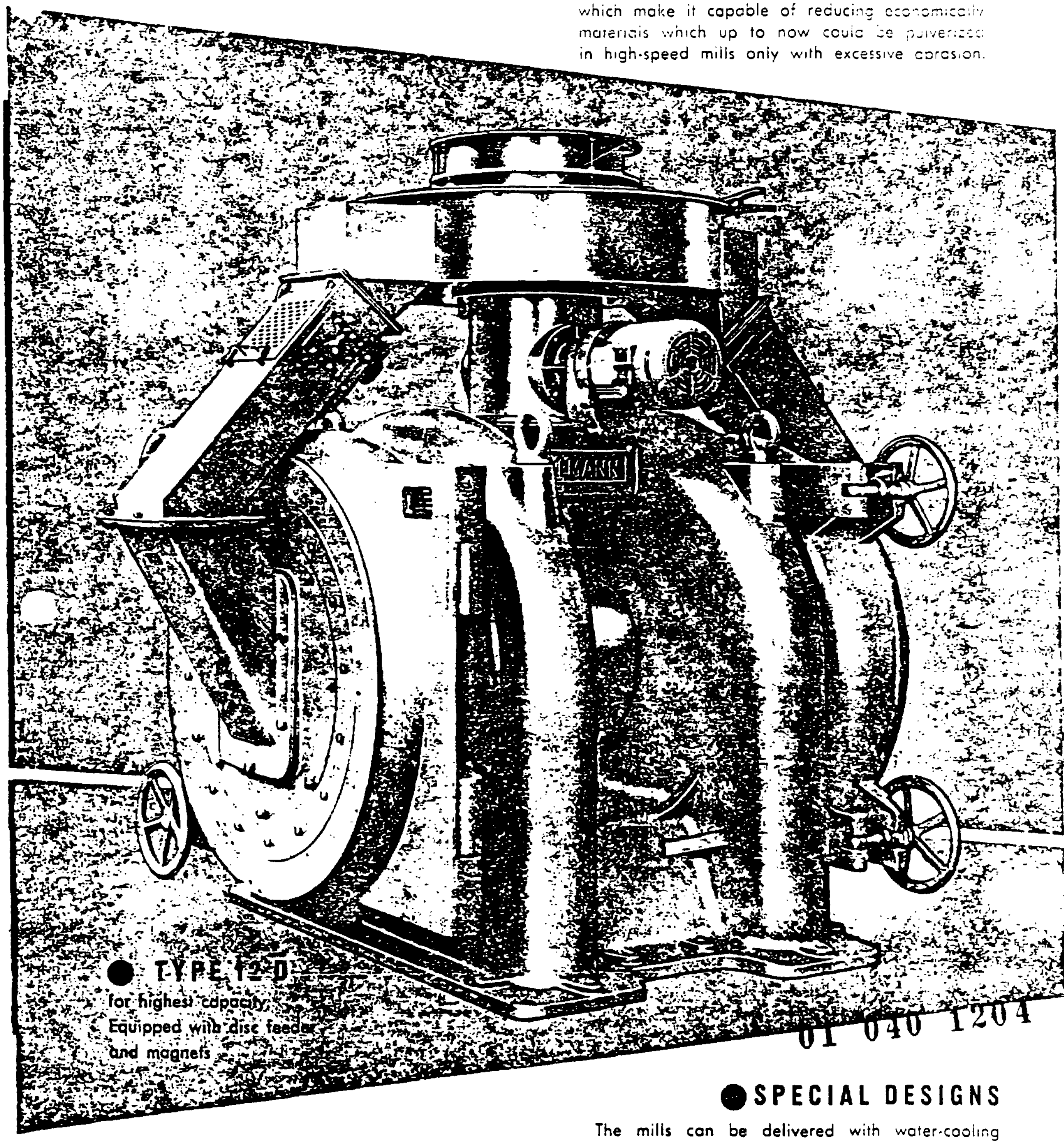
The pulverizer can be either V-belt or direct driven. Overdimensional bearings, low R.P.M. of the impeller compared to other high-speed pulverizers, and dynamic balancing contribute to trouble-free operation. The bearings are packed especially to prevent dust introduction.

FEEDER

Depending on the nature of the material, the pulverizer is fed by a vibratory, disc, or any mechanical apparatus providing a uniform flow. A magnet should be placed in the feed chute to trap iron or steel particles.

WEAR

The wearing points are the fixed hammer plates on the impeller and the grinding liners. A complete replacement of all the hammer plates is effected in ten minutes, resulting in savings through a minimum of downtime. A reason of the widespread use of the Pallmann Single-Motor Pulverizer is the wear resistance of the wear elements which make it capable of reducing economically materials which up to now could be pulverized in high-speed mills only with excessive abrasion.



TYPE 12-D
for highest capacity.
Equipped with disc feeder and magnets

01 040 1204

SPECIAL DESIGNS

The mills can be delivered with water-cooling jackets behind the cones, air-holes in the housing for additional air-cooling, or a system for blowing in warm air for drying material. All parts coming in contact with material can be made of stainless or an acid-resisting steel. The complete grinding system can be designed for hermetical enclosure for operation with insert gas, in which system we can supply an air-tight enclosed feeder.

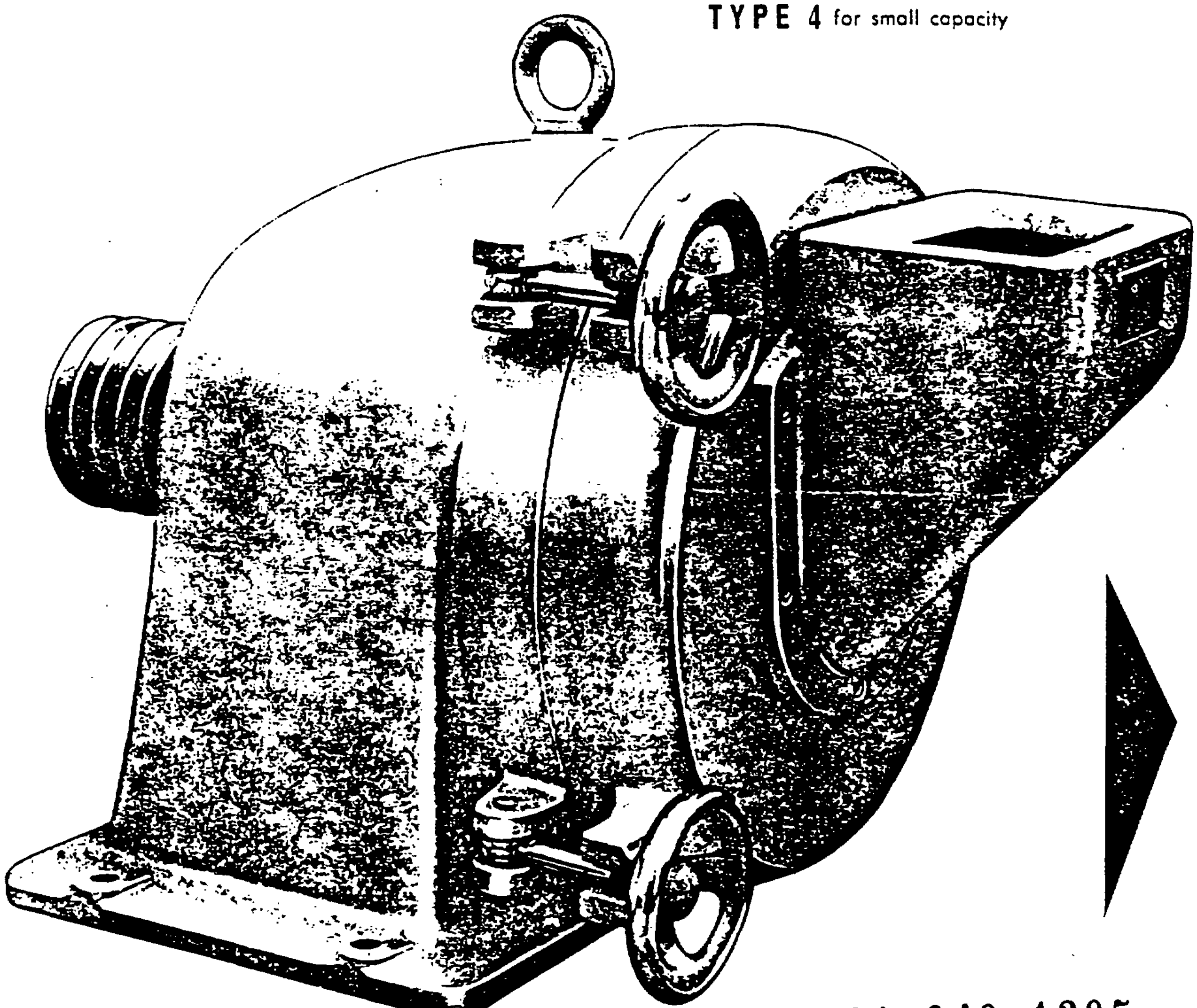
CLEANING

By the simple turn of two handwheels and removal of the impeller, the entire mill is accessible for cleaning.

THE GENERAL LINE OF PALLMANN GRINDERS

Pallmann Mills are available for coarse grinding, de-fiberizing, controlled granulating pulverizing, emulsifying, or mixing of soft, brittle, tough, smearing, hygroscopic, fibrous, fatty, heat-sensitive, and plastic products. Wet operation is possible with the Double-Rotating Mills, into which water can be added during grinding.

TYPE 4 for small capacity



01 040 1205

PRESENT APPLICATIONS

The following medium-hard minerals can be reduced efficiently: raw gypsum, anhydrite, bentonite, dry and wet clay, talc, medium-hard ores, graphite, mica, diatomaceous earth, fluorspar, chalk, barite, oil shale, shells, medium-hard limestone, kaolin, asbestos.

Coal-like products: coal, lignite, peat.

Colors: organic and inorganic dyes and pigments, iron oxides, lead oxides, ochre.

Pharmaceutical Products: drugs, leaves, ergot, china bark, maniok and other roots, bark.

Grinding and mixing of salts and phosphates, such as: potash, fertilizer salts, raw phosphate, triple superphosphate, metasilicate and other alkalis, glauber's salt, sodium phosphates.

Various Chemical Products: ammonium nitrate, aluminium sulfate, magnesium oxide, washing and detergent powders, soda, ammonium sulfate, so-

Oil and fatty products: spices, fish and fishmeal, meats, soap fat, fresh animal bones, nuts, malt, olive pits, crackling, bone glue.

Grain Milling Products: exra fine flour, farinaceous products, barley, wheat feeds, carob beans, hay, rice flour, potatoes, cocoa shells.

Fibrous Materials: wood flour, chips for particle board, paper pulp, straw, bagasse, asbestos, chrome and tanned leather for synthetic leather manufacture, cork granules and flour, textiles, board and paper waste, bamboo, hemp, reeds, tobacco stems, flocking chemical cellulose.

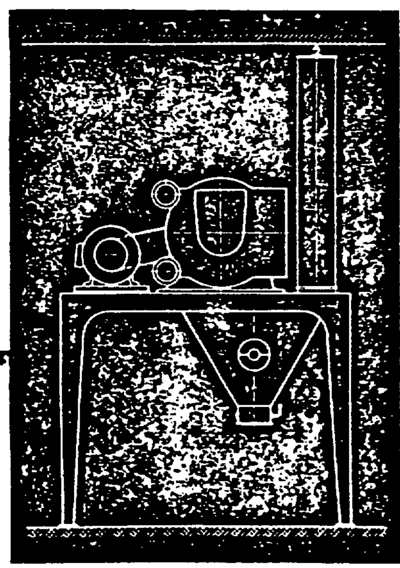
Cocoa and Coffee: cocoa beans, cocoa presscakes, coffee.

Plastic and elastomeric products: polyethylene, granules and scrap film, rigid and flexible P V C, styrene, nylon, foam rubber waste, record scrap, reinforced plastic waste, *foam plastics.*

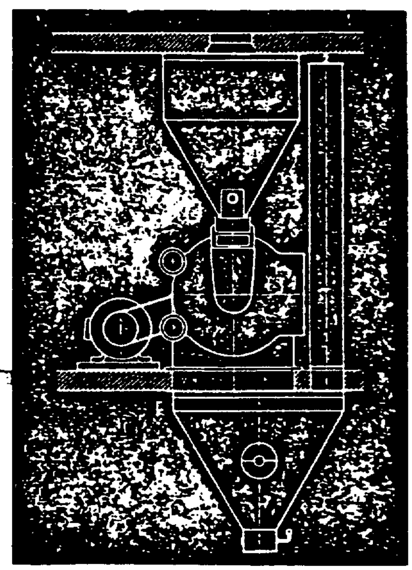
Natural resins and pitch: colophonium, bitumen, asphalt, cumaron, coal tar, hard pitch.

ADVANTAGES OF PALLMANN

1. high output with less power
2. gritless product
3. easy adjustment of fineness without additional investment
4. wear-resistant grinding surfaces
5. no screen in mill
6. frequently no need for subsequent classification
7. grinding of different feeds up to fist size
8. can achieve narrow particle size distribution
9. easy substitution of wear parts with downtime minimized
10. low grinding temperature due to high volume of air
11. less tendency to smear
12. little space
13. moist and dry grinding
14. pulverizes heat-sensitive materials
15. a proven robust construction with air tight housing
16. no attrition pins
17. no tooth discs
18. no gear transmission



Installation of mill on platform



Installation of mill on floor

Mills manufactured in five sizes according to rotor diameter: 18", 24", 32", 48" and double-chambered 48".

For carrying out free tests, modern testing facilities are available. Based on years of experience in size-reduction and accessory field. Pallmann technicans are able to discuss and handle many grinding problems. Complete installations are offered.

ORIGINAL·PALLMANN

01 040 1206

PALLMANN PULVERIZERS LIMITED

59, Brompton Road,
London, S.W.3.

Telephone: KEN 8464 & KEN 8474

Cables: ELDIMON, London

24

November 10, 1965

Mr. R. E. Cryor, President
North American Asbestos Corporation
Board of Trade Building
Chicago 4, Illinois

Dear Mr. Cryor:

I am now located at the Technical Center, at Granville, Ohio, and am in need of some information on your products, which you can readily supply.

Would you please send me data on your various grades of amosite asbestos, on fiber lengths and percentages of the same in the various grades that we use, as well as others you have. Would also like to have the chemical analysis as well.

Several years ago, Dr. Gage of Cape Asbestos Ltd. called at the Technical Center and talked with Dr. Kalousek, who is no longer with us. He, Dr. Gage, promised to send drawings and details of their equipment for fiberizing amosite asbestos, when he returned to England. He was accompanied by your Mr. Jerome. Perhaps this fiberizing equipment information is available from your office. He also recommended our use of your LD-3 grade of fiber. We never did receive the information, that is to the best of our knowledge. We have searched the files here to no avail.

We hope you can give us the above information we are seeking. Thank you for your kind service. We appreciate your help. We would be glad to see you again.

Yours very truly,

O. W. Pfeifer, Manager
High Temperature Products

OWP/md

01 040 1207

25

OCT 12 1961

OWENS-CORNING FIBERGLAS CORPORATION

INTRA-COMPANY CORRESPONDENCE

TECHNICAL CENTER — GRANVILLE, OHIO

ATTENTION OF Mr. R. F. Shannon

October 10, 1961

FROM G. L. Kalousek

SUBJECT CALL REPORT - NORTH AMERICAN AVIATION CORP.

W. E. Cass - Granville
A. C. Siefert - Granville
O. W. Pfeifer - Toledo
B. E. Boyd - Toledo
W. E. Sidwell - Toledo
R. C. Amos - Berlin

Dr. Gage of Cape Asbestos Ltd., suppliers of amosite asbestos through NAAC for Kaylo, came to Granville to discuss our problems with and needs for, amosite. Mr. Jerome of NAAC accompanied him. Dr. Gage has been closely associated with development of Caposil, a hydrous calcium silicate, nearly the same as Thermobestos, manufactured in England.

His company, in developing Caposil, made a study of various methods of opening amosite fiber. They found the Bauer mill very destructive to fiber length. In fact any rough wet handling of amosite causes rapid fiber length breakdown. Dr. Gage strongly urged, that if we are to obtain optimum performance from amosite fibers, to stop use of Bauer milling, and hydropulping in handling the fiber. He recommended the fiber be opened dry and added as the last ingredient to the slurry and then mixed just long enough in a paddle type or ribbon type mixer to disperse it. Pumping is also destructive and the Moyno pump is recommended for handling Kaylo slurries. The same recommendations were made to Production by Research. These are the basis for the Sprout Waldron experimental trials at Berlin.

Dr. Gage upon his return to England will forward complete drawings, and details, of their equipment for fiberizing Amosite. Caposil contains 18% amosite and is formed by pressure filtration similarily as Thermobestos. This product at 11 pcf density exhibits the amazing flexural strength of 250 psi. The high strength is not attributed so much to the molding process as to the fullest utilization of long amosite fibers. The LD-3 grade ($260/T compared to $203/T for W-3) is used. According to Gage, Caposil is resistant to impact breakage.

Cape Asbestos also produces a high temperature insulation, Caposite, which is similar to Unibestos. Their total high temperature insulation sales are close to $5,000,000/year. Caposite is being replaced by Caposil and it is planned to go over completely to the hydrous calcium silicate insulation.

M C [illegible] for

G. L. Kalousek

GLK:an

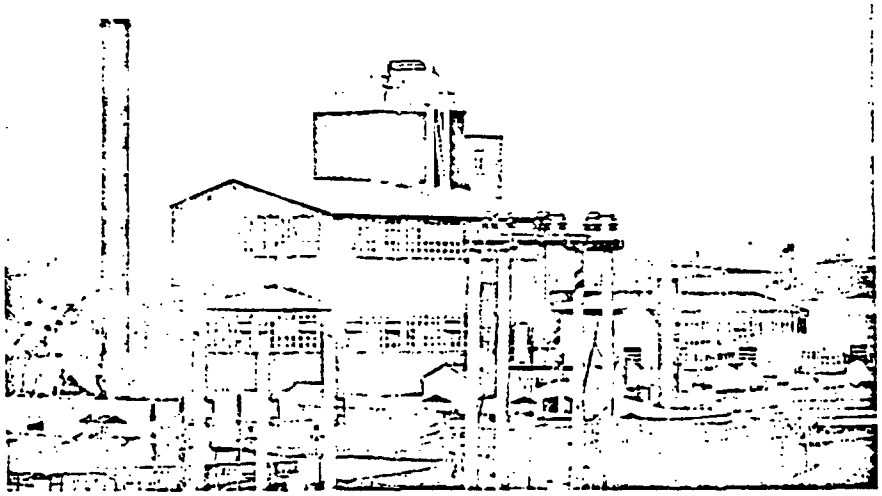
TAm

01 040 1208

26,

1 YEAR ......
5 MONTHS ......
DESTROY NOW ......

WHY FILE THIS?



SPROUT-WALDRON EQUIPMENT USED BY EHRET MAGNESIA MANUFACTURING COMPANY TO PRODUCE QUALITY INSULATION

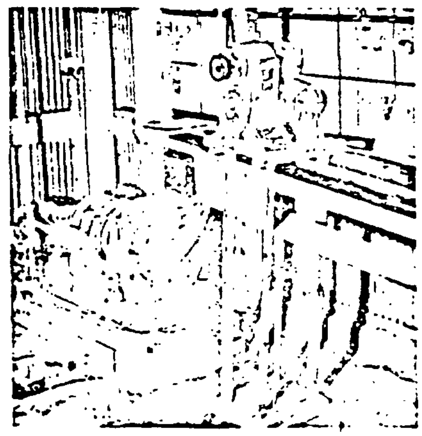
The concept of using carbonate of magnesia reinforced with asbestos fiber as an insulating material dates back to the 1880's and the commercial manufacture of the material by Ehret Magnesia Manufacturing Company has a history covering more than half a century. But something new has certainly been added!

The big difference in the process at Ehret and that employed by most magnesia insulation manufacturers is the use of a traveling robot, called a "Weigh Larry." Carrying two conical hoppers and equipped with blinking lights, rheostat adjustments, indicating devices and a variety of pushbuttons and control instruments, this compact pneumatic and electric brain operates the production cycle with amazing precision. The Larry carries its own air compressors pressure tank, and two conical hoppers. It moves from station to station, taking an accurately weighed charge from the mixers, filling the preheaters, which in turn automatically fill the molding machines.

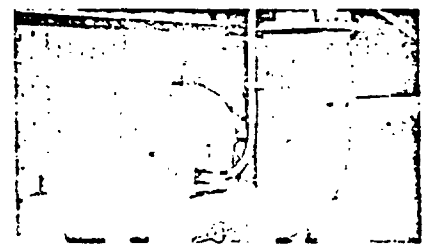
The Sprout-Waldron contribution to this modern magnesia insulation manufacturing system includes a 24" single runner heavy duty swing-head attrition mill and a pneumatic system for handling the fiberized asbestos. The mill operates intermittently on a 24-hour day, seven day a week schedule producing a batch every three-quarters of an hour. It is equipped with anti-friction bearings, adjustable runner head for coarse and fine grinding, spike tooth manganese steel shredding plates and a shaft mounted 30 hp, 1800 rpm open frame motor.

Both African and Canadian asbestos fibers are fed into the mill by means of a Sprout-Waldron 14" x 30' belt conveyor driven by a Reeves Vari-Speed drive with a 1 hp, 1800 rpm motor. Here the fiber bundles are opened and the individual fiber strands fluffed and separated so as to provide greater structural support and reinforcement to the magnesia insulation.

Fiberized asbestos is picked up by Sprout-Waldron products collecting system and conveyed into either of two different process streams, depending on whether Thermalite (85% magnesia insulation) or Thermasil (calcium silicate insulation) is being produced. The former is the most common and is utilized for temperatures in the range of 600° F. The calcium silicate insulation is suitable for use to 1200° F. The pneumatic system consists of roof mounted 42" dia. steep cone collectors with flanged inlet and outlet air connections and an 18" inside dia. discharge at the base of the cone, and No. 3 PHLM fan direct connected to a 10 hp, 1800 rpm standard open-type motor. A simple manually operated diverter in the line between the fan and the cyclones or cone collectors determines the system into which the milled asbestos is fed.



This S-W Belt Conveyor feeds into a Sprout-Waldron Single Runner Attrition Mill.



Sprout-Waldron products collecting fan picks up fiberized asbestos from attrition mill and conveys it to either of two process lines.

The adjustable runner head device on the attrition mill is used to advantage when changing from one type of insulation to another. When the high temperature insulation material is being prepared, the attrition mill is used in relatively wide open position because the fiberizing is followed by violent mixing in a hydrapulper and ribbon mixer. Closer plate adjustment is used on the 85% magnesia insulation because the process involves relatively mild mixing in rotary units.

01 040 1209

NORTH AMERICAN ASBESTOS CORPORATION

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

November 12, 1965

Mr. O. M. Pfeifer
Owens Corning Fiberglas
Technical Center
Granville, Ohio

Dear Mr. Pfeifer:

It was pleasant to have a chance to talk with you again on the telephone yesterday, and while I do not at this moment have the letter you sent me, I am taking steps to ask Dr. Gaze in London to give us up-to-date information on the Pallman Mill, and other types of opening equipment for both wet and dry opening. I expect I will have something I can pass on to you in about ten days time.

You also indicated you were interested in chamical analysis of the various types of asbestos, and I think the best I can do is to refer you to the Asbestos Textile Handbook (copy enclosed), which gives this information on Page 7.

You were interested too in information on the fibre length of the various gradings of Amosite, and in the same book on Page 22 a range of the approximate length of the unmilled Amosite fibres is shown.

Another indication of fibre length is in the comparison of Canadian Box Test values. As you know the Canadian Box Test method consists of shaking sixteen ounces of asbestos through three screens into a pan. The first screen is 1/2" mesh, the second screen is 1/4" mesh, the third screen is 10 mesh per inch, and anything that goes through the third screen is caught in the pan. Comparative Canadian Box Test values for the various grades of Amosite are shown below:

Amosite Grade				
LD-3	15-1/2	0	1/2	0
D-3	12-1/2	2-1/2	1	0
DX	14-1/2	1/2	1/2	1/2
MD	11-1/2	1-1/2	2	1

- continued -

01 040 1210

Mr. O. M. Pfeifer November 12, 1965

K-3	13	1	1-1/2	1/2
~~W-3~~	~~12-1/2~~	~~1-1/2~~	~~1-1/2~~	1/2
SW	6-1/2	4	4	~~1-1/2~~
GW	0	12	2-1/2	1-1/2
GK	0	12	2	2
S-33	0	10	3	3

Trusting you will find this information of some value in your work, and looking forward to the possibility of visiting you before too long.

Sincerely yours,

NORTH AMERICAN ASBESTOS CORPORATION

RECryor

President

RECryor/jc
encl.

01 040 1211

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

November 12, 1965

Mr. Dorsey McRae
Owens Corning Fiberglas
Toledo 1, Ohio

Dear Mr. McRae:

Referring to our conversations earlier this week, on the subject of Amosite gradings, we still anticipate quite a little difficulty in meeting your requirements in the grades you prefer.

In this connection, I call to your attention a grade that has not heretofore been tried by your associates at Berlin plant. This is Grade LD3, which is a grading considerably longer in fibre length than Grade W5, which has been more or less standard with you for several years.

Grade LD3 is normally priced considerably higher than W5, but in view of the shortage that we anticipate in the medium grades, we are prepared to supply you Grade LD3 at the same price as Grade W5. Provided there would be no serious technical problems in introducing the longer grading into your operations, the LD3 would represent a very good value in terms of fibre for reinforcement.

Enclosed herewith are small samples of both LD3 and W5 for visual examination, and if your Berlin plant could test and evaluate this grading we would be glad to send you sufficient material for plant test.

Sincerely yours,

NORTH AMERICAN ASBESTOS CORPORATION

President

LECryer/js
cc/ea: Mr. H. L. Hays
Mr. J. M. Fisher

01 040 1212

Long fiber amosite is used principally in the manufacture of thermal insulation.

Deposits located in Transvaal Province, Union of South Africa, provide the only commercial source of amosite fiber. Approximately 57,000 short tons were produced there in 1957[4].

Anthophyllite: Essentially a silicate of magnesium and iron, usually with a small amount of aluminum, anthophyllite belongs to the group of orthorhombic amphiboles. Its chemical formula may be expressed as $(Fe.Mg)_7 Si_8O_{22}(OH)_2$. The fibers of anthophyllite are usually brittle and lacking in tensile strength and are therefore not suitable for textiles.

Tremolite and Actinolite: These monoclinic amphiboles are least important of the commercially used varieties of asbestos.

Tremolite—$CA_2Mg_5Si_8O_{22}(OH)_2$—is a calcium-magnesium silicate whose fibers are often long and silky but generally too brittle and of inadequate tensile strength for use in the fabrication of textiles. It is of value principally for filtration purposes because of its freedom from iron and its resistance to attack by acids. Most of the tremolite fiber produced comes from deposits located in northern Italy.

Actinolite—$(Ca.Mg.Fe)_6Si_8O_{22}(OH)_2$—is similar in composition to tremolite except for the presence of iron which replaces some of the magnesium. Like tremolite, the fibers are too weak and brittle for spinning but have good resistance to acids. Its practical value is limited and production is small.

TABLE A—CHEMICAL COMPOSITION OF VARIOUS TYPES OF ASBESTOS*

	CHRYSOTILE	CROCIDOLITE	AMOSITE	ANTHOPHYLLITE	TREMOLITE
SiO_2	37-44%	49-53%	49-53%	56-58%	51-62%
MgO	39-44%	0-3%	1-7%	28-34%	0-30%
FeO	0.0-6.0%	13-20%	34-44%	3-12%	1.5-5.0%
Fe_2O_3	0.1-5.0%	17-20%	———	———	———
Al_2O_3	0.2-1.5%	———	2-9%	0.5-1.5%	1.0-4.0%
H_2O	12.0-15.0%	2.5-4.5%	2-5%	1.0-6.0%	0-5.0%
CaO	Tr.-5.0%	———	———	———	0-18%
Na_2O	———	4.0-8.5%	———	———	0-9%
$CaO+Na_2O$	———	———	0.5-2.5%	———	———

*Encyclopedia of Chemical Technology, Vol. 2—Anthrone to Carbon Copyright 1948. Interscience Publisher, New York and London.

01 040 1213

30

Amosite: For the same reason as stated under "Crocidolite" above, amosite is also supplied in a semi-milled condition and classified on the basis of length of fiber in the seams or unmilled cobs from which the various grades are obtained. Control of quality is also achieved by comparison with standard or "umpire" samples, supplied at regular intervals from the mills.

Fibers from the various mining properties in the Transvaal are graded as shown below:

Grade	Approx. Length Range of Unmilled Fiber	Designation	Color
D3	2" to 6"	Long	Gray
LD3	2" to 6"	Long (part fiberized)	Gray
D11	1" to 2"	Medium Long	Gray
DX	1" to 2"	Medium Long	Gray
MD	3/4" to 2"	Medium	Gray
M	3/4" to 2"	Medium	Gray
K3	1/2" to 2"	Medium Short	Gray
W3	1/2" to 2"	Medium Short	Gray
SX	3/16" to 1"	Shorts	Gray
SW	3/16" to 1"	Shorts	Gray
S2	3/16" to 1"	Shorts	Gray
GX	1/8" to 3/4"	Shorts (part fiberized)	Gray
GW	1/8" to 3/4"	Shorts (part fiberized)	Gray
S3	1/8" to 3/4"	Shorts (part fiberized)	Gray

01 040 1214

SECTION – 2

ASBESTOS THE RAW MATERIA

SECTION 2 -- ASBESTOS, THE RAW MATERIAL

Page 2 -- The last paragraph and the last sentence discloses that amosite asbestos is used in Cape Asbestos "Caposil" the 1400° calcium silicate, which is 200° higher than our Kaylo at 1200° F and only 400° F below Kaylo 20 products. The Cape's Caposil has a higher maximum temperature than any of the U.S. manufactured high temperature insulations, with the exception of Carey Temp claimed at 1600° F, which is not a calcium silicate, and Unibestos at 1600° F, which is not a calcium silicate either.

Page 3 -- The last paragraph gives the origin of the name "Crocididolite" coming from the Greek meaning 'wooly stone'. "Chrysotile" stems from the Greek also, meaning 'fine hair of gold'.

Page 5 -- The last paragraph here states the fineness of asbestos fibers, which are in the same millionths of an inch diameters as are Fiberglas filaments.

Pages 7 and 8 -- Here is described the difference between amphibole and chrysotile asbestos. The former fibers are solid throughout, while the chrysotile fibers are believed to be hollow.

Page 14 -- The grades of amosite asbestos are here listed at their mines of origin.

Page 24 -- "AW" amosite is described as a blend of fibers in a more opened condition than the other grades and is a processed, semi-short grade.

Page 26 -- Under "Amosite" are listed the various products of "Caposil". The 1800° F high temperature insulation is not a calcium silicate and is not made in pipe diameters. It is made in a plastic, hard setting cement as well.

NAAC NORTH AMERICAN ASBESTOS CORPORATION

U. S. Subsidiary, The Cape Asbestos Company Limited, London

BOARD OF TRADE BUILDING, CHICAGO, ILLINOIS 60604 • PHONE: (312) 922-7435 • CABLES: NORAMCO, CHICAGO

September 22, 1966

Mr. O. W. Pfeifer
Owens-Corning Fiberglas Corp.
Technical Center
Granville, Ohio

Dear Mr. Pfeifer,

Thank you for your letter of September 19, addressed to Mr. Cryor. In accordance with your request we are enclosing the following literature:

"Asbestos The Raw Material"
"Asbestos Reinforced Plastic Pipe"
"Asbestos Reinforced Plastics Resist Heat & Chemicals"
"The Use of Crocidolite Asbestos in Reinforced Plastics"

Very truly yours,

NORTH AMERICAN ASBESTOS CORPORATION

Jean Canzoneri

Secretary to R. E. Cryor

JCanzoneri/encl.

01 040 1217

asbestos the raw material

CAPE ASBESTOS FIBRES LIMITED 114 PARK STREET LONDON W1

01 040 1218

The myth

Asbestos in history

The Emperor Charlemagne

Marco Polo

Archeological studies have shown that as early as 2500 years before recorded time people in Finland knew how to add fine asbestos fibre to the raw material to strengthen the sides of lightly fired pottery. When the material had been strengthened, the sides of the vessels could be made thinner to produce cooking utensils which were not only lighter in weight but in which food could be cooked more quickly. In 438 BC Plutarch recorded that the Vestal Virgins who tended the ever-burning fire of the sacred royal hearth held 'perpetual lamps' with wicks of a woven material which was almost certainly asbestos mixed with vegetable yarn.

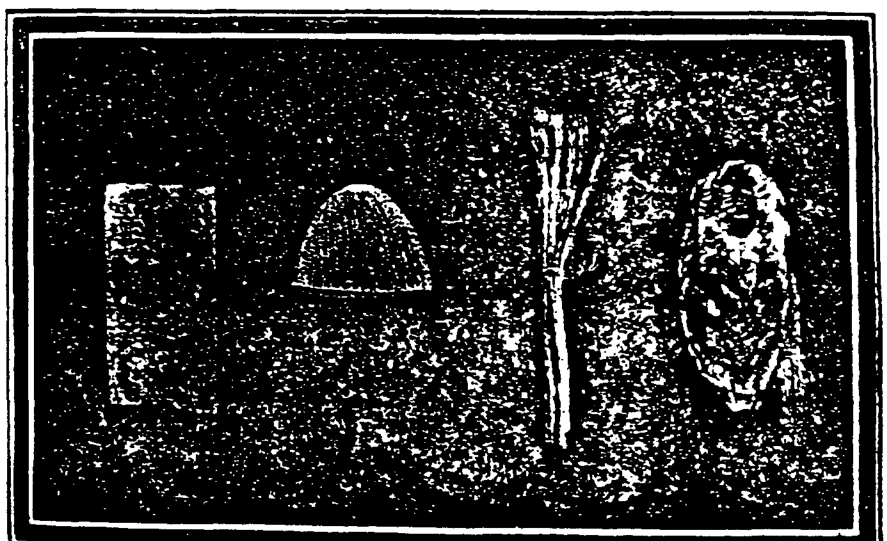
The ancient Romans who found asbestos in the Italian Alps regarded it as a vegetable and worked it up into cremation cloths, in which they wrapped the bodies of their kings to protect them from the all-consuming heat of the funeral pyre and so preserve the ashes.

Linum vivum (living linen) they called it. In 1702 a funeral urn was found near the Naevian Gate at Rome containing a skull, calcined bones and ashes wrapped in a long piece of asbestos cloth. It can be seen, with its contents, in the Vatican Museum today. A Greek doctor called Anaxilaus who was banished by the Roman Emperor Augustus in 28 BC for practising magic wrote: 'if a tree is surrounded with linen made of (asbestos) the noise of the blows given by the axe will be deadened thereby, and the tree may be cut down without being heard. For these qualities it is that this linen occupies the very highest rank among all the kinds that are known.' It was being used for acoustic insulation even then.

Down the centuries references are found in chronicles and proceedings of learned societies which indicate that the 'magic mineral' was never forgotten. For example, the Emperor Charlemagne, who lived in the 9th century, is alleged to have saved a desperate situation by throwing his tablecloth into the fire and recovering it unharmed. His enemy bowed in deference to the possessor of obviously supernatural powers. The cloth was undoubtedly made of woven asbestos.

In the Middle Ages the Venetian explorer Marco Polo described how in Siberia in 1250 he was shown a piece of unburnable cloth made, they said, from the skin of the salamander which lived in fire. His enquiries led him to asbestos mines which were probably those known to have been

A fragment of prehistoric Finnish pottery



An 18th century drawing of asbestos. Plate 32 – Volume V 'Fossils' of the collection of Natural History drawings which form part of the Royal Collection in the library of Windsor Castle, reproduced here by gracious permission of HM the Queen operating in the Russia of Peter the Great.

In the 15th century we hear of asbestos cloth being used for armour in battle. A contemporary rhyming account of the siege of Rouen (1420) talks about:

The Kyngis herauldis and pursuiauntis
In cotis of armys amyauntis

In 1671 there appeared in a magazine called *Journal de Letterati*, published in Venice, an account of 'a Substance found in great quantities in Some Mines of Italy out of which is made a kind of incombustible Skin, Paper and Candle Week.' A certain Signor Castagna who had come upon this asbestos could treat it so that it resembled lambskin dressed white. 'Of the same matter this Artist hath wrought a Week (Wick), never to be consumed as long as 'tis fed, nor altering its quality after the aliment is wasted away. And if that famous and incombustible Oyl were found out again, we read of, this matter would yield the Week for that everlasting Light so much celebrated by the Antients.' But of course it wasn't everlasting, someone was always topping it up.

It was only by the end of the 17th century that asbestos began to be regarded as something other than an object of superstition and curiosity. Asbestos came into its own with the discovery of the deposits in Canada in the middle of the 19th century, with the accent perhaps on the conservation of heat by 'lagging' rather than resistance to fire. When the price of coal began to increase, 'thermal insulation' gradually developed into the science it is today.

Sir William Logan, the first Director of Geological Survey in Canada, 'noted' asbestos as early as 1847. In 1876 it was rediscovered by Joseph Fecteau, and two years later the mining of the principal deposits at Thetford, Quebec, had become a going concern.

The asbestos Sir William Logan noted was White (Chrysotile) asbestos, as indeed was every deposit discovered up to that time. The Italian amianthus used by the ancients was White, and the asbestos in the Russian, Chinese, Indian and Cypriot mines was White.

Some time between 1803 and 1806, however, many years before Sir William Logan's findings in Canada, Mr H. Lichtenstein, a German geologist, was travelling near Prieska in the Orange River Valley in South Africa where he came upon a mass of heavy asbestos which was lavender blue in colour. This was something quite new and though there are deposits of Blue asbestos (Crocidolite) in Australia, South Africa, where it was first discovered, is still its main source for commercial purposes, the chief of which is in the manufacture of asbestos-cement products.

But as with the discovery of White asbestos in Canada, so with Blue in South Africa. The discovery was merely noted, and no attempt was made to explore its possibilities until 1891, when Francis Oats, a director of De Beers Consolidated Mines Ltd, who controlled the diamond mines of South Africa, formed a group of his associates into the Cape Mineral Syndicate to exploit it. Oats' attention had been called to the Blue asbestos at Prieska by a speculator called Cohen, to whom specimens of the rock had been brought by some African 'boys' working at the Kimberley diamond mines who had their home at Prieska.

Two years later Oats was persuaded to broaden the activities of the Cape Mineral Syndicate and establish a company in London which would undertake manufacture as well as mining. The name given to this company, which was incorporated on December 28, 1893, was The Cape Asbestos Company Limited.

In 1925 the company acquired a number of mines in the Transvaal of the kind of fawn-coloured asbestos, first discovered in 1907, known as Amosite. This had long, stiff, rigid fibres, and while unsuitable for easy spinning and weaving proved itself ideal for use in insulating materials. Today it is used in the Group's 'Caposite,' 'Asbestolux' and 'Marinite' products, and in 'Caposil 1400' calcium silicate materials.

Asbestos the word

The mineral has been known in England by two names – first amianthus or amiantus, and later asbestos.

Amianthus is the Greek *Amiantos. A* is the negative and *miaino* means to paint over something with another colour, to stain or dye it, and thus to defile, soil, taint, pollute, corrupt it, make it impure. The adjective *amianto* was applied to this undefilable mineral, for on being thrown into the fire it was not only not consumed by it or diminished by it, but seemed positively to be purified by it. Pliny reports that after the stains were burnt out, a piece of asbestos cloth 'came out of the flames whiter and cleaner that it could possibly have been rendered by the aid of water.'

Such words were doubtless based on observation, but he was guessing when he went on to say that the natural colour of the mineral was red, only becoming white through the agency of fire, and that it grew in the deserts of India scorched by the burning rays of the sun. 'Here, where no rain is ever known to fall,' he writes, 'and amid multitudes of deadly serpents, it becomes habituated to resist the action of fire.' It is very rare, and those who find it sell it at prices equal to those given for the finest pearls. Moreover 'it effectually counteracts all noxious spells, those wrought by magicians in particular.'

Apart from all this, the realisation that it was not affected by fire led to the belief that it did in fact ignite and, once ignited, went on burning for ever without being consumed. In this respect the word *amiantos* was probably also applied to a mineral which wasn't asbestos at all but a 'fabulous stone' which was reputed to burn with an unquenchable flame and was more likely to have been unslaked lime. However that may be, this second attribute gave the mineral its other name.

Asbestos is another Greek word. *A* is the negative again, and *sbestos* is the adjective from the verb *sbennumi* meaning to quench, die down, dry up, extinguish. Asbestos is the inextinguishable material, the mineral which once it starts burning never goes out. It has thus acquired a name which contradicts its essential characteristic, which is that it does not burn.

The mineral was called undefilable and inextinguishable, but never what one would have expected, incombustible. *Amiantos* came into the English language as *amianthus* and survived till the beginning of the 20th century, when it gave way to *asbestos*. In the early 19th century both words were used in England, though it is likely *amianthus* was reserved for the silkier, softer types. The poet Robert Southey (1774–1843) used both words in *The Young Dragon*, which he wrote about 1815:

> With amianth he lined the nest
> An incombustible asbest.

Asbestos is the word used in North America and in North European languages (German: *asbest*). But *amiantos* has held its ground in the southern Latin languages: *amiante* in French, *amianto* in Italian, *amianto* in Spanish.

Marco Polo found the mineral being called salamander; in Germany it has been known as Stone Flax (*steinflachs*), and French-Canadian miners have called it Cotton Stone (*pierre-à-coton*). One type of asbestos has been called by a Greek word which means Woolly Stone (*crocidolite*), another type by a Greek word meaning Fine Hair of Gold (*chrysotile*).

01 040 1221

The Cape Asbestos Company Limited was formed in London in 1893 to undertake the mining of asbestos in South Africa and the manufacture from it of thermal insulation materials (lagging) in Italy.

Since then it has expanded into a Group of associated companies manufacturing not only insulation materials from asbestos but also of mineral wool, as well as a range of asbestos-based brake linings.

Production of raw asbestos fibre from its own mines is still a basic activity of the Group, and is the subject of the present booklet. Two types of asbestos are mined – known as Blue asbestos and Amosite – which have unique qualities differentiating them from the great bulk of asbestos produced elsewhere (mostly in Canada, Russia and Rhodesia). The company's development has been based on making the most effective use of these special qualities.

In 1961 the responsibility for advising on negotiations and sale of all crude and processed fibres produced from our mines was delegated to a wholly owned subsidiary company with head office in London created for the purpose, Cape Asbestos Fibres Limited.

The Group's mines are based on two main centres in the Cape Province and in the north-eastern Transvaal, where small settlements have been built up entirely by the company, housing and providing for a population of some 900 Europeans and upwards of 9000 Africans.

The manufactured products of the Group cover a wide range, including Caposite asbestos, Caposil HT and 1400 calcium silicate, Noramite plastics reinforcement felts and dough moulding compounds, Rocksil and Rocksil-K rockwool, thermal insulation materials; Asbestolux asbestos board products; Marinite asbestos sheet; Don and Capasco automotive and industrial friction materials.

The reality

Contents

01 040 1222

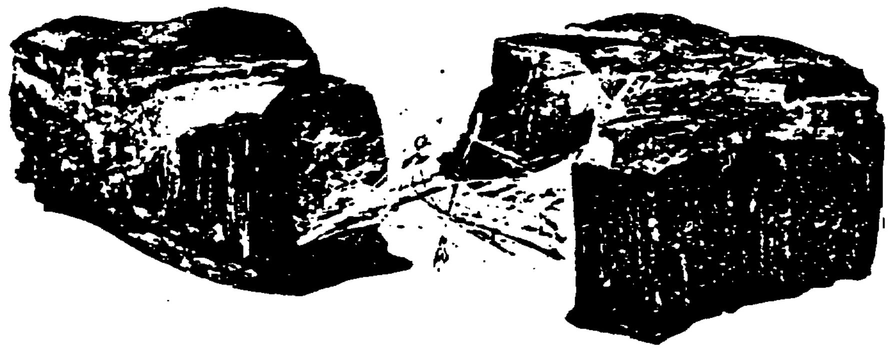
The natural fibre that will not burn

Asbestos has the exceptional property of being a natural fibre that will not burn. Fibres are the essential building materials of nature, but fibres of the vegetable and animal kingdoms will all burn more or less freely. Asbestos, the fibre of the mineral kingdom, stands apart: it is non-combustible.

Before it is mined, asbestos is a rock – as solid and dense as granite or marble. It is found in seams or layers between greater thicknesses of rock of almost identical composition. The asbestos rock breaks down to fibres when it is milled, but the accompanying rock becomes powder. The reason for the existence of the seams of asbestos is not completely known, but they are of entirely mineral origin. They are not caused by the decay of vegetable deposits like coal.

The great value of asbestos is its fibrous nature. Very fine fibres can be obtained by rubbing the surface of asbestos rock. Each fibre pulled away is seen to be composed of more fibres, and these in turn can be further subdivided. The most powerful optical microscopes cannot pick out the smallest fibres; these are between one millionth and one ten-millionth of an inch in diameter. The average thickness of the fibres used in our factories is about ten times this size, but even so some hundreds could lie side by side in the thickness of this paper. A piece of crude asbestos as big as the top of a finger yields many thousand millions of fibres, which would stretch round the world if placed end to end.

'It is found in seams or layers between greater thicknesses of rock of almost identical composition' – the rock face at one of our Amosite mines



'The asbestos rock easily breaks down to fibres'

01 040 1223

'Each fibre pulled away is seen to be composed of more fibres.' Amosite seam in our Penge mine

Mineralogical classification of asbestos

Any naturally occurring mineral which may be manipulated or processed into fibres may be called asbestos, but there are a number of different types that are quite distinct mineralogically, although they may conveniently be classified in two groups:

Group I Amphibole asbestos
The Amphibole group of minerals contains many varieties, including five which are fibrous. These are complex silicates having the general chemical formula $M_7Si_8O_{22}(OH)_2$, M representing calcium, magnesium, sodium or iron in various proportions. The fibrous amphiboles contain double chains of silica tetrahedra and this arrangement gives enormous strength along the chains and in the fibres; the bond between adjacent chains is very much weaker, and for this reason the fibrous amphiboles may be easily broken down to give strong fine fibres.

The two important varieties of Amphibole asbestos are:

Crocidolite or Blue asbestos and Amosite
Both are iron silicates – Crocidolite a sodium ferroso-ferric silicate; Amosite a ferrous magnesium silicate.

Crocidolite is found mainly in South Africa, but also in Australia and Bolivia. Amosite is found exclusively in South Africa.

Other fibrous amphiboles are Tremolite (calcium magnesium silicate), Actinolite (calcium magnesium iron silicate) and Anthophyllite (magnesium silicate), but these are only of limited commercial importance to the asbestos industry.

Group II Chrysotile or White asbestos
This is the fibrous variety of Serpentine, a magnesium silicate mineral having the chemical formula $Mg_6[Si_4O_{10}](OH)_8$. It is produced from extensive deposits in Canada, Russia, Rhodesia, and to a smaller degree in the Transvaal, Australia and elsewhere.

Difference between Amphibole and Chrysotile

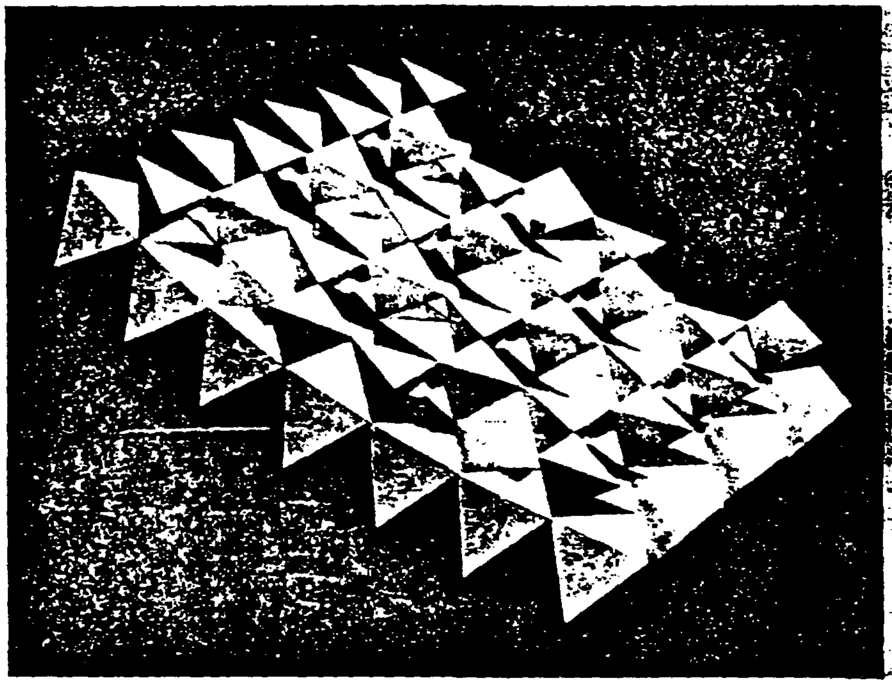
Scientists have shown that there is a fundamental difference in structure between the fibres of Chrysotile asbestos on one hand and of Amphibole asbestos on the other. The finest Chrysotile fibres are believed to be hollow, whereas the ultimate Amphibole asbestos fibres are solid throughout. This explains why Amosite and Blue asbestos fibres are hard and springy and why White asbestos fibres

From pieces of White (top), Amosite (centre) and Blue (bottom) asbestos rock of equal weight come piles of fibre of unequal volume. These photographs illustrate how the stiff resilient nature of Amphibole (Blue and Amosite) fibres give them considerably more bulk than White asbestos fibres

· soft, flexible and absorbent. As shown ine electron micrographs, Amphibole res are *larger in diameter. The finest* nite asbestos fibres are usually in the gion of 0·02 microns in diameter, whereas e finest Amphibole fibres are in the region · 0·1 microns in diameter. When sepa- ted by fiberising processes, Blue or mosite fibres will produce a great floccu- nt volume: this consists very largely of ill air which is held in minute cells by the caffolding of fine resilient fibres. On the ther hand, the soft flexible fibres of the Chrysotile variety are particularly suitable for use in asbestos cloth, engine packings, gaskets and like products.

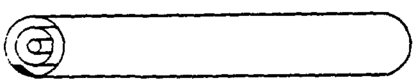
*The length of Amphibole asbestos de-*pends upon the grade, but, in general, Amphibole fibres are considerably longer than White asbestos fibres of similar price or grade. The additional length and the stiff resilient nature of the fibres means that a given weight of Amphibole asbestos will fiberise to a much greater volume than the same weight of White asbestos.

Customers who are used to purchasing White asbestos will notice that they receive their raw Blue or Amosite in a less finely milled condition than Chrysotile. Our asbestos is despatched in this relatively *crude or unfiberised form from our mines* deliberately in order to reduce shipping costs. If Blue or Amosite was milled at the mine to the same extent as White, the volume produced would be so great that the cost of transport would be inflated out of all proportion.

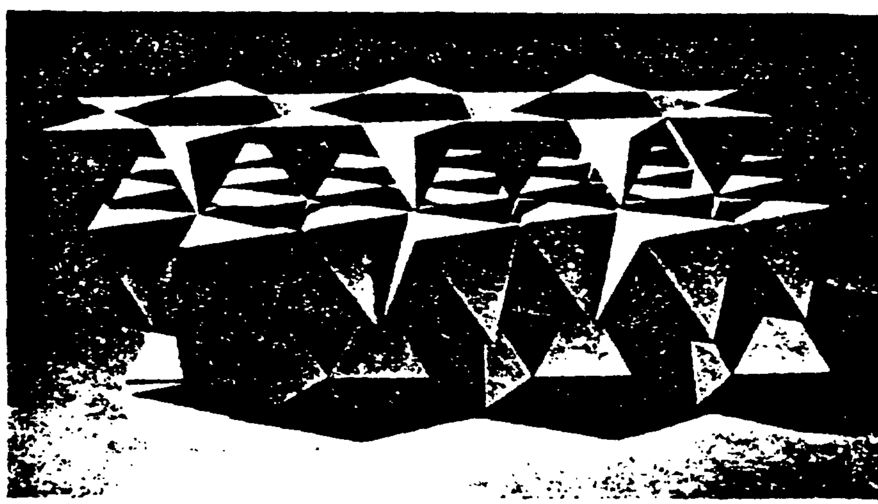


Photograph of schematic representation of the structure of Chrysotile asbestos

$3MgO2SiO_22H_2O$

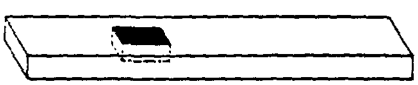


The molecules are fitted together to form a tubular structure. The diameter of the smallest tubes is less than one ten-millionth of an inch



Photograph of schematic representation of the structure of Amphibole asbestos

Crocidolite – Blue asbestos
$Na_2O3FeOFe_2O_38SiO_2H_2O$
Amosite asbestos
$1{\cdot}5MgO5{\cdot}5FeO8SiO_2H_2O$

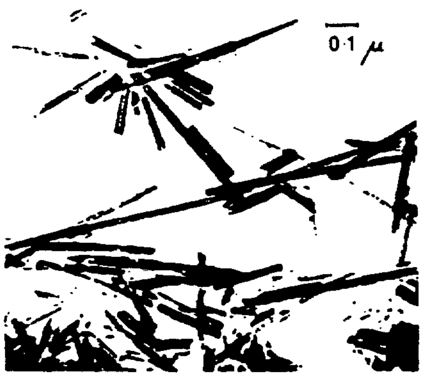


The molecules are fitted together to form straight, narrow strips. The smallest fibres are a few millionths of an inch in width and may contain as many as a hundred of these strips

01 040 1226

Photographs of Chrysotile and Amphibole asbestos fibres magnified 40,000 times on an electron microscope

They show that Chrysotile (White) asbestos forms very fine, hollow fibres, whereas Amphibole (Amosite and Blue asbestos) consists of long, solid and rigid fibres



Resistance to heat

Amosite and Blue asbestos fibres discolour and lose strength, as a result of oxidation, when they are heated at temperatures above 480 F. Textile and flocculent products made from these fibres alone, such as yarn and cloth, packings, mattresses, rope lagging and loose fill, should not be used above this temperature. But products incorporating Amosite or Blue asbestos with stable inorganic binders or fillers may be used safely at much higher temperatures. The resistance of such products is not adversely affected by the discoloration of Amosite due to oxidation, and any loss in fibre strength will not affect the integrity of the products within the limiting temperature ranges normally claimed for the various heat insulating materials.

Colour

Average tensile strength

Resistance to chemicals

Typical chemical analysis

Silica	SiO_2
Alumina	Al_2O_3
Ferrous oxide	FeO
Ferric oxide	Fe_2O_3
Manganous oxide	MnO
Calcium oxide	CaO
Magnesium oxide	MgO
Sodium oxide	Na_2O
Potassium oxide	K_2O
Carbon dioxide	CO_2
Water of crystallisation	H_2O

01 040 1227

CHRYSOTILE (White)	CROCIDOLITE (Blue)	AMOSITE
Matt White	Lavender blue, varying somewhat with slight changes in chemical composition associated with different mining areas.	Varies from almost white to yellowish-brown, according to small changes in iron content.
400000 lb/sq in	500000 lb/sq in. The strongest of all natural fibres, its basic tensile strength being one and a half times that of steel piano wire.	300000 lb/sq in.
Virtually no resistance to acids, which dissolve the magnesia component of the mineral. Good resistance to alkalis, neutral salts and organic solvents.	Outstanding in its resistance to acids. Good resistance to alkalis, neutral salts and organic solvents.	Good resistance to acids, but not as good as Crocidolite. Good resistance to alkalis, neutral salts and organic solvents.
%	%	%
39·8	51·4	49·3
3·3		
1·1	20·3	40·9
0·8	17·5	0·4
0·1	0·1	0·7
1·6	0·8	0·4
39·5	1·4	5·7
0·1	6·2	0·2
0·1		0·3
1·0	0·4	0·2
12·6	1·9	1·9
100·0	100·0	100·0

01 040 1228

01 040 1229

Our asbestos mines

We operate Amosite and Blue asbestos mines in South Africa at the places shown on the map.

Extensive deposits of Amosite and Blue asbestos occur in the banded ironstones of the Cape Province and the Transvaal. The asbestos was originally mined from the surface where the seams emerge, but our mines now penetrate many hundreds of feet into the rock where fresh asbestos of excellent quality is obtained.

Unlike the deep deposits of White asbestos that occur in serpentine, Amosite and Blue asbestos occur in relatively narrow strata extending over great areas of South Africa. The deposits do not usually persist in great depth, and for this reason variations of properties exist in fibres mined in different areas. This enables us to supply a range of fibres having individual characteristics which may be used to the maximum advantage in particular processes.

The crude ore is brought to the surface and purified by processes that have been developed and perfected over many years in the asbestos mining industry.

Our mining activities in South Africa are controlled by Cape Asbestos South Africa (Pty) Limited, through its subsidiaries Cape Blue Mines (Pty) Limited and Consolidated Blue Asbestos Corporation Limited, on the production of Blue (Crocidolite) asbestos; and Egnep (Pty) Limited, with its wholly owned subsidiary company, Amosa (Pty) Limited, which produce Amosite asbestos.

Kokerboom (quiver tree) with a distant view of one of our mines across the river

BLUE ASBESTOS

As already mentioned, in 1890 the Cape Mineral Syndicate was formed and acquired mining rights over certain farms in the Prieska and Hay districts of the Cape Colony. The Cape Asbestos Company was formed in 1893 to take over these rights from the syndicate, and in 1948 Cape Blue Mines (Pty) Limited purchased all the assets and mining rights of The Cape Asbestos Company's Blue Crocidolite mining activities.

Cape Blue Mines (Pty) Limited

Cape Blue Mines operates Blue asbestos mines and plants at Koegas/Westerberg in the North-Eastern Cape; the Pomfret Mine in the Vryburg District of the Cape Province, and the Malipsdrift Mine in the Pietersburg District of the Transvaal.

Koegas and Westerberg Mines

Situated on the north and south banks respectively of the Orange River some 46 miles downstream from Prieska, the two mines being connected by the Riley Bridge, constructed in 1951. In this area the company owns, in addition, large tracts of asbestos-bearing ground, on which several small mines have in the past yielded quantities of Blue asbestos and are awaiting further exploration.

Burlington House, Rissik Street, Johannesburg, where Cape Asbestos South Africa (Pty) Limited have their offices

The grades of Blue asbestos produced at the Koegas/Westerberg mines are:

S	Medium grade
H	Medium/short grade
WDS	Short grade
A, B, C	Machine-treated long grades

Pomfret Mine

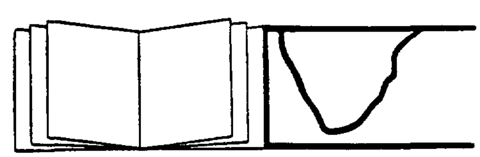
Situated some 134 miles north-west of Vryburg in the Northern Cape, near the Bechuanaland border and the edge of the Kalahari Desert. The farm Pomfret, where the mine is established, is one of the farms in this area over which Cape Blue Mines (Pty) Limited holds the asbestos mining rights, the total area of these farms being 59,000 morgen (about 125,000 acres).

The grades produced at Pomfret are: S (medium grade) and A, B, C (machine-treated long grades). Special hand-cobbed grades are also available for specific requirements.

Consolidated Blue Asbestos Corporation (Pty) Limited

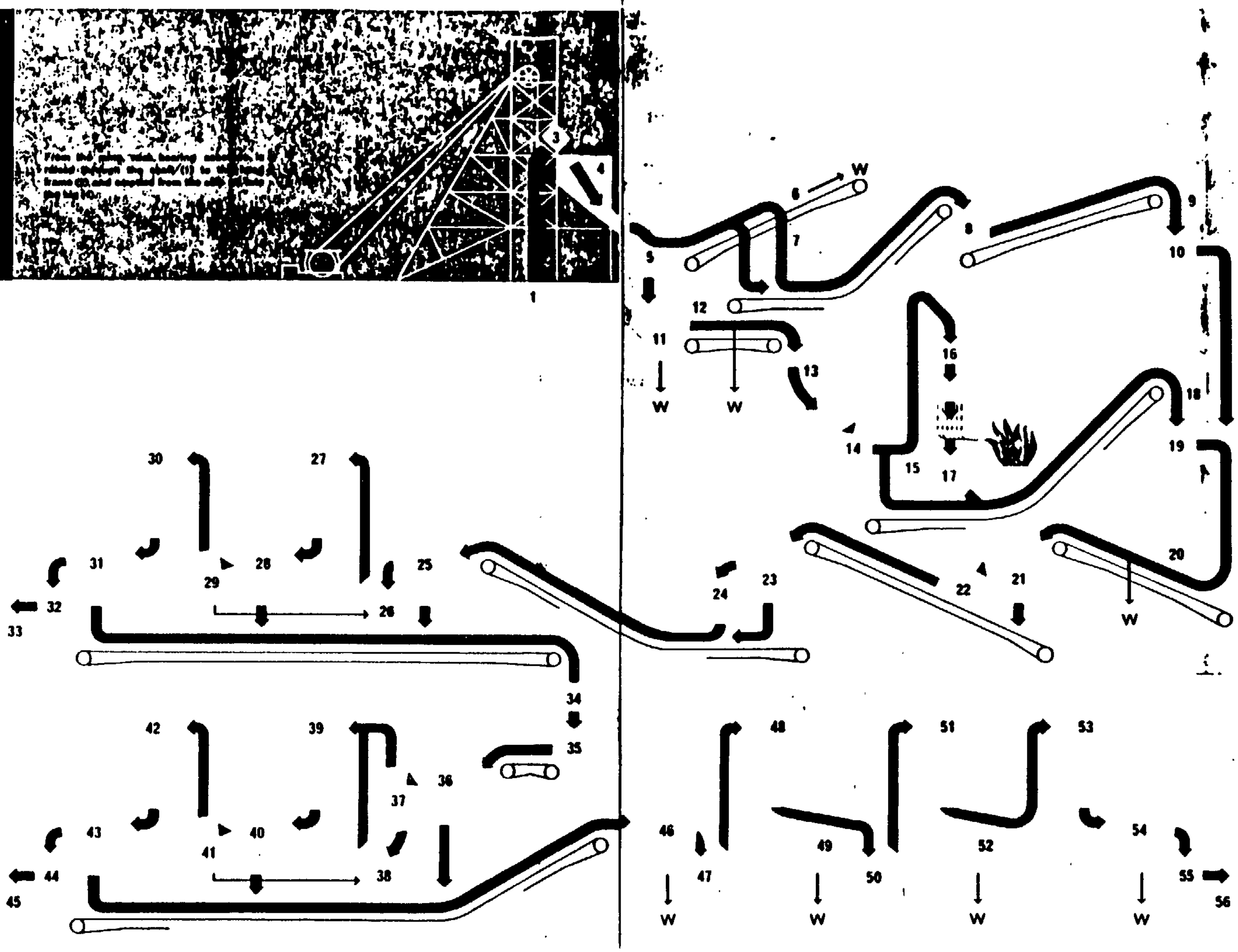
The share capital of this company was purchased in July, 1958. The company owns a mine on the farm Warrendale, 8 miles from Silverstreams station on the Kimberley–Postmasburg branch railway line.

Please fold out map on page 19



Flow Diagram of the Production of Asbestos

Here are illustrated in diagrammatic form the various processes through which the pieces of crude asbestos rock pass after they have been brought to the surface at one of our South African mines.



From the bin (4) the rock and asbestos move to the vibrating grizzley (5) and are sorted on the reel picking conveyor belt (6). The asbestos falls into the reef bins (7), the waste (W) goes to the dump. The asbestos is fed through the jaw crusher (8), thence into the dry ore (reef) storage bin (9) and into the feeder (10).

From the vibrating grizzley (5) the unders are fed over the washing screen (11), the waste (W) goes to the slimes dam and the remainder over the waste sorting conveyor belt (12). The waste (W) proceeds to the dump and the asbestos to the ore (reef) bin (13), through the feeder (14) up bucket elevator (15) and down the tower dryer (16). Then the asbestos goes down to the feeder (17) or by way of the dryer bypass. From here the asbestos is conveyed into the dry ore (reef) storage bin (18) and into the third feeder (19).

The contents of feeders (10) and (19) are fed on to the waste sorting conveyor belt (20). The waste (W) goes to the dump and the asbestos on to the screen (21), fine pieces falling through the screen and the remainder passing on through the jaw crusher (22). The total is passed on to the screen (23). While fine pieces fall through the screen the remainder goes through the cone crusher (24). The total is conveyed to the long fibre plant.

Long fibre plant

From the preparatory cleaning plant the asbestos is fed on to trommels (25), through the fiberiser (26) and into the cyclone (27). Then it proceeds down on to the trommels (28), through the air separators (29), the unders being recirculated back to the fiberiser (26) from the separators (29) into the cyclone (30). The asbestos proceeds to the final cleaning trommels (31), where it is put into bags (32). It is then weighed and after inspection and quality control the asbestos is sent to storage sheds at the mine and then by road transport to the railhead (33).

Medium fibre plant

The unders from the long fibre plant (25) and (31) are fed to the medium fibre plant storage bins (34) into feeder (35) and on to trommels (36), then to air separators (37), and into the fiberiser (38). Then the asbestos goes to the cyclone (39) and on to the trommels (40), then to the air separators (41). The unders are recirculated to the fiberiser (38) and the remainder to the cyclone (42). Then the asbestos goes on to the trommels (43) and is put into bags (44). It is then weighed, and after inspection and quality control the asbestos is sent to the storage sheds at the mine and by road transport to the railhead (45).

Short fibre plant

The unders from the medium plant (36), (40) and (43) are fed to the short fibre plant on to the trommels (46). The tailings are deposited on the dump while the remainder goes into the fiberiser (47), then to the cyclone (48), over the screen (49), through the fiberiser (50), then to the cyclone (51), over the screen (52), then to the cyclone (53), then into the final cleaning trommels (54) and finally into bags (55). It is then weighed, and after going through inspection and quality control is conveyed to the storage sheds at the mine and thence by road transport to the railhead (56).

01 040 1231

AMOSITE ASBESTOS

Egnep (Pty) Limited and Amosa (Pty) Limited

These companies were registered in 1916 to acquire leases of the mineral rights over the farms Penge and Streatham on the banks of the Olifants River in the native area of Sekhukhuneland in the Lydenburg district of the Eastern Transvaal. The mining camp at Penge is 65 miles from Lydenburg, the then railhead. Later the railway line was extended to Steelpoort, bringing the railway station at Burgersfort on the Lydenburg-Steelpoort line to within 22 miles of the mine.

These companies were purchased by The Cape Asbestos Company Limited in 1925, by which time the mining leases had been extended over the farms Havercroft, Riverside, Weltevreden, Zamenloop and Kromellenboog. In 1927 Egnep (Pty) Limited purchased the assets of Malipsdrift Asbestos Company, which held 943 mining claims in the Pietersburg area, and in 1958 the 186 adjoining mining claims of Uitkyk asbestos were purchased.

The farms Havercroft, Streatham, Penge, Riverside, Weltevreden, Zamenloop and Kromellenboog cover an area of approximately 25,000 morgen (53,000 acres) bounded on the north by the Olifants River and on the east by the Steelpoort River. Four separate mines are in production on these farms. The Amosite asbestos ore from the mines on Streatham and Penge is treated in plants on the farm Penge, the grades produced being:

D3, LD3	Extra long fibre
DX, D11	Long fibre
M, MD	Medium long fibre
S2	Medium short fibre
S33	Short fibre

The mine at Weltevreden has its own treatment plant, and the grades produced are:

W3	Medium fibre
SW	Medium short fibre
GW	Short fibre

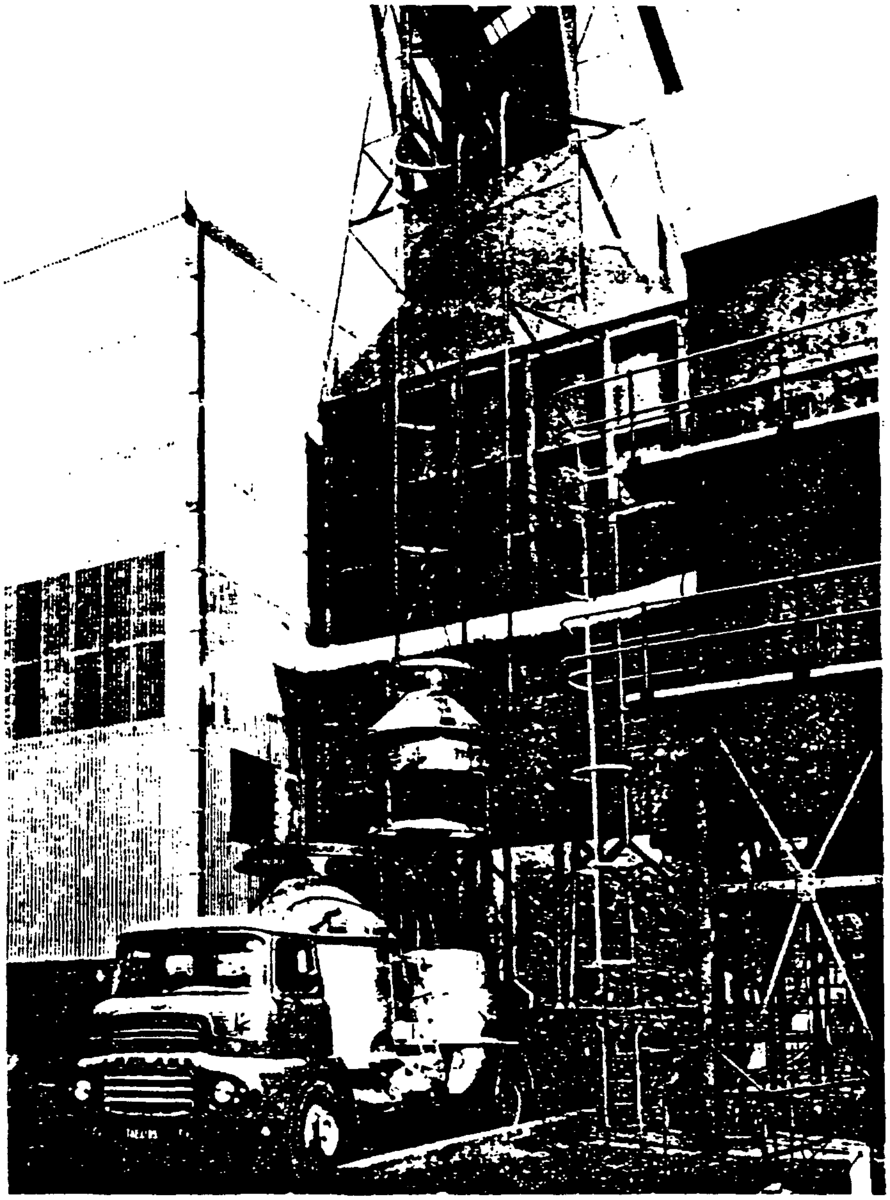
At Kromellenboog the treatment plant produces:

K3	Medium fibre
SK	Medium short fibre
GK	Short fibre
RK	Short fibre

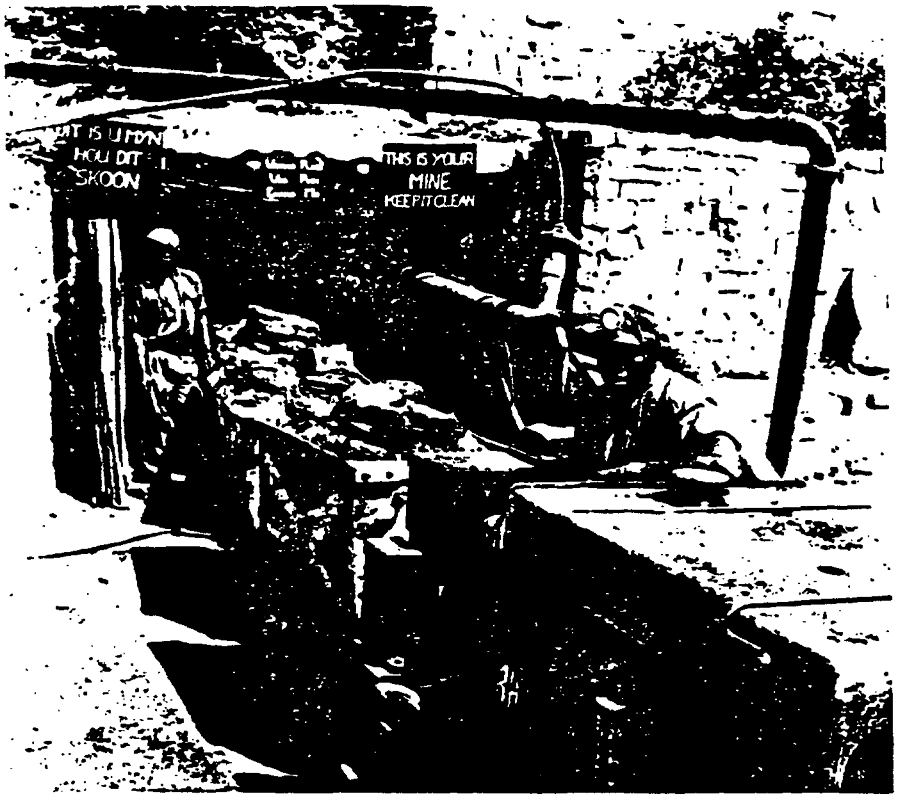
BLUE AND AMOSITE

In the Malipsdrift area Blue asbestos is mined for Cape Blue Mines (Pty) Limited and Amosite for Egnep (Pty) Limited. The Blue production is blended to produce Standard Transvaal S, while the Amosite grades are blended with production from other mining areas to produce opened fibres against specific demand.

The feed end of one of the amosite mills at Penge



01 040 1232

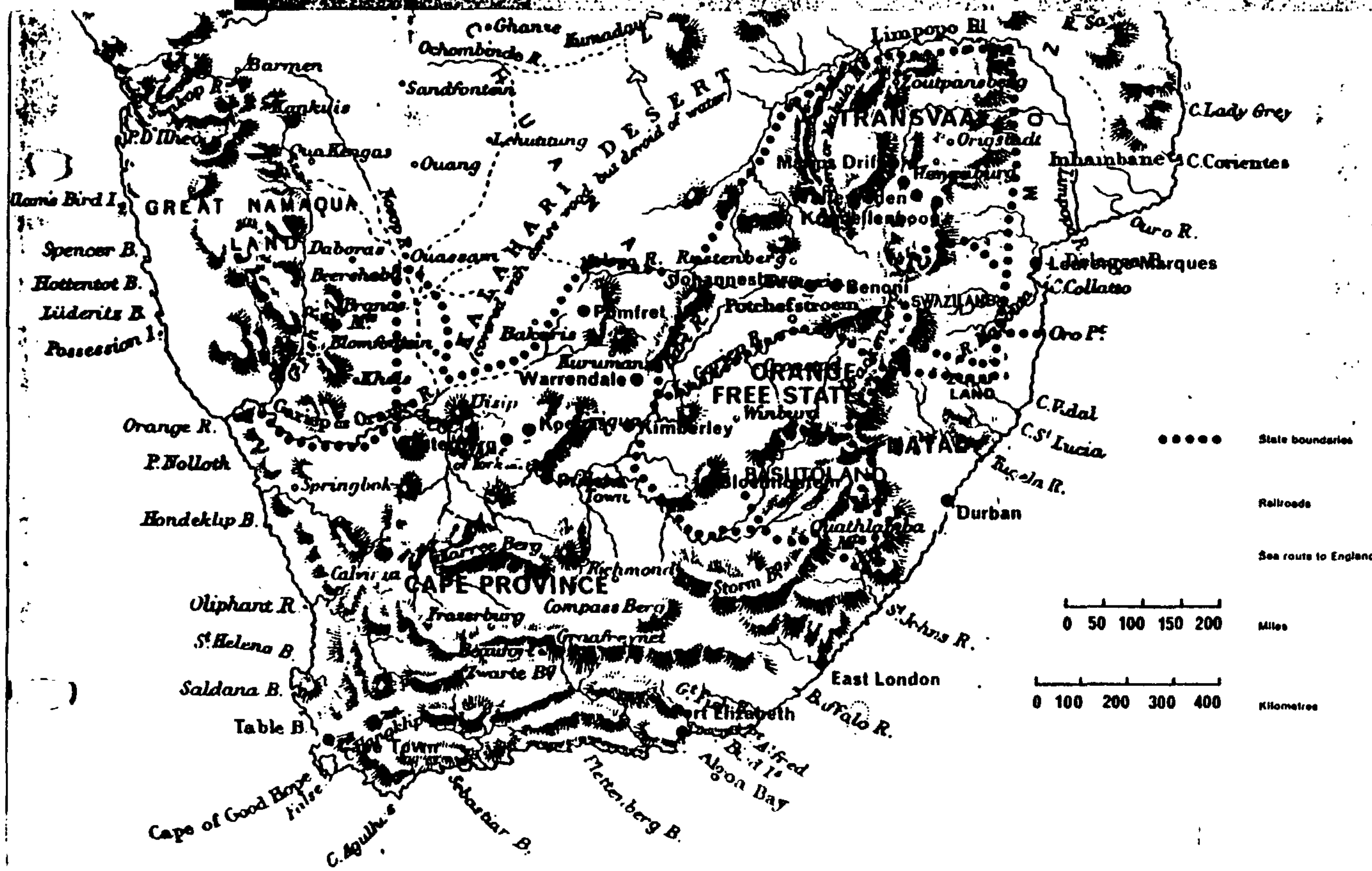


The broken asbestos-bearing rock – ten parts of asbestos to a hundred parts of rock – is brought to the surface by diesel train

Batch sampling of bagged fibre for quality control plus visual assessment of fibre quality and uniformity being carried out under European supervision after milling

01 040 1234

Our South African asbestos mines



From this map you can see the location of each of our asbestos mining areas in the Republic of South Africa, indicated by the white circles

The main Blue asbestos mines are at Koegas, Westerberg and Pomfret in Cape Province and are operated by Cape Blue Mines (Pty) Limited, those operated by Consolidated Blue Asbestos Corporation (Pty) Limited are at Warrendale, also in Cape Province between Postmasburg and Kuruman and there is also one at Malipsdrift in the Transvaal

The Amosite mines are at Penge Weltevreden Kromellenboog and Malipsdrift in the Transvaal and are operated by Egnep (Pty) Limited and Amosa (Pty) Limited

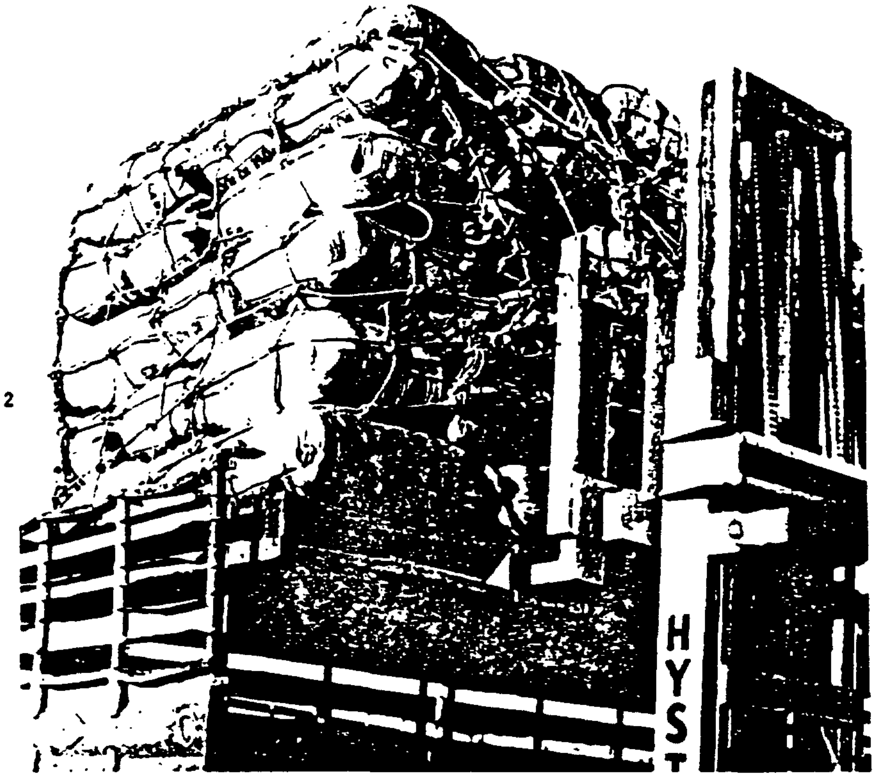
From Mine to Factory

k

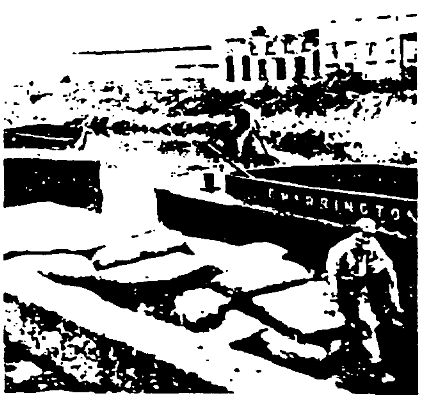
1 By road from the mine to the railhead

2 From the truck by fork lift into the train which will take the sacks of asbestos to the port for shipment overseas

1



2



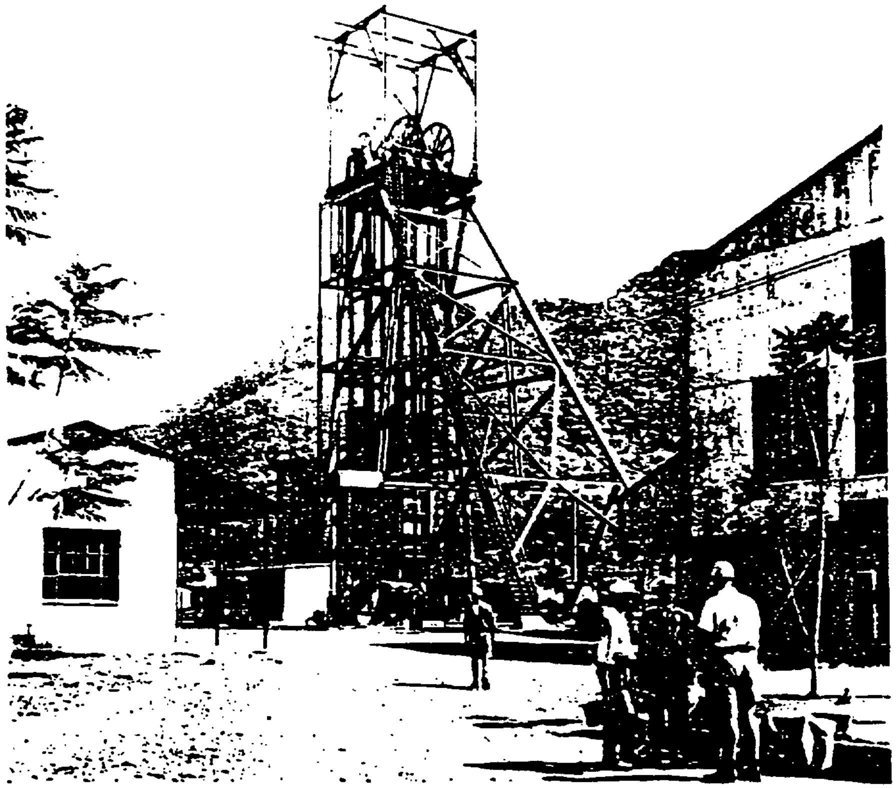
3

4

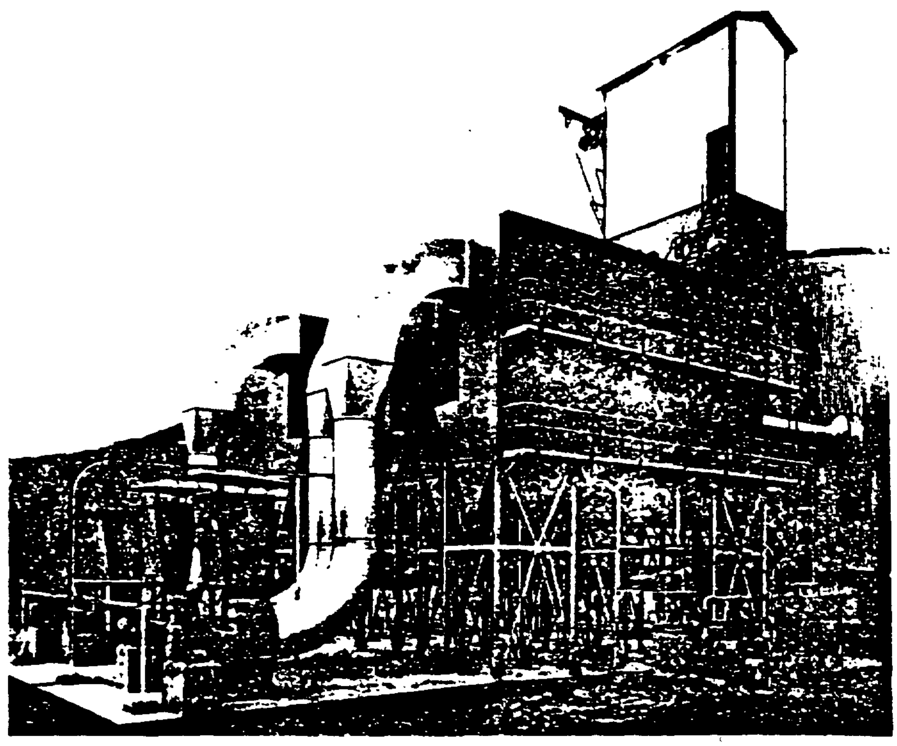
3 From the docks sacks are taken by barge to the Works

4 At the warehouse the long journey from the mine comes to an end

A view of the Penge mine from the Burgersfort Road against the backcloth of the bush-covered Drakensburg



Headgear of the Keep Shaft at Penge, the depth of which is 1436 ft

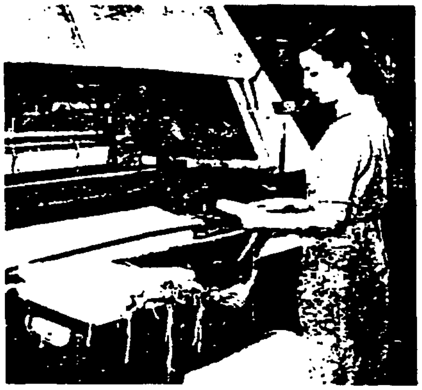


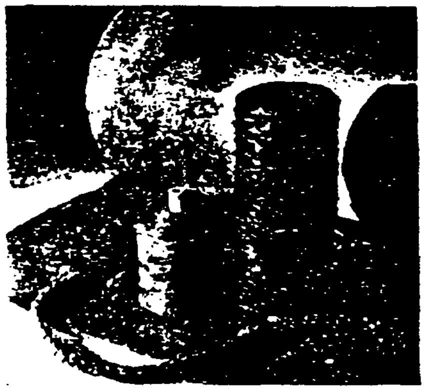
Dust collection units at one of the new amosite mills at Penge

Uses for Blue asbestos and Amosite

Commercial applications

In the preceding pages we have pointed out the distinctive properties of Blue asbestos and Amosite. These properties lead to distinct and specialised uses – Blue and Amosite have never been regarded as substitutes for White. In the following pages we discuss some of the wide range of commercial applications for Blue asbestos and Amosite either alone or blended with White asbestos.



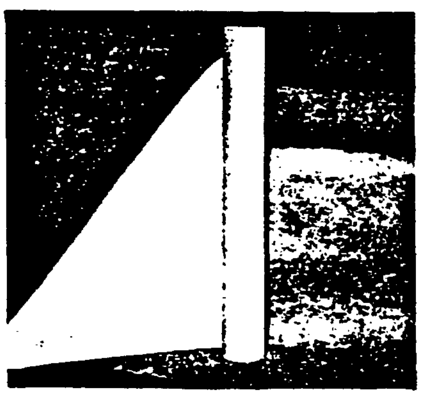


YARNS AND CLOTHS

Blue asbestos, long fibred grades

Yarns and cloths woven from long Blue asbestos fibres are strong and have high chemical resistance.

Typical uses for Blue asbestos cloth are:
Filtration cloths
Diaphragms in electrolytic cells
Curtains, forming dampers in fume exhausts
Smoke chutes
Heat insulation in mattress covers for use on railway locomotives and in acid-containing atmospheres generally.



PACKINGS

Blue asbestos, long fibred grades for plaited packings.
Blue asbestos, medium and short grades for Blue asbestos millboard.

Packings woven from Blue asbestos yarns are used for glands and stuffing boxes in chemical plants, particularly where resistance to acids is required. The packings are plaited in the usual way, graphite or grease being incorporated as required.

Polytetrafluorethylene covers or sleeves may be used in conjunction with Blue asbestos packings if extreme conditions of acidity are involved.

Millboard prepared from short Blue asbestos is also used as a packing or gasket material on chemical plant where acid resistance is particularly required.

REINFORCED PLASTICS

Blue asbestos, long fibred grades for felts. Amosite asbestos, extra long grades for felts. Blue asbestos, medium and short grades for dough moulding compounds.

The elastic modulus of Blue asbestos is over twice that of glass fibre. Felts prepared from long Blue and/or Amosite asbestos are being developed for use with epoxy, polyester and phenolic resins, particularly for applications where great stiffness or chemical resistance is needed. The adhesion of plastics to asbestos is superior to that of glass, and this increases the chemical and water resistance.

Shorter Blue asbestos fibres may be used in 'premix' or 'dough' moulding compositions to confer dimensional stability and water or chemical resistance, together with good dielectric properties.

FELTS

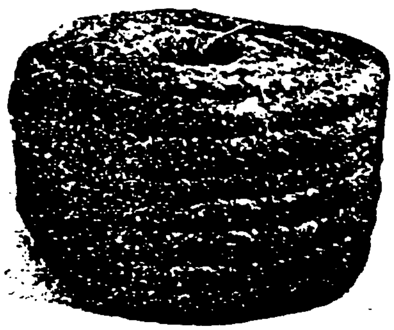
Blue asbestos, long fibred grades
Amosite asbestos, long fibred grades

Felts from long fibred Blue and Amosite asbestos for a wide range of reinforcing, roofing and insulation compounds; with bitumen or other waterproof impregnation for weather and corrosion resistant applications.

HEAT INSULATION

Amphibole asbestos is particularly suitable for use in heat-insulating materials. It is in this field that the long fibred Amosite is especially useful. There are two reasons for this: firstly because the long, resilient fibres form a large volume, enclosing a high proportion of still air which confers good heat insulation; and second, because Amosite provides excellent reinforcement in magnesia or calcium silicate and, more important, enabling the slurries from which these materials are prepared to be filtered rapidly.

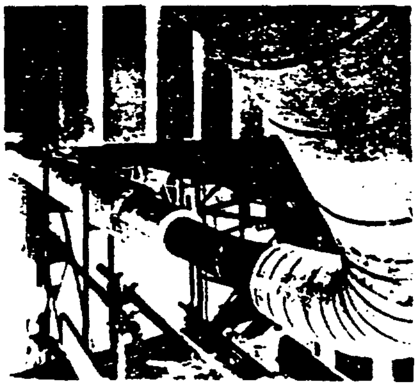
Details of the use of Amosite and Blue asbestos in various products for heat insulation are given below.



Amosite rope lagging

Amosite grade D3

Long fibred Amosite is particularly suitable for use in rope lagging. The long fibres lend themselves for use in simple carding machines in which the fibres are rolled and twisted together to form a rope that may subsequently be covered in a braiding made from an asbestos or glass yarn. The high bulk volume of this asbestos gives a rope that is very light in weight and having better heat insulating value than ropes made from the softer White asbestos.



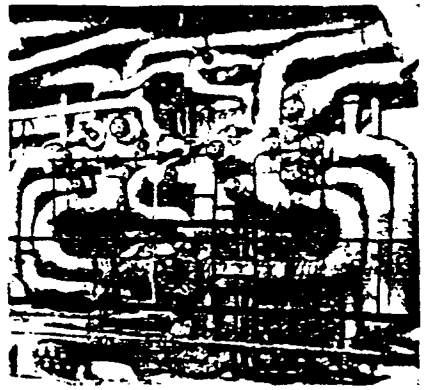
Preformed asbestos blocks and pipe sections

Amosite long and medium long grades

'Asbestos' blocks and pipe sections for use in heat insulation are best made from Amosite.

These materials have been used for many years on oil refineries, generating stations and in all conventional heat insulating applications against hot surfaces at temperatures up to 1200° F.

One of the particular features of this material is in its fibrous, resilient nature. This means that it may be transported over great distances with less risk of breakage than is usually encountered with light-weight materials.



Preformed magnesia or calcium silicate blocks and pipe sections

Amosite long and medium grades

Experience has shown that Amosite is the best reinforcing fibre to use in these products.

The function of the fibre is to provide reinforcement and resistance against impact, heat stress and accidental damage.

Between fifteen and twenty per cent of Amosite, fiberised in such a way as to retain a good proportion of coarse, crude bundles, is usually employed.

A particular virtue of Amosite in these processes is that the long resilient fibres keep the wet slurry 'free' and 'open,' thus enabling it to be filtered quickly and cleanly.

Blocks and pipe sections for use against higher temperatures are usually denser and contain high proportions of diatomaceous earth or calcined magnesia.

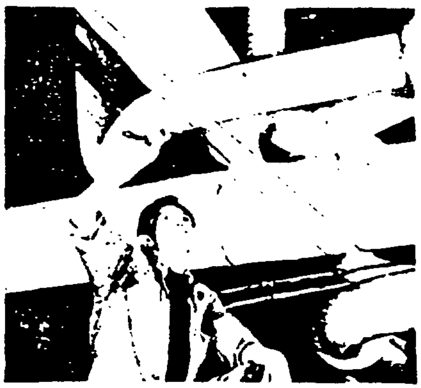
These are usually made by the same processes and, for the same reason as given above, Amosite fibres are incorporated with advantage.

Loose fill

Blue asbestos or Amosite medium long and short grades. Use longer fibres if greater bulk is required.

Well-fiberised Blue asbestos and Amosite may be used for loose fill insulation and as the filling in heat insulating mattresses, particularly where some measure of chemical resistance is required.

01 040 1239



Insulating compositions

Amosite medium long grades for insulating compositions
Amosite short grades for finishing and self-setting compositions

Amosite is a very convenient fibre to use in heat insulating compositions. Its long, stiff fibres ensure that a good bulk is obtained and also provide the necessary reinforcement.

Mixtures of between twenty and fifty per cent of well-fiberised, long Amosite with magnesium carbonate or a good grade of diatomaceous earth will give a composition having good thermal insulating properties. Up to ten per cent of clay may also be added to give some 'slip' and 'bind.'

For finishing compositions, up to ten per cent of well-fiberised Amosite may be used with cheap fillers such as chalk or sand; again, add up to ten per cent of clay to give 'slip' and 'bind.'

Self-setting compositions are prepared from cement containing between ten and thirty per cent of well-fiberised, short Amosite.

ASBESTOS SPRAY

Blue asbestos and Amosite medium and short grades

Short, well-fiberised Amosite or Blue asbestos is the best fibre to use in asbestos spray.

Asbestos spray has been extensively developed as a heat insulating, acoustic, and anti-condensation medium.

The fibres are usually sprayed in a fine mist of water, and a soluble adhesive is sometimes added to the water.

When dry, the sprayed asbestos will have a density of 9–13 lb/cu ft (depending upon the conditions), at which its thermal conductivity will be in the region of 0·32 Btu/sq ft/hr/(°F/in).

BITUMEN AND PITCH MOULDING COMPOUNDS

Blue asbestos and Amosite medium and short grades

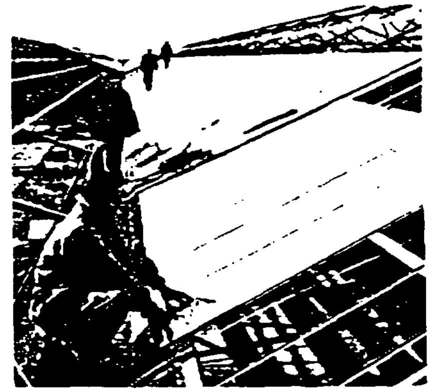
Mouldings for use in conjunction with water and chemicals have for many years been prepared from mixtures of bitumen or pitch with blue asbestos. Amosite asbestos may also be used.

It is usual to employ a short, well-opened Blue asbestos or Amosite for this purpose and to mix it hot with bitumen or pitch, then to press it in water-cooled moulds or to extrude or otherwise form it into pipes.

A particular use for Blue asbestos in this connection is in bitumen composition battery boxes.

Both Amosite and Blue fibres strongly resist the acid content of all types of bitumen and are therefore suitable for the production of pitch fibre pipes. They can also be considered for special road surfacing applications.

'Dagenite' battery boxes being made from a Blue asbestos-bitumen composition at Pritchett and Gold's works, Dagenham



ASBESTOS-CEMENT AND OTHER BUILDING BOARDS

Asbestos-cement sheets

Blue asbestos and Amosite medium and short grades

Blue asbestos and Amosite are, with great advantage, added to the fibrous component for the production of asbestos-cement sheets.

The unique filtration properties of Amosite and Blue asbestos are well known to manufacturers; both types of fibre disperse Chrysotile in the slurry, because of their resilience. Besides giving this greater dispersion of fibre and increased surface contact with the cement, Blue and Amosite increase the slurry bulk and can thus give greater laminate thickness when required. Up to forty per cent of the fibrous component may usefully consist of Blue asbestos and/or Amosite in flat or corrugated sheet manufacture.

01 040 1240

Lightweight asbestos insulating boards

Amosite asbestos medium and short grades

Lightweight asbestos insulation boards may be prepared on the same type of machine using between twenty-five and thirty-five per cent of Amosite blended with lime and diatomaceous earth. After forming the sheets in the usual way, a calcium silicate bond is formed in high-pressure steam. Hydraulic cement may also be used as the binding medium in this process.

Asbestos-cement pressure pipes

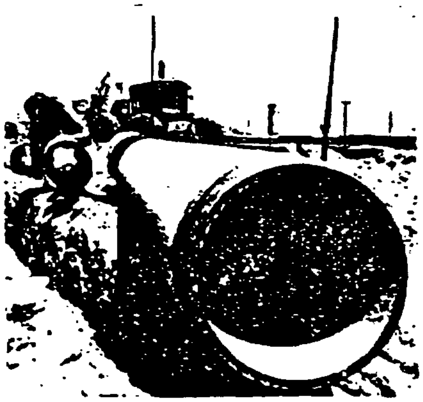
Blue asbestos and Amosite medium and short grades

The factors that have been outlined regarding the use of Blue asbestcs and Amosite for asbestos-cement sheet apply to an even greater degree to the manufacture of asbestos-cement pressure pipes, where a high rate of production is required together with a strong product.

In such processes it is usual to apply pressure to the surface of the pipe as it builds up on the machine by means of a blanket roll or a rubber roll. It is essential that the mix does not squeeze out or move as a result of this pressure, and the fast-drying properties conferred by the use of Blue asbestos in particular are of great value in this respect.

Depending upon the type of process employed, between twenty and fifty per cent of the fibrous content of the mix may usefully be Blue asbestos or Amosite.

Johns-Manville asbestos-cement pipes of the type in which our Cape Blue asbestos fibre is used



Preparation and fiberisation

As has been explained, it is customary to supply Blue asbestcs and Amosite in a relatively 'crude' form in order to save transport costs.

It is therefore usually necessary to open the asbestos further before using it in the various processes that have been described.

For textile processes, the same opening machinery as is used for White asbestos is employed.

For heat insulating products it is usually desirable to open the asbestos as much as is reasonably possible, and high-speed hammer or attrition mills are recommended. (For reinforcement of magnesia insulation and like products, a less severe opening is recommended.)

For use in asbestos-cement products and other board-making processes the best filtration properties are obtained from relatively coarse fibres, and it is therefore advisable not to open the fibres any more than is necessary to produce a smooth, uniform sheet or pipe.

Slow-speed mills or kollergangs as are conventionally used for White asbestos may be used for Blue asbestos and Amosite, but the hard, springy fibres may be damaged by excessive heavy milling, and this treatment should be kept to a minimum.

If wet milling is preferred, approximately thirty per cent of water should be added to the fibre in the mill.

If this type of opening is used, it is often preferable to introduce the Blue and/or Amosite last so that the Chrysotile can act as a cushion against any grinding effect of the opening process.

Processed asbestos fibres

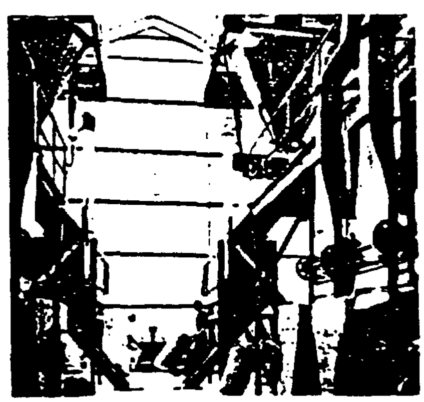
Apart from producing raw asbestos from our mines and selling it in that form throughout the world, we also meet the demands of customers who require their fibre already processed; and our factories at home and overseas are equipped with the latest machinery for processing and preparing all types of asbestos fibres, Amosite, Blue and White asbestos for all trades and uses. Our experience in this field is at the disposal of all actual or potential users of asbestos. Types, blends, lengths, and degrees of opening can be varied to suit customers' requirements.

We shall be glad to give advice on the selection, preparation and blending of asbestos for use with cements and bituminous products for building materials, roofing compounds, plastic and electrical mouldings, etc. Specially prepared fibres are available as a heat insulation medium either alone or as the binder for various types of plastic non-conducting materials.

Our processed Blue asbestos fibres are widely used for loose-fill acid packing or insulation, filtration of liquids or gases, absorption and mechanical reinforcing; our Amosite processed fibres for many varied types of insulation products, absorption and mechanical reinforcing.

Mixing fibres will inevitably, by attrition, assist the opening process and may consequently result in loss in fibre strength.

Processed fibres plant



01 040 1241

Summary of grades

BLUE ASBESTOS

[illegible] grades: C&B, A, S, TS, MLS, B15, R, WDS

C, B

Long fibred asbestos for use in asbestos textiles, reinforced plastics, packings, acid resisting and reinforcing felts, chemical filtration, etc. The lengths of the crude asbestos from which these grades are obtained are:

Grade	Length of crude fibre in inches
[illegible]	[illegible] to [illegible]
[illegible]	longer than [illegible]

A

This is an intermediate grade, being prepared from asbestos seams between [illegible] and [illegible] inch long. It may be used for Blue asbestos textiles, packings, acid resisting and reinforcing felts, chemical filtration, etc., and also in order to speed filtration in wet manufacturing processes and increase the strength of asbestos-cement products.

S, TS, MLS

Prepared from seams below [illegible] inch long. These are the grades of Blue asbestos used most commonly in asbestos-cement sheet and pressure pipe. They are also used as loose fill and in moulding compounds and asbestos spray.

B15

A blend of processed Blue fibres of fibre length intermediate between S and A. This asbestos is in a more open condition than either S or A and requires very little or no further treatment before use in asbestos-cement mixtures, moulding compounds, loose fill or asbestos spray.

R

A short but particularly uniform and closely graded asbestos. Used in asbestos-cement sheet and pressure pipe. Also in the production of felts, millboard and dough moulding compounds for acid resistant and reinforcement purposes.

WDS

A short, strong fibre, particularly useful in asbestos-cement sheet manufacture.

Note:
Blue asbestos in most of the length gradings given above is available from different areas. One of these yields particularly hard, resilient fibres giving the best filtration and the maximum reinforcement in asbestos-cement products. Another yields a somewhat softer fibre, opening more easily, which is applicable in processes where a more fully opened fibre is required.

AMOSITE

Seventeen grades: D3, D11, LD3, DX, MD, M, K3, W3, S2, SK, SW, S33, GW, GK, RK, AW, A10

D3

The longest asbestos fibre of any type in standard production, used for the manufacture of rope lagging on simple carding machines, open mesh felts for insulation and fire resistance purposes, felts for reinforcement and filtration purposes.

D11

Long fibred: for use in heat insulating products.

LD3, DX

Long fibred: for use in heat insulating products. They are somewhat softer and more easily opened than Grade D11.

MD

Medium long fibre for use in heat insulation products.

M, K3, W3

Fibre of intermediate length for use in heat insulating products, reinforcement of acoustic and fire resistant boards, etc.

S2, SK, SW

Medium short fibre length for use in asbestos-cement products, asbestos spray, asbestos insulation board, loose fill, insulating compositions and moulding compounds.

S33, GW, GK, RK

Short fibre length for use in asbestos-cement products, finishing compositions, moulding compounds, loose fill and in asbestos spray.

AW

A fully processed, semi-short grade, for use in asbestos-cement products, as loose fill, and in moulding compounds or asbestos spray. This is a blend of fibres in a more opened condition than the preceding grades and may be used in many products without further fiberisation.

A10

A fully processed short grade of blended fibres. An alternative to AW if shorter fibre is required and perhaps more acceptable to the majority of asbestos-cement plants where the longer AW fibres are not required.

01 040 1242

Appendix

Ordering information

Cape Asbestos Fibres Limited in London acts as the commercial office for all raw asbestos produced by the Cape Group of Companies, and all enquiries should be sent to 114 Park Street, London W1.

Orders arising from these enquiries, however, are placed by the buyer with the mining company concerned. Orders for materials produced in South Africa are accepted for payment in South African currency.

By special arrangement however, Cape Asbestos Fibres Limited will accept orders on behalf of the mining companies, in which case payment is made in London in sterling.

All grades of asbestos except for processed fibres supplied by our United Kingdom manufacturing companies are sold in short tons of 2000 lb net (2020 lb gross), normally packed 20 bags to the short ton, each 100 lb net (101 lb gross).

BLUE ASBESTOS is supplied f.o.b.* African port, bags included, by Cape Blue Mines (Pty) Limited, who operate the mining companies within the Group producing Blue asbestos.

Payment terms: net cash by irrevocable letter of credit opened in their favour negotiable with and confirmed by Barclays Bank DCO, Rissik Street South Branch, Johannesburg; alternatively an approved London bank for orders accepted by Cape Asbestos Fibres Limited.

AMOSITE is supplied f.o.b.* African port, bags extra by Egnep (Pty) Limited, who operate the mining companies within the Group producing Amosite.

Payment terms: net cash by irrevocable letter of credit opened in their favour negotiable with and confirmed by the Standard Bank of South Africa Limited, Rissik Street South Branch, Johannesburg; alternatively an approved London bank for orders accepted by Cape Asbestos Fibres Limited.

PROCESSED FIBRES produced by our South African manufacturing company, Cape Asbestos Insulations (Pty) Limited, at Benoni, Johannesburg, and other associated companies in the Union, for direct shipment from South Africa, are supplied f.o.b.* African port, bags included, by Cape Asbestos South Africa (Pty) Limited.

Payment terms are net cash by irrevocable letter of credit opened in their favour negotiable with and confirmed by Barclays Bank DCO, Rissik Street South Branch, Johannesburg; alternatively an approved London bank for orders accepted by Cape Asbestos Fibres Limited.

Processed fibres produced by our United Kingdom factories and subsidiaries for delivery within the U.K. and overseas are supplied f.o.b. United Kingdom ports or delivered within the U.K. by Cape Insulation and Asbestos Products Limited. These materials are packed in standard bags each 112 lb and/or 56 lb net; alternatively 50 kilos and/or 25 kilos net.

ANNUAL CONTRACT

To assist in economic mining programming and to avoid disappointment to end users, Blue asbestos and Amosite asbestos for direct shipment from South Africa are generally sold on an annual contract basis, the annual contract period being from January 1 to December 31 each year, the contracts being negotiated in the October of the previous year.

* At customers' request, freight will be prepaid and charged at cost, insurance covered and premiums debited at cost.

Blue asbestos and Amosite products of the Cape Asbestos Group of Companies and of overseas associates

BLUE ASBESTOS

PLUTO
Blue asbestos mattresses
by
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

PLUTO
Blue asbestos cloth
by
Cape Insulation and Asbestos Products Limited (at Acre Mill, Yorkshire)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

PLUTO
Blue asbestos millboard
by
Cape Insulation and Asbestos Products Limited (at Barking Works, Essex)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

PLUTO
Blue asbestos fibre filled rope lagging
by
Cape Insulation and Asbestos Products Limited (at Acre Mill, Yorkshire)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

AMOSITE

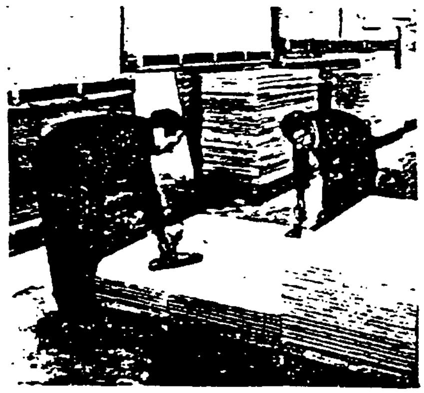
CAPOSITE
preformed moulded insulation materials
by
Cape Insulation and Asbestos Products Limited (at Barking Works, Essex; Acre Mill, Yorkshire)
Caposite Insulations Limited, Canada
Cape Asbestos Insulations (Pty) Limited, South Africa
James Hardie and Company (Pty) Limited, Australia
Isolamiante SA France (as 'Isolamiante')
Capamianto SpA, Italy
J. de Boer and Company, Holland
Eduardo Rosa, Spain
Montisol Argentina SRL, Argentina
Nippon Asbestos Company, Japan
Pittsburg Corning Corporation, USA (as 'Unibestos')

CAPOSIL 1800
high temperature block insulation
by
Cape Insulation and Asbestos Products Limited (at Barking Works, Essex)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

CAPOSITE and CAPOSIL
plastic compositions, hard setting cements and insulating concretes
by
Cape Insulation and Asbestos Products Limited (at Kentmere, Westmorland)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

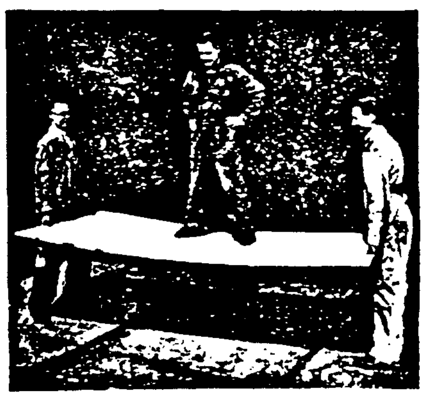
CAPOSITE
pure asbestos fibre filled lagging
by
Cape Insulation and Asbestos Products Limited (at Acre Mill, Yorkshire)
Capamianto SpA, Italy
Cape Asbestos Insulations (Pty) Limited, South Africa

CAPOSIL 1400
calcium silicate preformed insulation
by
Cape Insulation and Asbestos Products Limited (at Barking Works, Essex)

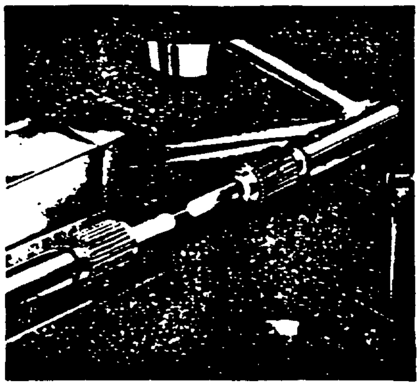


ASBESTOLUX
asbestos board products
by
Cape Building Products Limited (at Cowley Bridge Works, Uxbridge, Middlesex)
Dansk Eternit Fabrik A/S, Denmark
James Hardie and Company (Pty) Limited, Australia

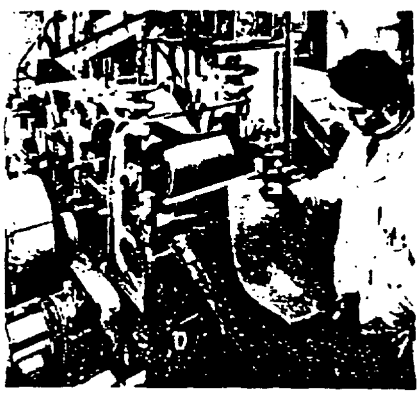
MARINITE
asbestos sheet (by arrangement with Johns-Manville International)
by
Marinite Limited (at Germiston Works, Glasgow)



01 040 1244



Basic research on blue asbestos. A micro-fibre of blue asbestos mounted in a machine for determining tensile strength



Applied research on blue asbestos. Investigating a blend of asbestos fibres in a small-scale board-making machine

Addresses

Fibre sales

Cape Asbestos Fibres Limited
114 Park Street
London W1
Grosvenor 6022
Cables: Amoblue London
Telex: 23758

Represented in USA by
North American Asbestos Corporation
Board of Trade Building
141 West Jackson Boulevard
Chicago 4
Illinois

Represented in Canada by
Cape Asbestos (Canada) Limited
8313 Bloor Street West
Toronto 14
Ontario

Represented in South Africa by
Cape Asbestos South Africa (Pty) Limited
P.O. Box 8644
Burlington House
22 Rissik Street
Johannesburg
Telegraphic Address:
Amosite Johannesburg

Mining companies

Amosa (Pty) Limited
P.O. Box 8644
Burlington House
22 Rissik Street
Johannesburg
Telegraphic Address:
Amosite Johannesburg

Cape Blue Mines (Pty) Limited
Registered Office
P.O. Box 8644
Burlington House
22 Rissik Street
Johannesburg
Telegraphic Address:
Amosite Johannesburg

Egnep (Pty) Limited
Registered Office
P.O. Box 8644
Burlington House
22 Rissik Street
Johannesburg
Telegraphic Address:
Amosite Johannesburg

Members of the Cape Asbestos Group of Companies

Designed and produced by The Woudhuysen Design Group and printed in England by The Kynoch Press, Birmingham

01 040 1246

SECTION - 3

TEST METHODS FOR BLUE & AMOSITE ASBESTOS FIBRES

SECTION 3 -- TEST METHODS FOR BLUE AND AMOSITE FIBRES

-- Under "Contents" are listed six (6) Sections, which are self-explanatory as they are studied. These six sections are divided in information as follows:

Section 1 -- Length Tests

Section 2 -- Measurement of Degree of Openness

Section 3 -- Cleanliness

Section 4 -- Asbestos-Cement Fibre Tests

Section 5 -- Chemical Tests

Section 9 -- General Information

Test Methods for Blue and Amosite Asbestos Fibres

Cape Asbestos Fibres Limited
114 Park Street London

01 040 1249

Contents

Section 1

LENGTH TESTS

Section 2

MEASUREMENT OF DEGREE OF OPENNESS

Section 3

CLEANLINESS

Section 4

ASBESTOS-CEMENT FIBRE TESTS

Section 5

CHEMICAL TESTS

Section 9

GENERAL INFORMATION

The Testing of Asbestos Fibres

By far the majority of the world's asbestos production is of chrysotile (white) asbestos and testing methods for asbestos have been generally associated with the qualities and characteristics of this type of fibre. The most authoritative information we have seen covering asbestos fibre testing is undoubtedly the Manual of Testing Procedures prepared jointly by the Asbestos Textile Institute, the Asbestos Cement Products Association and the Quebec Mining Association. This book does, however, clearly specify as its objective the testing of chrysotile fibres.

The different physical and chemical characteristics of the amphibole types of asbestos call for the development of other testing procedures and/or modification of the testing methods applied to chrysotile asbestos.

Our many friends who use asbestos have frequently asked how the blue and amosite fibres in which we specialise should be tested and how they should equip their laboratories to establish a practicable system of quality control. With this in mind, we have endeavoured to summarise our own technical experience of this rather specialised problem and this manual of test methods is the result.

The Cape Asbestos Group of Companies is the world's biggest producer of crocidolite (blue) asbestos and is responsible for the majority of the world's production of amosite. Its experience of production of amphibole fibres extends over more than 70 years and throughout this time these fibres and chrysotile fibres have been used in developing a wide range of products by the manufacturing companies within the Group. The use of amphibole fibres in the manufacture of other products outside the Group's manufacturing range has been pioneered and fostered by The Cape Asbestos Company in association with manufacturers; the development of asbestos-cement pressure pipes in Italy in the 1920's is a good example of this co-operation.

It is in the spirit of co-operation with chrysotile producers in the interest of asbestos users that this manual has been prepared by the Laboratory staff of Cape Asbestos Fibres Limited. It assumes that, as the greater part of production of amphibole asbestos is used in conjunction with and support of chrysotile, chrysotile testing methods should be applied to amosite and blue asbestos as far as possible.

Specific tests for the asbestos-cement industry include a method for the measurement of reinforcing value of asbestos fibre in asbestos-cement boards, using a simple air-curing technique, and wet bulk volume and filtration tests for asbestos-cement slurries. The latter two tests depart from recognised methods as, by making these tests on suitably diluted asbestos-cement slurries, important differences in the bulking, dispersing and filtration properties of the different types of asbestos are brought out.

We are grateful to our friends in the asbestos industry and to equipment suppliers for their help in compiling this manual. We have taken information from many and varied sources. It is impossible to list them all but our sincere appreciation is freely extended to all technicians who have been responsible for working out sound testing procedures for asbestos fibres.

The continuous development of knowledge and interest in these types of fibre call for constant re-examination and adaptation of testing methods. This manual is printed in loose leaf form to accommodate additional or replacement pages which will be issued as necessary, to ensure that it is kept as up to date as possible.

Cape Asbestos Fibres Limited
114 Park Street
London W1

Section 1
LENGTH TESTS

01 040 1252

Quebec Standard Asbestos Testing Machine

Equipment 1 The Quebec Standard Asbestos Testing Machine (or Canadian Box Tester) consists of a nest of three testing boxes, a pan and a cover, clamped to a shaking table. The base of each testing box consists of a brass screen, the mesh specification of each screen being as follows:

Box Number	Screen Opening	Diameter of Wire
1 (Top)	0.500"	0.105"
2	0.187"	0.063" (4 mesh)
3	0.053"	0.047" (10 mesh)
4 (Pan)	aluminum sheet base	

These are US Standard Sieves, or Tyler equivalents.

The shaking table is driven by an eccentric having $\frac{21}{32}$" throw and $1\frac{5}{16}$" travel, the speed of rotation being 327 rpm. A timing device governs the motor so that the eccentric makes exactly 600 revolutions in each test and then automatically stops.

Complete details of this machine are given in publication NRC 3470 of the National Research Council of Canada, entitled 'Specifications and Drawings for Quebec Standard Asbestos Testing Machine, Model No 2, 1938'. The essential features of the machine, derived from these drawings, are shown diagrammatically on page 1·1/3. It is particularly important that the direction of rotation of the eccentric is counter-clockwise, when the machine is viewed from the side shown in the diagram.

2 A balance with a capacity of at least 1 lb and a sensitivity of 0.1 oz will be required. The scale should preferably show both pounds and ounces and kilogrammes and grammes. The balance should be equipped with a large scoop.

Method 16 oz or 454 gm of asbestos are placed in No 1 box, which is then covered and clamped. The machine is started and at the end of the timed test the contents of each box are weighed.

Results The results of the Quebec Standard Test are usually expressed in ounces weight of the fibre on each box; alternatively they may be expressed as percentages:

Box	1	2	3	4
Ounces	a	b	c	d
%	—	—	—	—

The total is always 16 oz and the results may be expressed to 0.1 oz.

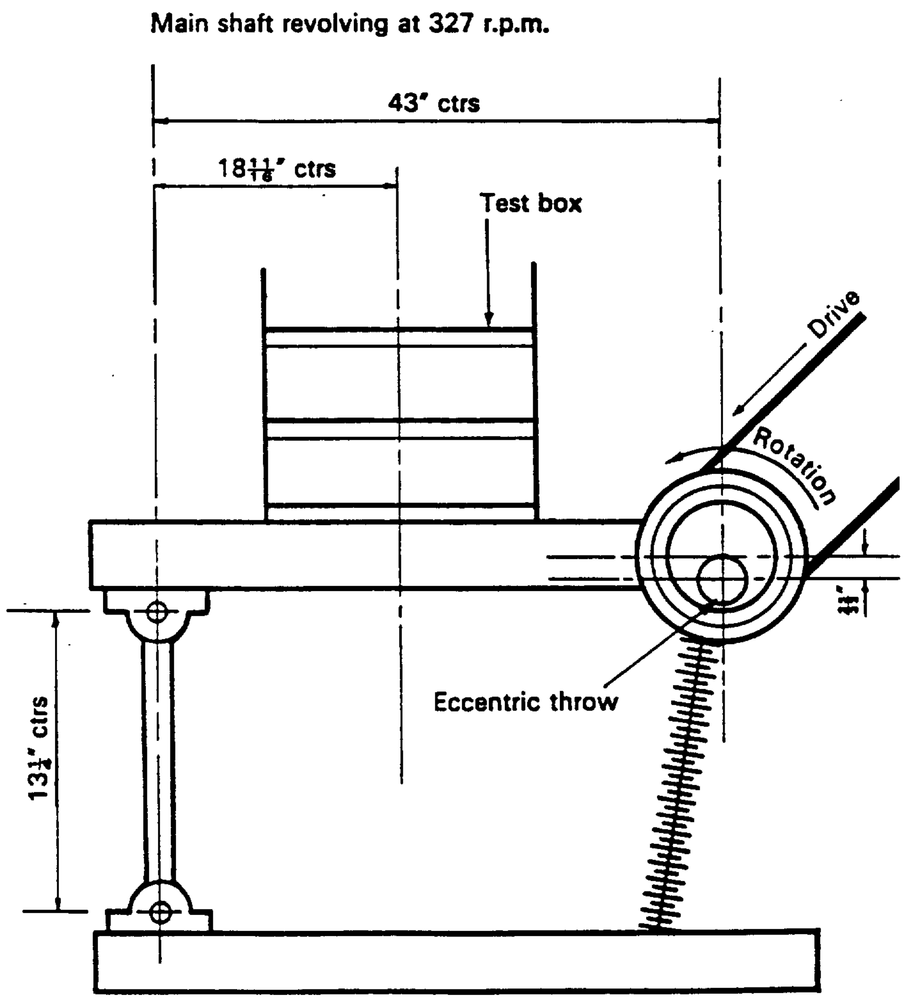
01 040 1253

Interpretation of Results

The Quebec Standard Test was developed as a primary method for classifying chrysotile asbestos fibres. Canadian producers provide a minimum shipping specification for run-of-mill chrysotiles by means of this test. The machine is entirely suitable for chrysotile fibres, but the same cannot be said for amosite and blue asbestos fibres. For this reason producers of amosite and blue asbestos do not quote the Quebec Standard Test for purposes of specification, though at the same time the results of this test may be taken as a guide to the grading of these fibres.

The disadvantage of the box test becomes apparent when it is applied to processed types of amosite and blue asbestos and, to a lesser extent, to processed chrysotiles. In the milled state these fibres produce a bulky flock, the greater part of which will remain on the first tray of the box tester, although in the non-processed state a large proportion may pass through the first tray. Any results obtained in the box test therefore should be interpreted with due regard to the degree of openness of the fibre (see Section 2). The general rule here is that the higher the degree of openness for any grade of amosite or blue asbestos, the greater the proportion of fibre retained by the first tray; a limit to this rule is reached when the fibre has been excessively shortened by progressive milling.

Because of the bulky nature of milled amosite and blue fibres, it is often impractical to use the full 16 oz of fibre for this test. The fibre as such will pack the top box and little or no agitation of the mass will take place, with the result that no proper separation occurs. It is therefore recommended that a sample of 100 gm be taken for such fibres, the result of the test being expressed directly as a percentage.



Quebec standard asbestos testing machine

01 040 1255

Bauer McNett Fibre Classifier

The Bauer McNett Fibre Classifier determines the length distribution and fines content of medium and short grades of asbestos by a wet classification method. A sample of fibre is washed over a series of four screens of diminishing aperture, and the material collected at each screen is dried and weighed. Five such fractions are determined.

The action of the Classifier is such that in each of its four tanks the fibre, dispersed in a large volume of water, passes through the gap between a vertical screen and baffle plate parallel to the screen (see pages 1·2/4, 1·2/5). The fibre thus lays parallel to the plane of the screen, while at the same time the water flows through the screen. Fibres of length greater than the average mesh size of each particular screen are retained by that screen and smaller fibres pass through.

It is important that the agitator speed and direction of rotation should be correct, so that the classifier functions properly.

Agitator Speed 540 ± 40 rpm
Agitator rotation clockwise when viewed from top.

Equipment 1 The Bauer McNett Fibre Classifier No 203A.
The essential details of this machine are shown in the diagram on page 1·2/5, and the design of the vacuum cups used when draining the tanks is shown on page 1·2/6. These cups are not supplied with the machine and require to be built separately.

2 a Balance, sensitivity 0.01 gm
b Drying Oven, operational temperature 105°C
c Filter papers 18.5 cm diameter, Whatman No 541

Sample weights Screen sizes and Times

Type of Fibre	Screen Sizes (Tyler Mesh)	Sample Weight in grams	Duration of Test in minutes
amosite and blue asbestos, groups 2 to 7	4, 14, 35, 100	10	20
chrysotiles, groups 3 to 6 and 7D	4, 14, 35, 200	10	20

Method With screens and tank stoppers in place, fill the tanks with water. Adjust the flow so that there is slight overflow from the constant head tank and start the motor to set the agitators in motion.

Stir the 10 gm sample of fibre into 500 ml water in a beaker and pour the suspension into No 1 tank. Record the time.

While the classifier is running the tanks should be watched, should they tend to overflow. An overflow will be caused by accumulation of the bulk of the sample on one particular screen, and if this occurs the screen must be cleaned in situ, either by brushing it with a long handled brush, spraying with the small hose pipe used in the final operation, or simply agitating the water between the baffle plate and screen with a suitable rod. The latter method is probably the more preferable, but in any event care must be taken that this cleaning process does not cause fibre to pass end on through the screen while the machine is operating.

Meanwhile, fit one 18.5 cm filter into each filter cup and clamp the cups in place. When the classifier has run for 20 minutes, shut the water off and stop the motor.

Withdraw the stoppers from the tanks and allow the contents to drain through the filter cups. Connect the nipple at the bottom of each filter cup to a water vacuum pump to speed up drainage. As each tank empties, wash down the screen and the interior of the tank with a small hose pipe, ensuring that all fibre has been washed through to the filter cup.

After completely draining the cups, take out the filter papers carrying the fibre fractions. Fold each filter paper and place them in the drying oven for a minimum of two hours.

Weighing the Fractions

The type of analytical filter paper recommended is of constant weight within 0.10 gm. Weigh each fraction therefore with its filter paper, and subtract the weight of the filter paper to find the weight of the fraction. (The average tare weight of the filter papers should be predetermined on batches of 20 or more.)

Results

Determine the percentage of fibre collected on each screen. Subtract the total percentage of the four screens from 100% to find the percentage of fibre passing through the fourth screen. Express the results as follows:

McNett Classification

	+4M	+14M	+35M	+100M	—100M
%	a	b	c	d	e

Interpretation of Results

Many types of chrysotile fibres contain a proportion of extremely finely divided serpentinous matter. The assessment of this fine material is done on the Bauer NcMett classifier by accounting for all the fines which pass the 200M screen.

The 4M —14M —35M —200M screen sequence is not necessary when testing amphibole fibres and therefore a 100M screen may be used in place of the 200M. (It may be added that 200M screens are fragile and require frequent replacement.) For most practical purposes the 4M —14M —35M —100M sequence is adequate for all types of fibres.

The McNett Index

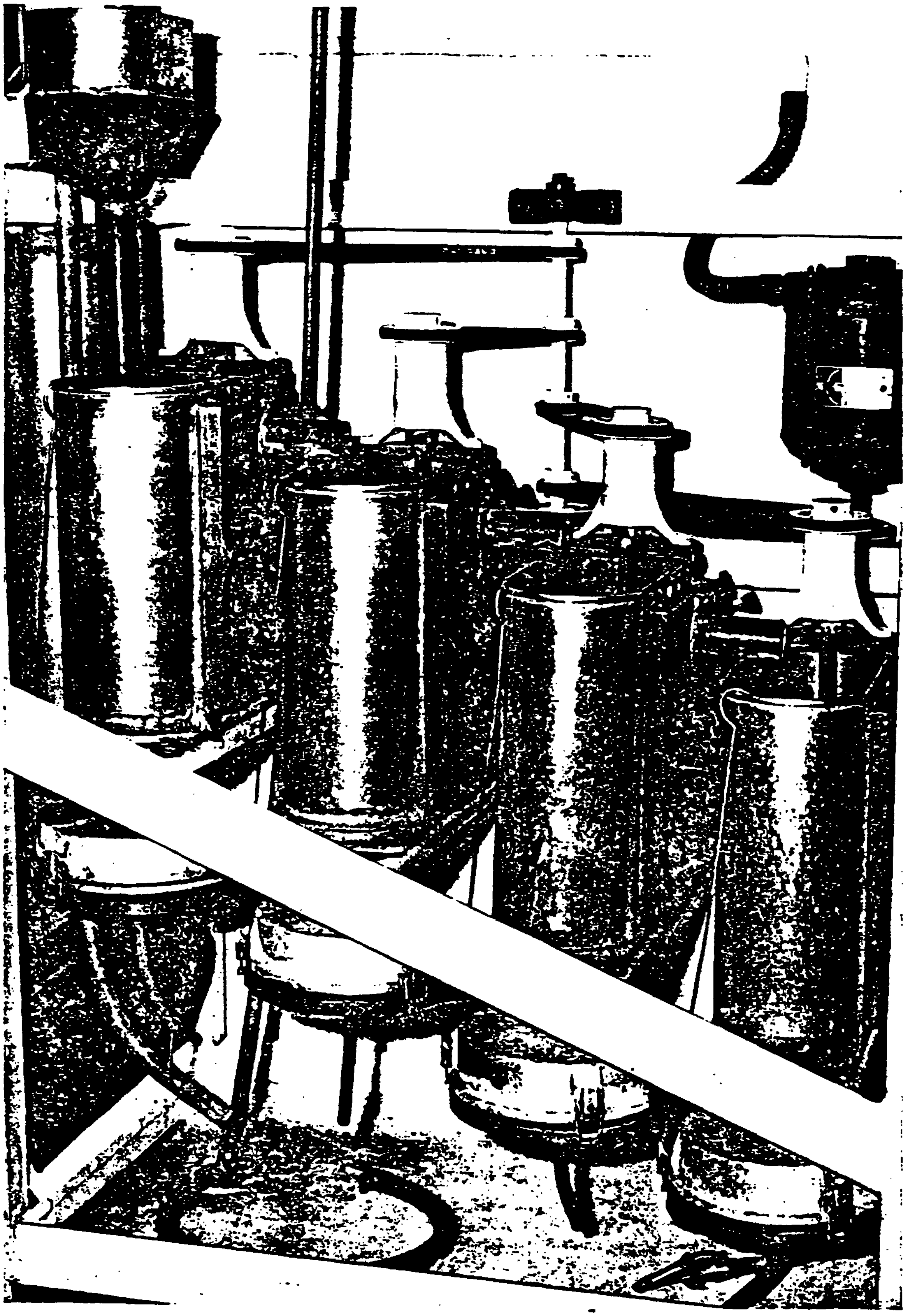
This is a simple arithmetical relationship allowing the assessment of McNett classification to be expressed as a single figure. It is derived as follows:

1 x %	4M	=	a
2 x %	14M	=	b
3 x %	35M	=	c
4 x %	100M	=	d
5 x %	–100M	=	e

McNett Index (MI) = a + b + c + d + e

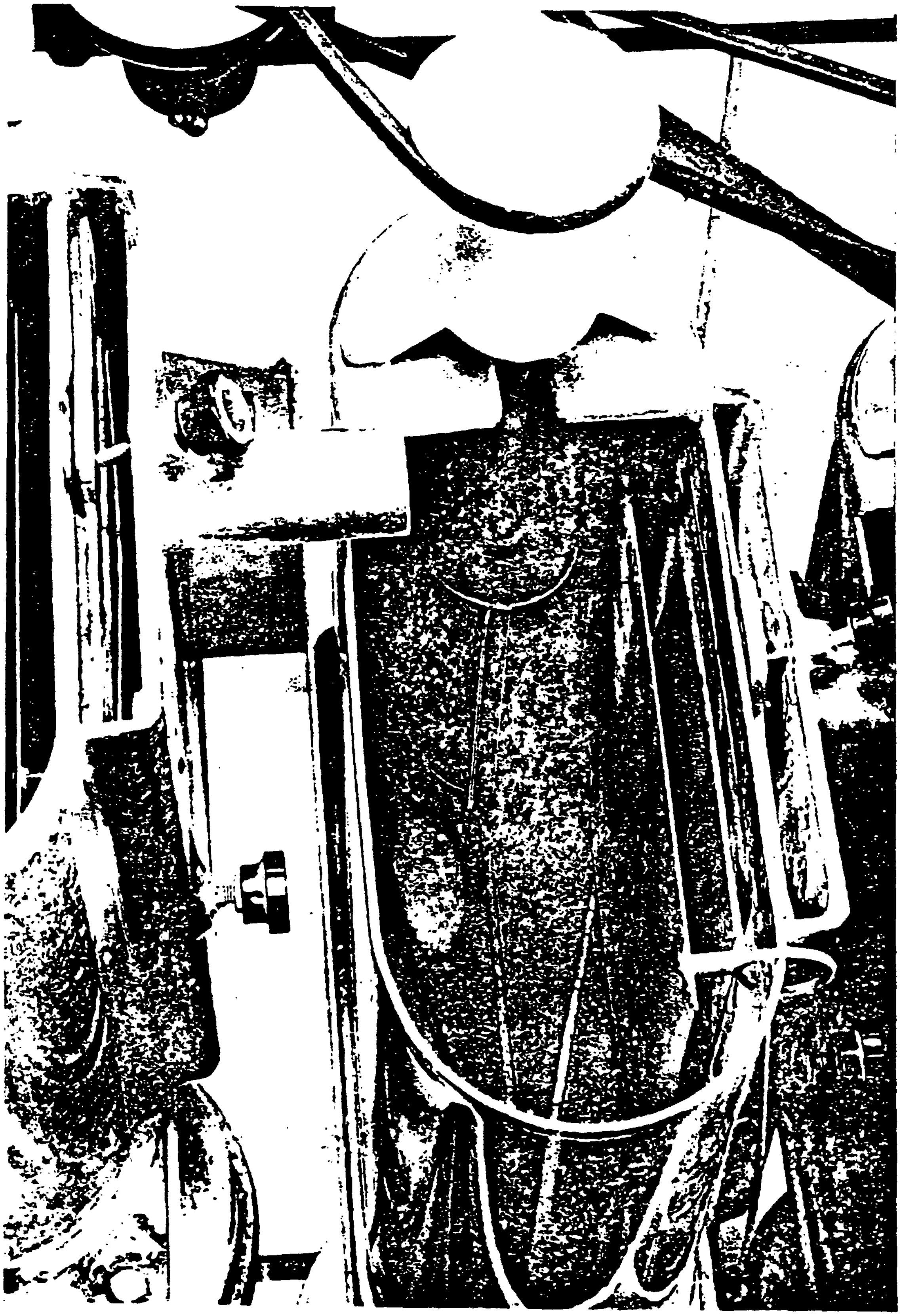
All McNett Indices lie between 100 and 500. A long fibre, all of which is retained on 4M, has an index of 100, while a finely ground fibre, all of which passes 100M, has an index of 500.

Although the McNett Index is based on a purely arbitrary relationship, it serves to bring into prominence the degree of overall shortness of a fibre, particularly after processing. For example, a useful approach in assessing the performance of fiberising machinery combines the measurement of both degree of openness and McNett index on fibre after processing under different operating conditions in the same mill. The graphical expression of McNett index in relation to degree of openness will indicate to what extent the particular mill fiberises and shortens the fibre. The same approach may be used to assess a sequence of fiberising (or dry fibre processing) operations, each of which individually may contribute to the opening and shortening of a fibre.



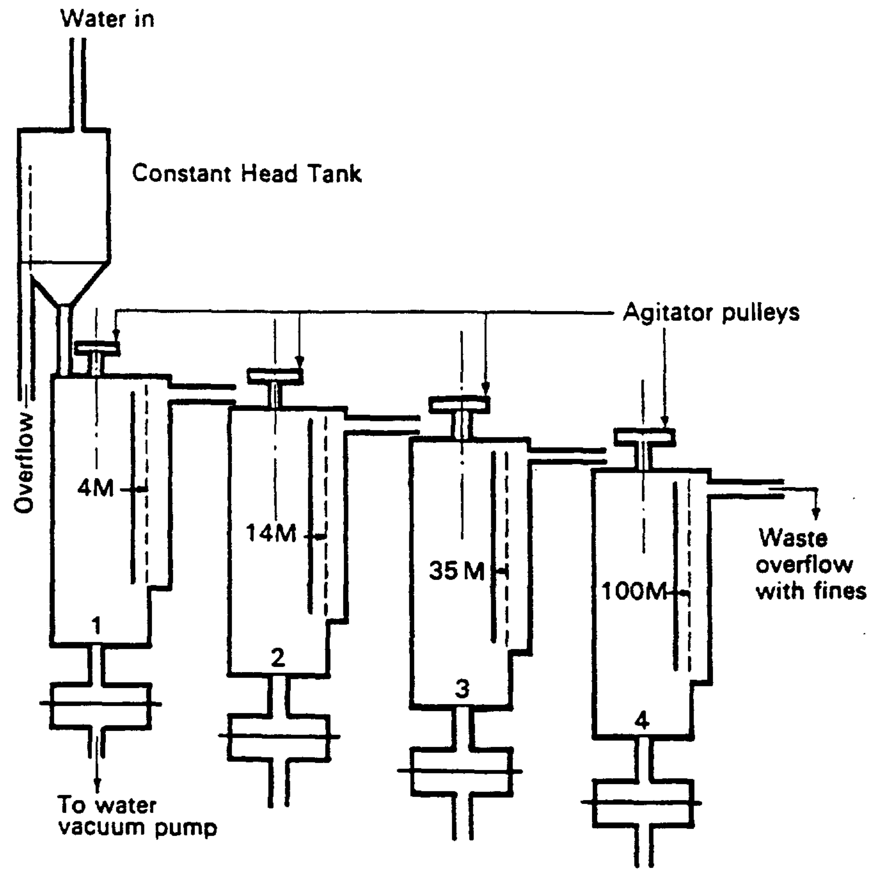
Bauer-McNett classifier

01 040 1258

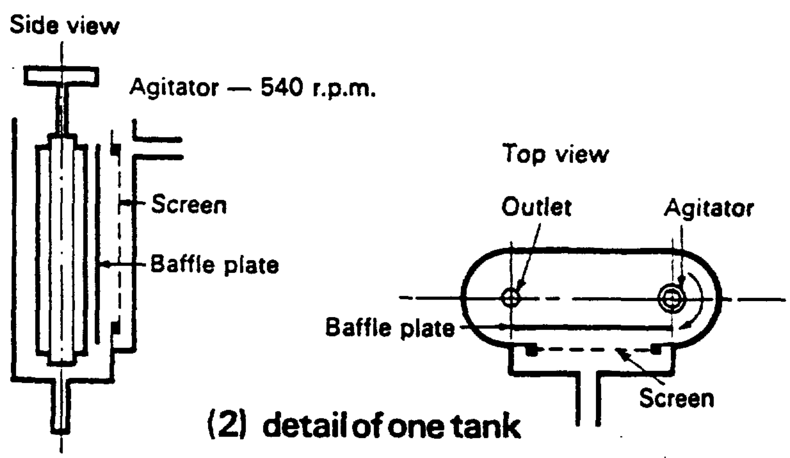


Bauer McNett classifier
detail of tank and agitator

01 040 1259



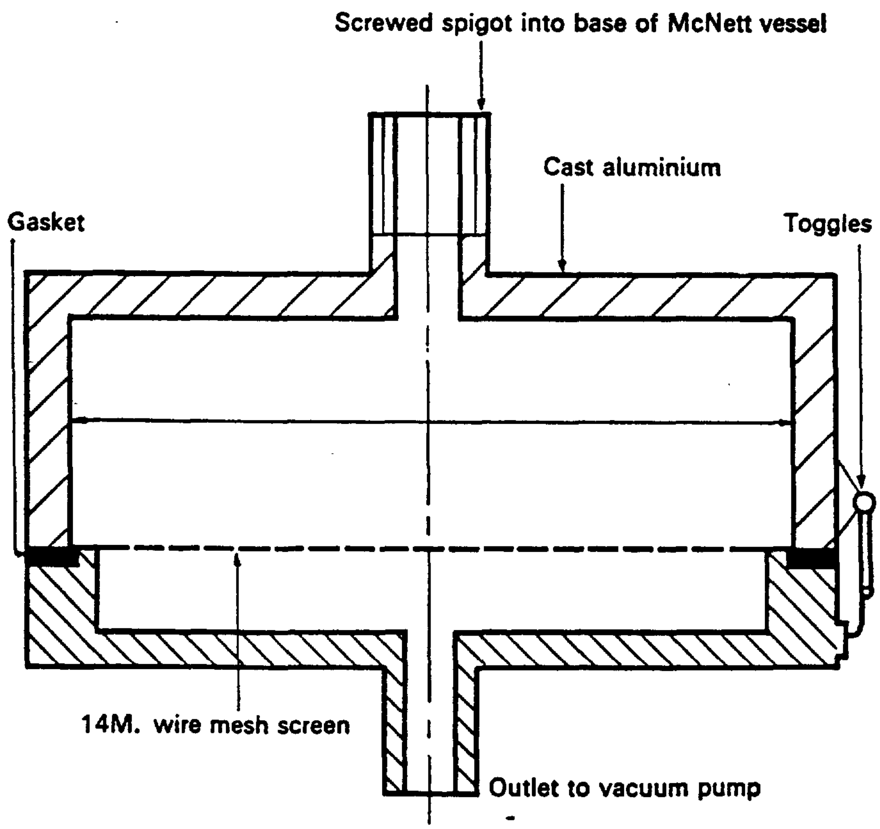
(1) flow diagram



(2) detail of one tank

Bauer McNett classifier

01 040 1260



(3) detail of vacuum filter cup

Bauer McNett classifier 01 040 1261

Length sorting of asbestos textile fibres

Experience has shown that the only reliable method of determining the fibre length of long asbestos is by the manual separation of a suitable sample into length groups. Each length group is then weighed and its percentage of the whole sample determined. No machine has yet been devised to enable this separation to be made automatically. In relation to the maximum separable length which can be sorted by means of the Quebec Standard Testing Machine or the Bauer McNett classifier, manual separation remains the only method whereby fibres of $\frac{1}{2}$" length and over can be classified.

The manual length sorting of fibres requires time, patience and skill in manipulation if no mechanical aid is available. The test method is considerably aided by the Suter-Webb comb sorter, a device developed for the length sorting of cotton and wool fibre and the like, and adapted for use with asbestos fibres.

Equipment 1 For unaided length sort: Velveteen pads (white for amphibole fibres, black for chrysotile fibres) mounted on stiff board or aluminium sheet; two pairs wide tweezers with prongs lined with soft rubber; hard rubber roller and steel plate; an analytical balance, sensitivity 1 mgm.

2 Alternatively: the Suter-Webb comb sorter, adapted for use with asbestos fibres, complete with all accessories for manipulating fibres (see page 1·3/3).

Method 1 Preparation of Sample

Take approximately 25 gm of the sample of fibre, and repeatedly divide this sample by halving until a representative 3 gm portion is obtained. Place the fibres portion by portion on the steel plate and fiberise the crude stalks by passing the roller over them in longitudinal direction. Spread the fibres out on a velvet pad and take five pinches of them to obtain a 1 gm sample, repeating the procedure to reduce this 1 gm sample to 0.2 gm.

2 Sorting by Manual Method

a Separate the 0.2 gm sample into small groups aligning the fibres in each group by pulling them lightly between two pairs of tweezers. Lay the fibres in parallel alignment on a velvet pad, teasing them out as much as possible.

b Cut a number of narrow strips of paper into lengths according to the length groups devised. A useful series is: 1, less than $\frac{1}{4}$"; 2, $\frac{1}{4}$" to $\frac{1}{2}$"; 3, $\frac{1}{2}$" to $\frac{3}{4}$"; 4, $\frac{3}{4}$" to 1"; 5, 1" to $1\frac{1}{2}$"; 6, $1\frac{1}{2}$" to 2"; 7, over 2". Place the strips on a velvet pad, parallel to each other with 1" gaps between them.

c Pick the asbestos fibres one by one, matching them against the strips of paper and laying them alongside each. When all the fibres have been sorted, weigh the amount in each length group.

3 Sorting with the Suter-Webb Comb Sorter

The Suter-Webb sorter consists of two banks of 16 fine steel combs, each set of combs being spaced by $\frac{1}{8}$" from the next. Sixteen length groupings are thus available.

a Commencing from 2a above, the fibres are spread uniformly on the left hand bank of combs. To facilitate this, small particles of the sample held in the tweezers are opened up by pulling them over a single comb on the right hand bank before laying them on the left hand bank.

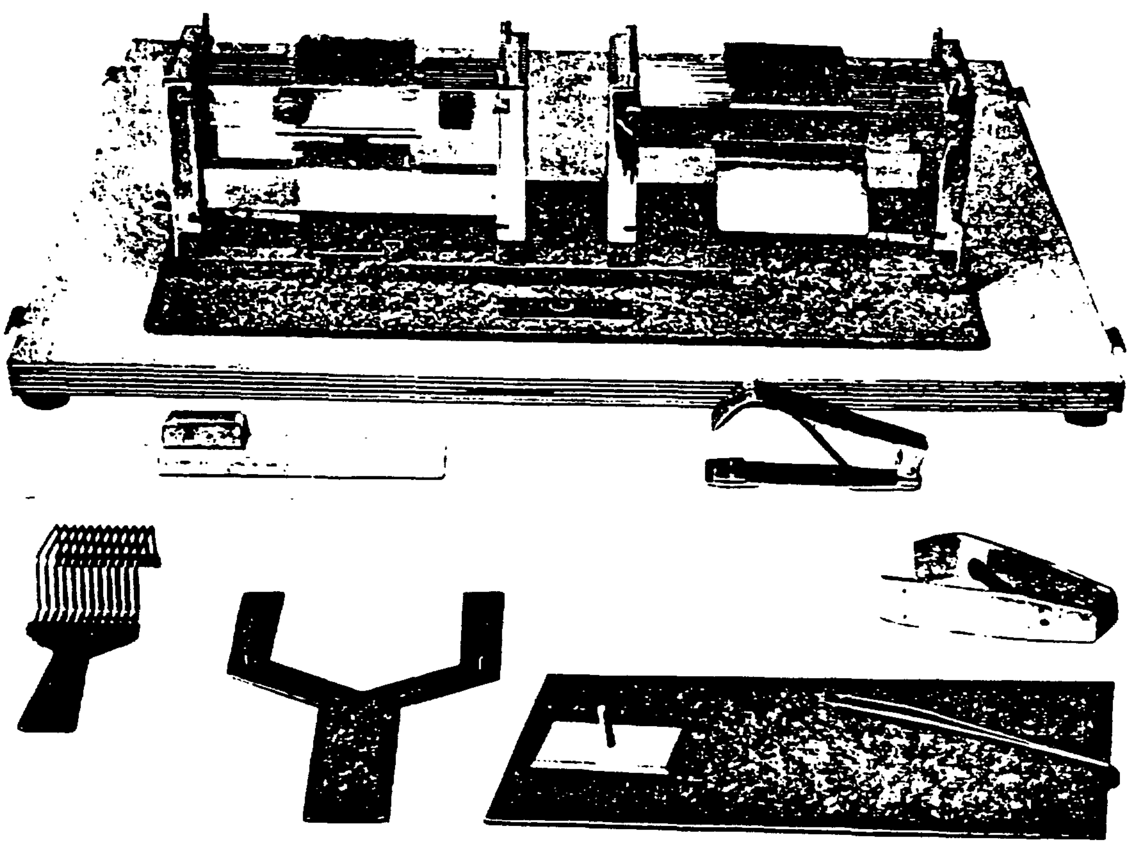
b Drop the left hand bank of combs one by one, extract with the tweezers all protruding fibres and transfer them to the right hand bank. Lay the fibres in this bank allowing $\frac{1}{8}$" of fibre length to protrude from the front comb.

c When all the fibres have been so transferred turn the bank of combs round and commence extracting all the fibres which protrude from this side. These will constitute the length group of fibre over 2" in length. Put these to one side on a velvet pad. Drop the combs one by one and extract the protruding fibres so that a number of length groups diminishing in steps of $\frac{1}{8}$" are obtained. When all the fibres have been sorted, weigh the amount in each group.

Results 1 The length distribution of the sample may be expressed in terms of the percentage weight of fibre in each fraction.

2 The results may be expressed visually in a block histogram, putting length of fibre on the vertical co-ordinate and weight along the horizontal co-ordinate. The weight of each group is marked off in order of decreasing length from the left hand side of the graph paper.

3 The sorted fibre sample may be photographed for permanent visual record. Each length group is spread out side by side on a velvet pad, starting with the longest group at one end, aligning the bottom ends of all groups along a straight line. A photograph of this array indicates both length distribution and textural characteristics.



Suter-Webb sorter

01 040 1264

Rotap Dry Sieve test

The Rotap dry sieve test, described in the 'Manual of Testing Procedures for Chrysotile Asbestos Fibre', is more useful on chrysotile fibres, where it can be applied as a classifier. The action of the Rotap sieve shaker is such that it imparts a horizontal oscillatory motion to a pile of sieves, while at the same time giving a vertical tapping action to the pile. A series of 8" diameter Tyler standard sieves are used, a typical descending sequence for Group 3 fibres being 3M, 4M, 6M, 10M, 20M, 35M, Pan.

The test does not classify amosites and blue asbestos fibres in terms of length. This machine however possesses the useful property of separating the medium and short grades of these types of fibres into fiberised material and non-fiberised spicules. The fiberised material fluffs up and remains on the top three screens, while spicules fall end on through the lower screens.

Equipment

1 Rotap Testing Sieve Shaker complete with automatic timer. The machine operates at 154± 4 taps per minute, at a speed of 285 rpm (UK Suppliers: International Combustion Products Limited.)

2 Tyler Standard Mesh sieves: 3M (or ½" mesh), 4M, 6M, 10M, 14M, 20M, 28M, 35M, 65M and Pan.

3 Balance capacity 200 gm, sensitivity 0.1 gm.

Method

Screen sequences, weights of fibre and test duration times are given in the table below.

1 Weigh the specified amount of fibre into the top sieve of the sequence chosen. Close the nest of sieves into the Sieve Shaker, set the automatic timing switch to the required time and switch on the machine.

2 At the end of the test period, weigh out the amount of fibre collected on each sieve and in the pan.

Results

Express results as the % amount of fibre retained on each sieve.

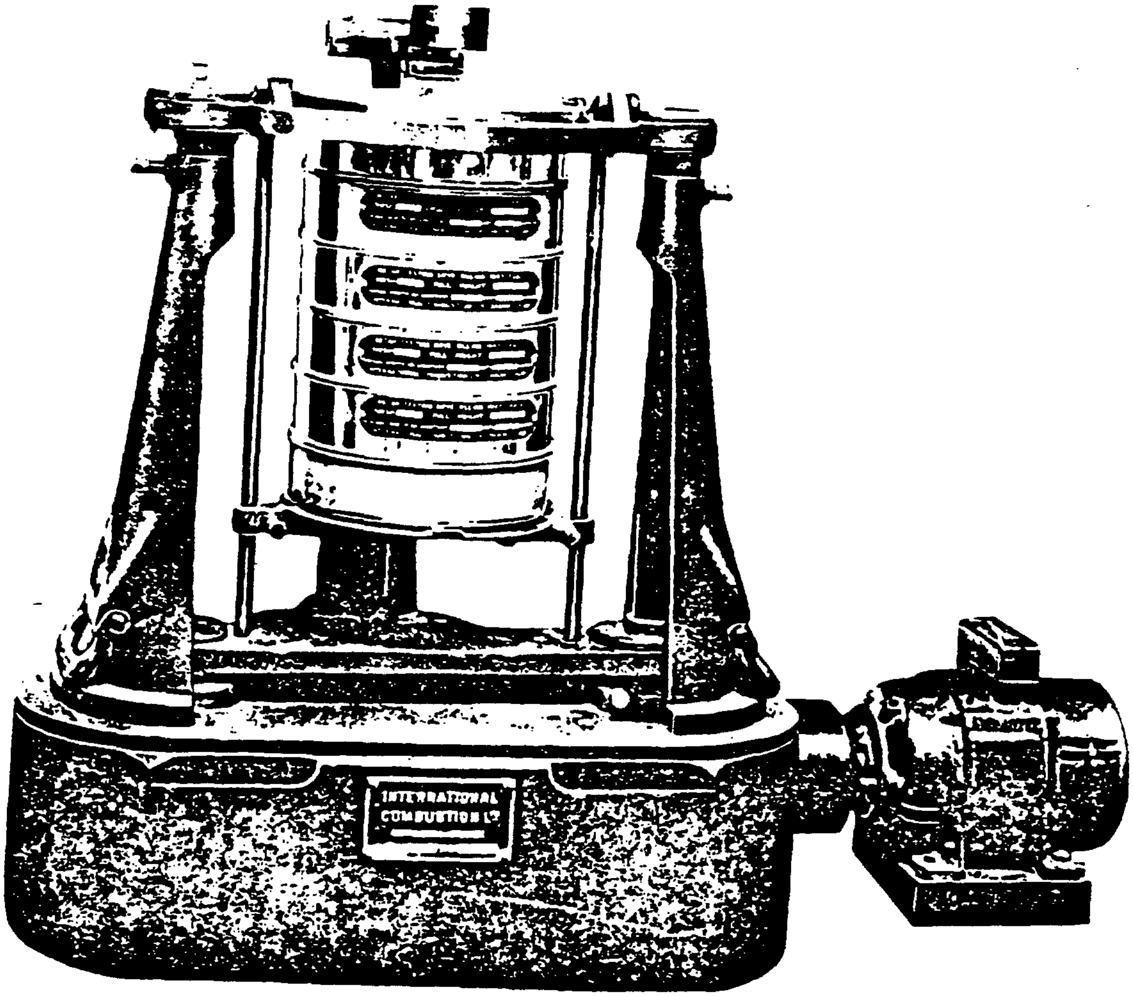
Table of screen sequences, sample sizes and test durations for Rotap Sieve Tester

Screen sequences:

Fibre type	Mesh
Amosites and blue asbestos. Group 4 chrysotiles	3, 4, 6, 10, 20, 35. Pan
Group 5 chrysotiles	4, 6, 10, 20, 35, 65. Pan
Group 6 and 7D chrysotiles	6, 10, 14, 20, 35, 65. Pan

Sample sizes and test durations:

Fibre group	Sample size	Test Duration
Amosites and blue asbestos 4 chrysotiles	5 gm 50 gm	30 min 10 min
5 chrysotiles	50 gm	10 min
6 and 7D chrysotiles	100 gm	10 min



Rotap sieve shaker

01 040 1266

Section 2
MEASUREMENT OF DEGREE OF OPENNESS

01 040 1267

Measurement of Degree of Openness

An assessment of degree of openness is probably the most important test which can be applied to asbestos fibres. The test method involves measurement of the rate of flow of air through a tightly packed plug of fibre. The technique has the advantages of rapidity and of not interfering in any way with the characteristics of the fibre, which can be used again in other tests.

The two types of air permeability apparatus hereafter described are the Blaine Dyckerhoff apparatus, and the Rigden apparatus. The principle of operation of both these is identical, but there are certain differences in manipulation.

The plug of asbestos must be contained in an accurately dimensioned air permeability cell, and a description of such a cell suitable for use with amosite and blue asbestos is included.

Blaine Dyckerhoff Air Permeability tester

Equipment 1 The Blaine Dyckerhoff apparatus consists essentially of a U-tube of accurate bore, one end of which is connected to an air pump and to the air permeability cell, the other end being free to atmosphere. The U-tube is filled up to a prescribed level with the liquid supplied with the apparatus. By operating the air pump the liquid is raised in one limb of the U-tube. The liquid is then allowed to fall under its own volition towards its equilibrium level, as it does so, sucking air through the plug of fibre in the air permeability cell. The time taken for the liquid to fall between two predetermined points is recorded automatically on a clock. This time is a measure of the degree of openness of the fibre.

The diagram on page 2·1/3 shows the essential parts of the apparatus. As received from the manufacturers, the U-tube and liquid are packed separately. The apparatus should be set up as follows.

a Fill the U-tube (1) with the liquid supplied, up to within about 2 mm of the ring scratched on the longer limb.

b Unwrap the electrode assembly (2) and insert it into the shorter limb, ensuring that the plug is pushed home.

c Check the oil level (3) and if necessary, add more liquid drop-wise until the bottom of the meniscus aligns with ring. (It may be necessary to check the oil level from time to time, when the apparatus is in operation.)

d Push the end of the longer limb into the wide rubber tubing (4) attached to the valve assembly (5). Clamp the U-tube in position on the base of the clock cabinet with the clamp (6).

e Connect the apparatus to the mains electricity supply.

2 A balance of capacity up to 200 gm, sensitivity to 0.1 gm will be required for weighing samples.

3 Porous paper plugs, and filter papers for use with the Blaine Dyckerhoff cell. (These are supplied with the apparatus.)

Method 1 Weigh out 50 gm of the sample of fibre to be tested.

2 Prepare the cell (7) by placing the perforated metal plate (9) in the bottom, laying upon this a filter paper (10).

3 Put the fibre in the cell in small quantities at a time, ramming the fibre down firmly with the packing rod provided. (This operation will be facilitated with a wide mouthed metal funnel, made to a suitable size to fit into the top of the cell.) When all the fibre is in the cell, cover the fibre with the flow distributing plate (11), with its wire mesh against the fibre.

4 Insert the cell plunger (12) and ensure that it is tight against the top edge of the cell body. It may be necessary to place the complete cell in a vice to compress the two parts together.

5 Place a porous paper dust plug (8) inside the bayonet fitting on top of the clock cabinet. Attach the cell to the bayonet fitting twisting it to ensure a tight fit.

method continued

6 Switch on the apparatus. Turn the hand wheel operating the air piston, so that the liquid rises in the left-hand limb. Observations should be made at the back of the apparatus to ensure that it functions correctly both mechanically and electrically. The oil level will begin to rise in the right-hand limb as soon as the air piston has been drawn to its fullest extent. When the oil level touches the middle electrode, the clock will start, stopping when the oil level touches the top electrode.

7 The time T, in seconds recorded on the clock is proportional to the degree of openness of the fibre. (See page 2·4/1 and Table I, page 2·4/3, for interpretation of results.)

Faults in Operation

1 Incorrect functioning of the apparatus arises through faults developing at the electrode assembly. These result in the clock failing to start until the oil level has risen up to several cm above the end of the middle electrode, or even failing to start at all. The following points should be observed:

a The electrodes must not touch each other, nor must they touch the side of the glass tube. If they do, they must be re-aligned so that they are equidistant from each other and from the sides of the tube.

b The electrode holder must not be allowed to be wetted with oil, otherwise this will cause a short in the electrical system. If it has inadvertantly become wetted it should be taken out, cleaned with alcohol and allowed to dry. The inside rim of the left hand limb should be wiped free of oil before re-inserting the electrode assembly.

c Electrical polarisation of the liquid may occur if the apparatus is left switched on for long periods of time. To avoid this it is advisable to switch the apparatus on only during the period of making a measurement.

d If the apparatus still does not operate satisfactorily it may be found necessary to improve the conductivity of the liquid by adding to the liquid 2 to 3 mg of potassium chloride crystals.

2 Air leaks. These may develop in the valve assembly or across the rubber cushion between the bayonet fitting and the cell. It is advisable to smear silicone vacuum grease inside the rubber sleeve (4) and round the chamfered rim of the bayonet fitting.

a Test for air leaks by smearing petroleum jelly or silicone grease round the top of the bayonet fitting and covering it with a ground glass plate. Raise the oil level in the left hand limb. The level should remain stationary for at least ten minutes.

Fit the cell in position, without the cell plunger, and repeat the operation with a ground glass seal over the top of the cell.

b In the event of a persistent air leak, strip down the valve assembly (5) and examine the rubber sleeving on the non-return valve.

Alternative Cells

The cell supplied with the Blaine Dyckerhoff apparatus will accommodate 50 gm of an average chrysotile fibre, without the need to use a great deal of force to close the cell. The cell will accommodate 50 gm samples of the shorter, less open amphibole fibres, but usually the dry bulk of amphibole fibres is so much greater than that of chrysotile that it is not possible to pack the requisite amount into the cell. Further difficulties arise with long amosite and blue fibres, which will not pack satisfactorily in a narrow cell. If less than the requisite amount of fibre is packed into the cell then factors must be introduced to allow comparison of the readings for different weights of fibre. Further factors must be introduced to account for the different specific gravities of amphibole and chrysotile fibres.

For these reasons, two modified cells are used, each mounted in a small hand press to facilitate packing of the fibre to a fixed volume. The smaller of the two cells has an internal diameter of $1\frac{3}{4}$", and is intended for general purpose use with all medium and short types of asbestos fibres. The larger cell has an internal diameter of 3" and is intended for use with long amphibole fibres. Both cells provide fibre bed depths of 1". The essential details of this design of cell are shown diagrammatically on page 2·2/2

These cells have been designed for connection to and use with any type of air permeability apparatus suitable for measuring surface areas of asbestos fibres. They are therefore referred to as the $1\frac{3}{4}$" Universal cell and the 3" Universal cell.

To connect these cells to the Blaine Dyckerhoff apparatus, it is necessary to remove the existing Dyckerhoff cell, and fit a $\frac{1}{4}$" screwed spigot into the hole of the bayonet fitting at the top of the clock cabinet. A length of rubber pressure tubing should then be connected between the spigot and the cell.

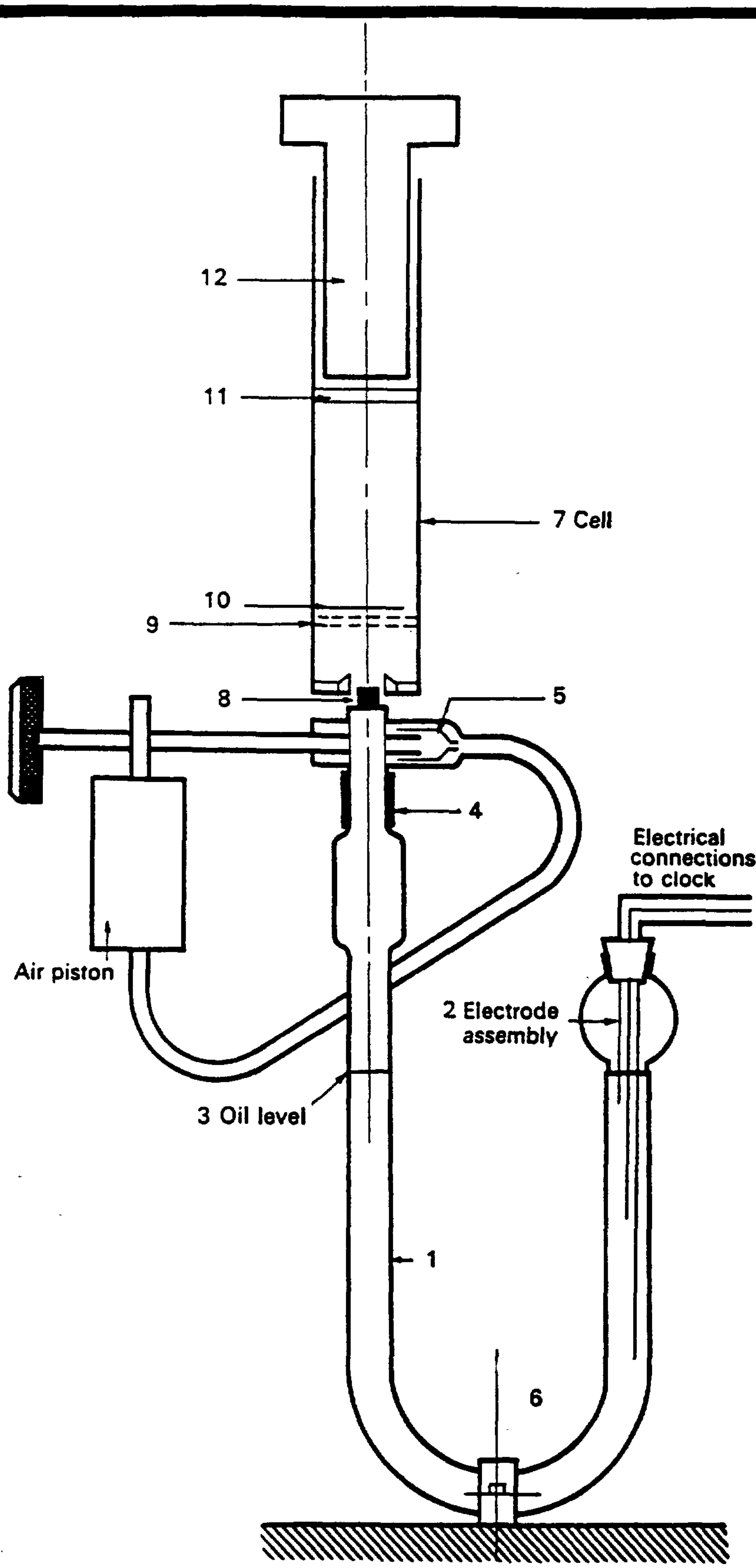
Method a Disconnect the cell from the rubber tubing before attempting to fill it with fibre.

b Refer to Table II, page 2·4/3 and choose an appropriate weight of fibre according to its visual degree of openness. Weigh out the fibre sample and pack it into the cell using a funnel and a ram, adding the fibre in small quantities of about 5 gm at a time and pressing each lot down firmly.

c Fit the piston into the cell and return the whole into the press, tightening up until the edge of the piston mates with the rim of the cell body.

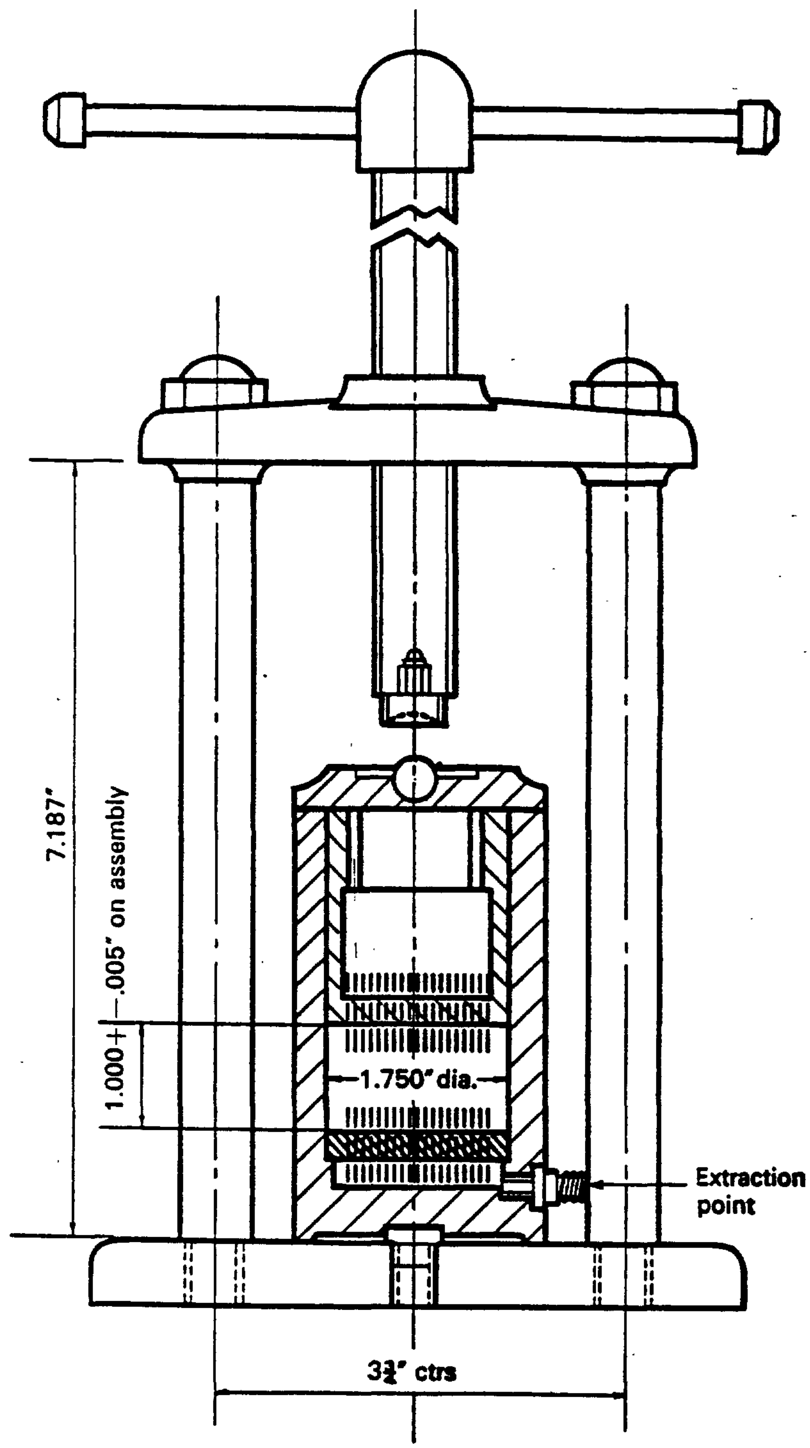
d Connect the cell to the Blaine Dyckerhoff apparatus and make the air permeability measurement as described above.

e The time T, in seconds is proportional to the degree of openness of the fibre.



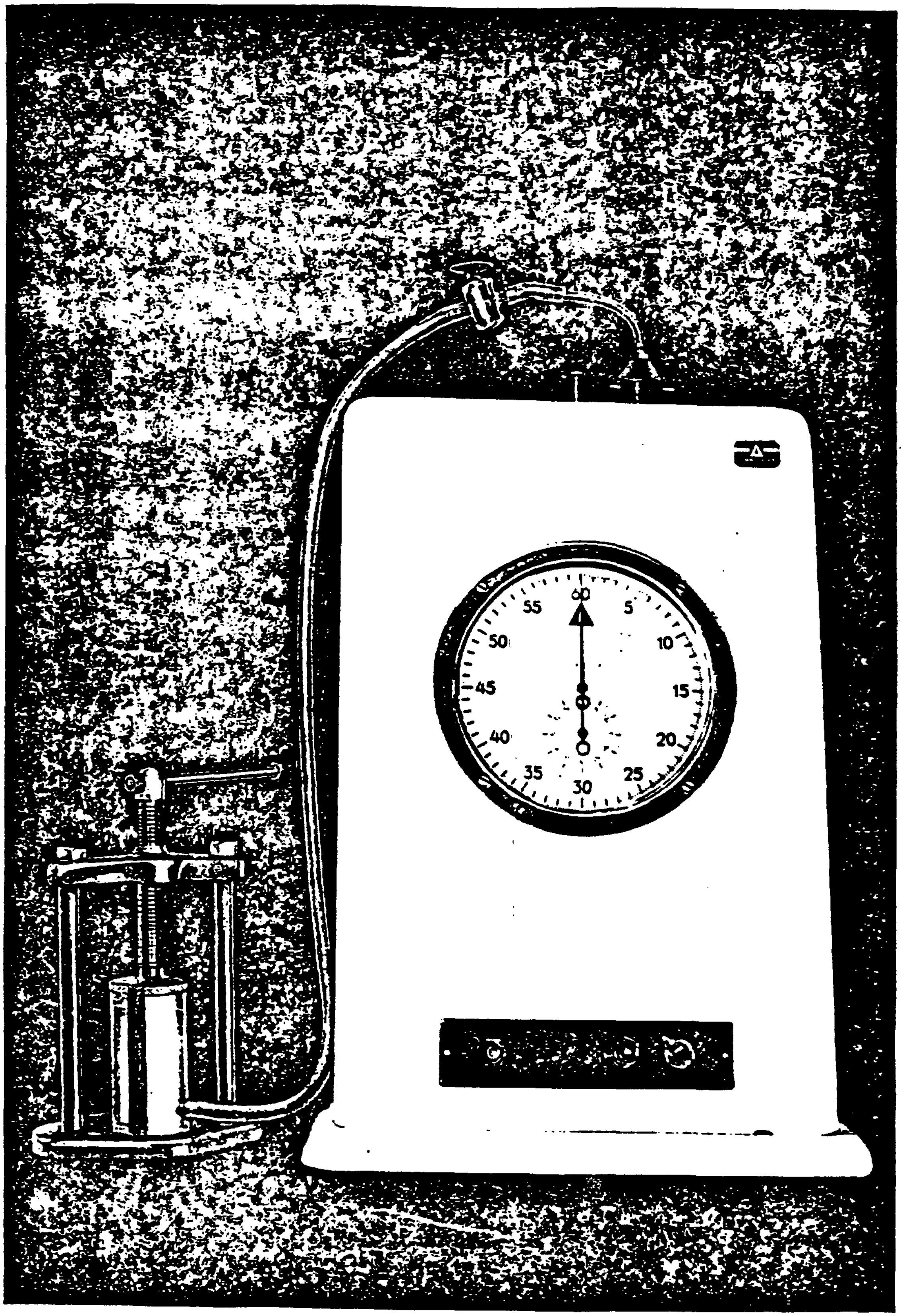
Essential details of Blaine Dyckerhoff apparatus

01 040 1272



Assembly of universal air-permeability cell

01 040 273



Blaine-Dyckerhoff apparatus
with universal cell

01 040 1274

Equipment 1 The Rigden apparatus is a simpler and less expensive apparatus than the Blaine Dyckerhoff, certain elements of its construction making it nevertheless slightly more accurate and less variable than the latter.

The diagram on page 2·3/3 shows the essential part of the apparatus. There are no electrical components and the apparatus does not include a clock or an air permeability cell suitable for asbestos fibre. The instrument as supplied has all the necessary internal connections made. As it may be used in alternative ways, certain additional connections are included. These may be ignored, but the following points should be checked.

a In normal operation the twin bore 3-way tap (1) should be left in the position shown (page 2·3/3). The connection (7) between the top of the limb L and the top of limb R should be maintained in position so that limb R is *not* connected to atmosphere.

b Limb L has a side connection at the top to the spigot (3) marked 'cell'. This spigot should be left clear to atmosphere at all times, and the cells should *not* be connected here. Ignore the spigot (2), marked 'gauge'.

c Connect the hand pump to the spigot (4) marked 'pump', at the side of the cabinet.

d Connect a piece of rubber pressure tubing to the spigot (5), projecting up from the base at the front of the cabinet. The air permeability cell is connected to this tubing.

2 A supply of dibutyl phthalate will be required for filling the apparatus. (This is obtainable from the manufacturers.)

3 A stop watch or stop clock.

4 A 1½" or 3" Universal air permeability cell of the design recommended on page 2·2/1.

Setting up the Rigden Apparatus a Filling with oil: Turn the tap (1) to the up position and pour the dibutyl phthalate in through the tube (8), using a small funnel to facilitate this. Tip the instrument forward while doing this, to avoid oil escaping down the side connection at the top of limb L.

Add the oil up to the mark 'Oil Level', ensuring that when the upper part of limb L has drained free of oil, the oil level is correct. Return the tap (1) to its original position.

b Checking for leaks: Turn tap (6) to suction and operate the hand pump, raising the level of oil in limb R above the line marked 'start'. Turn tap (6) to 'off'. The oil level should remain stationary for at least ten minutes. Check the rubber tubing connections at the back of the apparatus if it does not do so. Ensure also that the taps (1) and (6) are sufficently greased with petroleum jelly, and that their bores are not choked with grease.

Connect the air permeability cell to the spigot (5). Remove the cell piston and cover the upper rim of the cell body with a greased ground glass plate. Turn tap (6) to 'cell'. The oil level will fall a little, but should then remain stationary provided that the cell and its relevant connections do not leak.

Method a Turn tap (6) to 'Suction' before attempting to fill the cell with fibre.

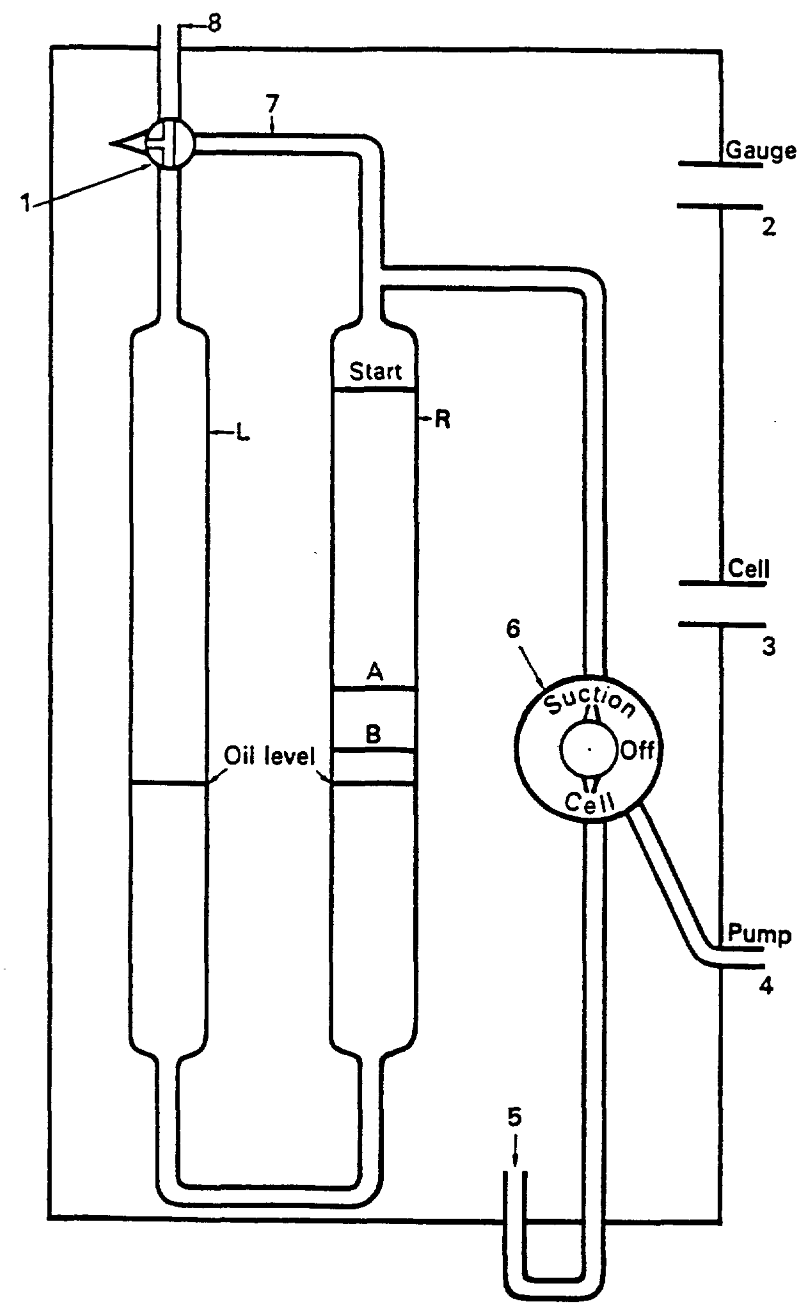
b Refer to Table III, page 2·4/4 and choose an appropriate weight of fibre according to its visual degree of openness. Weigh out the fibre sample, and pack it into the cell using a funnel and a ram, adding the fibre in small quantities of about 5 gm at a time, and pressing each lot down firmly.

c Fit the piston to the cell, return the whole into the press, tightening up until the edge of the piston mates with the rim of the cell body.

d With tap (6) at 'suction' operate the hand pump and raise the liquid level in limb R to about 1 cm above the line 'start'. Quickly turn the tap (6) to 'off'.

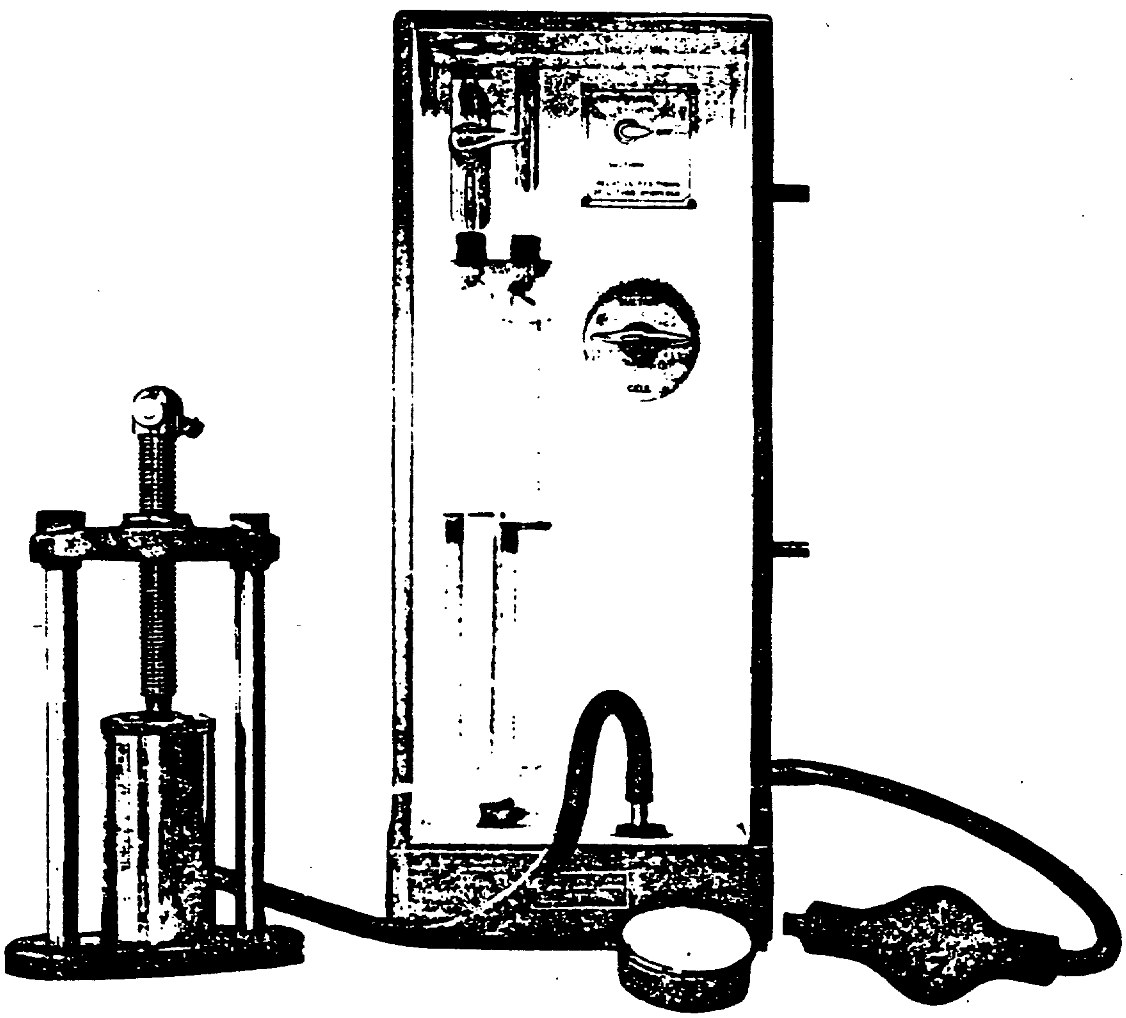
e Start the watch when the bottom of the meniscus level reaches the line 'start', and measure the time taken for the bottom of the meniscus level to reach the line 'B'. (Line 'A' marks exactly half-way.)

f The time T, in seconds recorded, is proportional to the degree of openness of the fibre.



Essential details of Rigden apparatus

01 040 1277



Rigden apparatus
with universal cell

01 040 1278

Air Permeability Tests using Blaine Dyckerhoff Apparatus and 1¾" Universal Cell.

1 Amosite, crude

Wt of test sample	=	46.5 gm
Measured Dyckerhoff time (T)	=	15 sec
FRF = T x 1	=	15 units
Surface Area = $980\sqrt{T}$	=	3800 cm ^{2}/gm

2 Blue Asbestos, standard

Wt of test sample	=	38 gm
Measured Dyckerhoff time (T)	=	30 sec
FRF = T x 2	=	60 units
Surface Area = $1380\sqrt{T}$	=	7500 cm ^{2}/gm

3 Chrysotile, standard

Wt of test sample	=	36.7 gm
Measured Dyckerhoff time (T)	=	110 sec
FRF = T x 0.98	=	108 units
Surface Area = $1230\sqrt{T}$	=	12800 cm ^{2}/gm

Note on the Theoretical Background

'The Manual of Testing Procedures for Chrysotile Asbestos Fibres' recommends that the Blaine Dyckerhoff apparatus be calibrated initially against materials of known surface areas. These of course may not be immediately available, and in any event they should be fibrous materials similar to asbestos. Their surface area should also have been determined by an air permeability method.

Tables I, II, III have been drawn up to eliminate the calibration procedure. The values for FRF and surface area have been derived from first principles by the Kozeny-Carman equation, taking into account the physical dimensions of the apparatus, and the cells, and the densities of liquids used.

A further factor has been introduced to account for the viscous drag of liquid in the narrow U-tube of the Blaine Dyckerhoff apparatus. This drag has the effect of making the time T, measured on this apparatus larger than that theoretically calculated. The factor introduced corrects for this effect, but only in so far as making the Blaine Dyckerhoff readings directly comparable with Rigden readings. The Rigden apparatus has a wider bore U-tube than the Blaine Dyckerhoff, and is less susceptible to the effect of viscous drag liquid in the tube.

It should be recognised that with either of these types of apparatus, it is only possible to obtain apparent surface area measurements. Any such measurements made on asbestos fibres by air permeability methods are lower than those found by gas absorption methods, but for all practical purposes the air permeability method gives comparable, consistent and useful results.

References

Kozeny: Ger. Wien. Akad. 1927 Vol 136a, p 271
Carman: Trans. Inst. Chem. Eng., 1937 Vol 15, p 150; JSCI Vol 56
Lea & Nurse: JSCI, 1939, Vol 58, p 277
Rigden: JSCI, 1943, Vol 62, p 1
JSCI, 1947, Vol 66, p 130

Interpretation of Results

The results may be expressed as follows:

1 For routine measurements always made on the same type of fibre it would be sufficient to decide on a suitable weight of sample and express degree of openness simply as seconds (T). It is to be emphasised that this method does not give directly comparable results for amphibole and chrysotile fibres, nor is it suitable if used to compare a single grade of fibre in widely differing degrees of openness.

2 The measurement in seconds (T) is multiplied by a suitable factor, accounting for weight and type of fibre to give an expression of degree of openness called Flow Resistance Factor (FRF). This expression is comparable for all fibres and gives a scale of values for degree of openness proportional to $\frac{1}{(\text{fibre diameter})^2}$

3 Alternatively the square root of (T) is multiplied by a suitable factor accounting for weight and type of fibre to give an approximate Surface Area (cm^2/gm). This expression is comparable for all fibres and also with other methods of measurement of surface area. It is proportional to $\sqrt{FRF}$.

Tables I, II, III give a number of factors for converting T on either type of apparatus to FRF or surface area, whichever is desired. A conversion factor for the Blaine Dyckerhoff with the Blaine Dyckerhoff cell is included.

For purposes of international comparison of degree of openness of asbestos fibre, a figure in surface area terms is to be preferred, as this can be understood independently of the type of air permeability method used.

In applying these factors, the user has the choice of several weights of fibre to be packed into the cell, depending on the degree of openness of the fibre. The more open amphibole fibres are, the more difficult it becomes to pack a specified weight of fibre in the cell. Chrysotile fibres will consolidate with less difficulty over a wide range of degrees of opening.

The tables give three choices of weight of amphibole fibres, designated 'Crude', 'Standard' and 'Very Open'. The 'Standard' weight will be found satisfactory for most applications. Only two such weights are necessary for chrysotile fibres.

The following examples indicate the type of calculations and results involved:

Table I
FRF and Surface Area Constants

Application Blaine-Dyckerhoff cell with the Blaine-Dyckerhoff apparatus.

Amosite and Blue Fibre	Weight of Fibre in Cell (gm)	FRF Units	Surface Area cm^2/gm
Standard	50	T x 1.91	$1350 \sqrt{T}$
Very Open	35	T x 5.01	$2190 \sqrt{T}$
Chrysotile			
Standard	50	T x 0.84	$1170 \sqrt{T}$

Blaine-Dyckerhoff clock reading = T sec.

Table II
FRF and Surface Area Constants

Application CAFCO Universal cells with the Blaine-Dyckerhoff apparatus.

1¾" Universal Cell

Amosite and Blue Fibre	Weight of Fibre in Cell (gm)	FRF Units	Surface Area cm^2/gm
Crude	46.5	T x 1.0	$930 \sqrt{T}$
Standard	38.0	T x 2.0	$1380 \sqrt{T}$
Very Open	33.3	T x 3.0	$1690 \sqrt{T}$
Chrysotile			
Standard	36.7	T x 0.98	$1230 \sqrt{T}$

3" Universal Cell

Amosite and Blue Fibre			
Crude	153.2	T x 1.89	$1340 \sqrt{T}$

Blaine-Dyckerhoff clock reading = T sec.

Note Use the 1¾" cell for medium and short amosite and blue fibres.
Use the 3" cell for long spinning blues and long amosite fibres.

Table III
FRF and Surface Area Constants

Application CAFCO Universal cells with the Rigden apparatus.

1 ¾″ Universal Cell

Amosite and Blue Fibres	**Weight of Fibre in Cell (gm)**	**FRF Units**	**Surface Area cm^2/gm**
Crude	50.0	T x 0.53	$720\sqrt{T}$
Standard	38.3	T x 1.35	$1140\sqrt{T}$
Very Open	30.0	T x 2.85	$1650\sqrt{T}$
Chrysotile			
Standard	36.7	T x 0.68	$1050\sqrt{T}$

3″ Universal Cell

Amosite and Blue Fibre			
Crude	153.2	T x 1.35	$1140\sqrt{T}$

Rigden stop-watch reading = T sec.

Note Use the 1 ¾″ cell for medium and short amosite and blue fibres.
Use the 3″ cell for long spinning blues and long amosite fibres.

01 040 1282

Section 3
CLEANLINESS

01 040 1283

Grit and Dust Contents

The Quebec Standard Asbestos Testing Machine can be usefully modified for this purpose. The fourth tray or pan should be replaced by a similar pan, but of half depth, and superimposed on this there should be a half depth tray having a 50 mesh US Standard screen (or its Tyler equivalent).

The Quebec Standard machine possesses the facility, through its oscillatory action, of concentrating grit beneath the fibre on the 10 mesh and 50 mesh screens. A grit and dust separation may be made in the following steps.

1 Use 16 oz (450 gm) crude fibre or 100 gm milled fibre for each test.

2 On completion of the sieve cycle of the machine separate the fibre from each tray, spreading it out on a flat surface and hand pick from it any particles of grit retained in the fibre. (This is a simple operation with the material retained on the first, second and third tray, but it is more difficult with the +50M fraction). Combine the hand-picked grit with that retained on each relevant tray and weigh it in grammes. Detailed results are usually expressed as:

% +¼″ grit
% +4M grit
% +10M grit
% +50M grit

The material passing 50M consists of rock dust and fibre fines, and the amount of fibre it contains may well be variable. For practical purposes the material collected in the pan can be regarded as dust, weighed back in grammes and expressed as:
% —50M dust

Colour

The colour of blue asbestos fibre varies from dark blue for deep-mined fresh fibres to a brownish discoloured blue for weathered fibres. Amosite fibre varies from ash grey for fresh fibres to light reddish-brown for weathered fibres. Chrysotiles are white, cream, or even pale grey coloured. The only satisfactory way of making colour tests of asbestos fibres is to compare the fibre visually with a standard acceptable to the user.

Matching tests should always be done under identical conditions. The standard fibre should be packed into transparent containers, using a fixed weight of fibre and packing it into a fixed volume. (1" diameter glass test tubes or clear polystyrene pill boxes are suitable.) The unknown sample should then be packed in a similar container under the same conditions, and visual comparison made.

Section 4

ASBESTOS-CEMENT FIBRE TESTS

01 040 1286

Wet Volume and Filtration Tests 4·1

The object of these tests is to provide data on the properties of asbestos fibres in an asbestos-cement slurry under conditions which, as far as possible, are intended to resemble those in the vats and on the blankets of an asbestos-cement machine. By using an asbestos-cement slurry the wet volume test becomes independent of the initial pH and temperature of the water used. Both these parameters have marked effects in the usual method of wet volume testing where fresh water and asbestos fibres are employed, and lead to wide variations in the test figures.

The filtration properties of asbestos fibres are also highly dependent on both the pH and temperature of the prepared suspension of fibres in water. The effect of the cement in an asbestos-cement slurry is to provide what is virtually a buffer solution of high alkalinity so that dependence on pH can be eliminated in the filtration test. The test cannot be made independent of temperature and steps must be taken either to make the test at constant temperature, or to correct the results for temperature, as explained later.

The method of test both for wet volume and filtration requires an asbestos-cement slurry to be made with a preferred solids content of 5%, the solids having asbestos : cement ratios corresponding to those used in practice. (For example, asbestos : cement 15 : 85 for pipe furnishes and 12 : 88 for sheet furnishes.) Standard techniques have been devised for both tests. It is however both convenient and advantageous to use the board making apparatus described in subsection 4·2 for performing the filtration test.

Apparatus required

Wet Volume Tests (Standard Procedure)

1 2000 ml stoppered measuring cylinders.

2 Mechanical inverter for measuring cylinders, with speed of 30 rpm and auto-stop after 30 revolutions.
See pages 4·1/6, 4·1/7, 4·1/8 for details.

Filtration Test (Standard Procedure)

1 2500 ml capacity brass filtration cylinder, 3" (76 mm) internal diameter, having a detachable cone-shaped bottom end, screw fitted to the cylinder; the cone having an internal 3" (76 mm) diameter, 50 mesh screen and a $\frac{1}{4}$" (6 mm) outlet cock. The screen should be brazed to a $\frac{1}{4}$" (6 mm) wide annular ring which locates against a rim inside the upper portion of the cone, and should be backed by a soft rubber gasket. (See page 4·1/9.)

2 The outlet cock of the filtration cylinder is connected to a *vacuum pump* capable of pumping down to pressures of less than 5" (125 mm) mercury, at capacities of more than 5 litre/min. A vacuum gauge must be included in the circuit, together with a bleed valve or other means of control so that the vacuum can be adjusted to 5" (125 mm) mercury.

A mechanical vacuum pump, as such, is not recommended here, since efficent and complicated safeguards must be provided to prevent water vapour from entering the pump chamber. It is preferable to use a fluid pump such as the Watson-Marlowe Peristaltic Pump (Model HSHR) or a small Mono Pump (Model M13). Both of these will transport water and simultaneously provide adequate vacuum. The Mono Pump must be provided with a separate input water bleed, as this type of pump cannot be allowed to run dry.

A simpler method employs a water vacuum pump such as is generally used for filtration processes in the laboratory. Such a pump can only be recommended where the direct water mains pressure is sufficient to give the vacuum required.

3 A stop-clock is required for making time measurements in the filtration test.

Filtration Test (Alternative Procedure)

The board making apparatus described in the subsection beginning on page 4·2/1 is eminently suited for filtration testing, and in fact the board test as described includes time measurements to determine the filtration properties of the slurries from which the boards are prepared. Such measurements are however only comparative within the particular conditions of the board test, and the filtration test described here should be made under the standard conditions set out below. The advantages of using the board test apparatus lie in the larger volume of slurry, and hence larger and more representative fibre samples; and in the larger area of filtration used, in comparison with the standard apparatus described above.

Techniques in Wet Volume and Filtration Measurements

1 Standard Cement

Both the composition and fineness of cement will affect the results of these tests. The compositions, and hence rates of hydration, of cements vary considerably and the fineness of grinding may be such that surface areas of cements lie between 2200 and 4000 cm^2/gm. The normal products of different cement works cannot be expected to provide identical results in these tests. The cement component is usually, however, the one invariable in the raw materials used in asbestos-cement works, and therefore it should be chosen as the standard for these tests within that particular environment. If possible the fineness of the cement should be standardised at say 3000 ± 100 cm^2/gm, and the standard cement should be kept in air tight containers.

2 Process Water

In asbestos-cement manufacture, it is usual to recirculate the water used in process. This water is saturated with lime, gypsum, and soluble alkalis and traces of other ions dissolved out of the cement used in process; all these affect the state of suspension and the filtration properties of the asbestos fibres in the slurry. To ensure that these effects are repeated on the laboratory scale, supernatant water from wet volume tests and filtrates from filtration tests should be retained for use in subsequent tests. All this 'process' water should be kept in a closed polythene container for use as required.

3 Temperature

The filtration properties of an asbestos-cement slurry are dependent on temperature to the extent that standard filtration times may decrease by as much as five seconds or more for every 1°C rise in temperature of the slurry. While changes in the viscosity of water come into play here, increases in temperature have a marked effect on the gel phases formed in the early stages of hydration of cement, these tending to form larger and more stable particles as the temperature rises. Different types of cement will of course produce different results. Over a fairly wide range of temperature (5 to 25°C) the decrease in filtration rate per degree C is almost constant, so that as an alternative to preparing all filtration tests at constant temperature, a correction can be made for whatever temperature at which a test is performed. A calibration graph should be prepared from observations of the filtration rate of a standard asbestos-cement slurry at different temperatures, and a suitable reference temperature should be chosen depending on the mean ambient temperature of the environment. The slope of the calibration graph is not affected by different types of asbestos fibre, provided that all other conditions are kept constant.

4 The Degree of Opening of the Asbestos Fibre

As a general rule asbestos fibres will give higher wet bulk volumes and higher filtration times in the asbestos-cement slurry test, as the degree of opening (or surface area) of the fibres is increased. Chrysotiles deflocculate in alkaline solutions however, and thus the effect of opening on this type of fibre in the wet bulk volume test is much less marked than on amphibole fibres (amosite, blue asbestos, etc). On the other hand the filtration properties of amphibole fibres are much less dependent on degree of opening of fibre than are chrysotile fibres.

The results of wet bulk volume and filtration tests on different types of asbestos can therefore be strictly compared only at some constant reference point of surface area, although for most practical purposes a compromise can be reached by reference within a range of surface areas appropriate to asbestos-cement manufacturing processes.

Methods The test methods are given in step by step descriptions in the following pages. Both the filtration and wet volume tests include two separate procedures. One procedure concerns the testing of individual grades of fibre, the other concerns the testing of blends of fibres. For purposes of standardisation such blends always comprise 80% chrysotile fibre, and 20% blue or amosite fibre. The objective here will be a comparative assessment of one of the components of the blend by varying its grade or degree of openness, the other component being invariable. The choice of a standard chrysotile, blue or amosite fibre will depend on local circumstances allied to the requirements of an asbestos-cement plant or similar process.

Results 1 Results should be reported as:
WV (A/C) ml at 20°C (eg)
and Filt (A/C) secs at 20°C (eg)

2 The complete properties of a fibre grade may be obtained by measuring wet volume and filtration properties at a number of different degrees of openness. Graphs showing the variation of these properties with degree of openness (surface area) may then be drawn up.

For purposes of absolute comparison wet volumes and filtration times of fibres at a surface area of 10,000 cm^2/gm should be obtained from such graphs.

For general purposes of comparison wet volumes and filtration times of fibres may be taken for degrees of openness in the range 6000 to 10,000 cm^2/gm, but the exact degree of openness should be stated.

3 Test results generally fall into the following groups:

	WV (A/C) Standard Procedure ml	**Filt A/C Standard Procedure sec**	**Filt A/C Alt. Procedure sec**
Chrysotile	350 to 700	600 to 900	100 to 200
Blue	1000 to 1500	200 to 350	50 to 70
Amosite	1000 to 1800	100 to 200	40 to 60

Filtration times of amosites and blues are generally independent of degree of opening; those of chrysotiles are dependent on degree of opening, but do not follow a logical pattern.

01 040 1289

Wet Volume Test – WV (A/C)
Standard Procedure

Mixes 5% slurries (20 : 1 water : solids).

Test A For one grade of fibre	**Test B** for blends of 80 per cent chrysotile and 20 per cent blue or amosite
1 1400 ml process water	1 1400 ml process water
2 15 gm fibre	2 12 gm chrysotile fibre
3 85 gm cement	3 3 gm blue or amosite fibre
4 600 ml process water	4 85 gm cement
	5 600 ml process water

Method

1 Put the components of the mix into an adequately sized can in the order given above excepting the last 600 ml water. Mix the slurry vigorously by hand with a large spatula for one minute starting from the time that the fibre is added.

2 Transfer the slurry to a 2000 ml cylinder and wash down and make up with the 600 ml water.

3 Fit the stopper to the cylinder and clamp the cylinder into the mechanical inverter.

4 Run the inverter for one minute.

5 Take the cylinder from the inverter and stand it on a level bench, starting the stop clock at the same time.

6 Measure the wet volume of the solids after the slurry has settled for 30 minutes.

Filtration Test – Filt (A/C)
Standard Procedure

Mixes 1.75% slurries (55 : 1 water : solids).

Test C For one grade of fibre	**Test D** For blends of 80 per cent chrysotile and 20 per cent blue or amosite
1 1400 ml process water	1 1400 ml process water
2 5 gm asbestos fibre	2 4 gm chrysotile asbestos
3 30 gm cement	3 1 gm blue or amosite asbestos
4 600 ml process water	4 30 gm cement
	5 600 ml process water

Preparation of the Apparatus

1 Testing for leaks. Fit a 3" (76 mm) diameter metal disc in place of the screen and fill the cylinder with water. There should be no leakage into the cone or past the screw threads.

2 Apparatus constant. Place a 3" (76 mm) diameter filter paper on the 60 mesh screen, and replace it in the apparatus. Put 2000 ml water in the cylinder. Open the outlet cock and measure the time taken for the apparatus to drain completely – *not* under vacuum. This time is the apparatus constant, which should be checked occasionally. Corrosion or clogging of the screen or outlet cock will show up in an increase in this constant.

01 040 1290

Method

1 Put the components of the mix into an adequately sized can in the order given above, excepting the last 600 ml water. Mix the slurry vigorously by hand with a large spatula for one minute starting from the time that the fibre is added.

2 Transfer the slurry to a 2000 ml glass cylinder and wash down and make up with the 600 ml water. Fit a stopper in the cylinder and clamp the cylinder in the mechanical inverter used for wet volume testing. Run the inverter for one minute to complete the mixing of the slurry.

3 Meanwhile, place a dampened filter paper on the 50 mesh screen in the cone of the filtration cylinder. Screw the cone up tight to the cylinder and adjust the gauge to 5" ± 1" (125 mm ± 25 mm) Hg vacuum.

4 Quickly empty the slurry from the glass cylinder into the filtration cylinder. Start the stop clock and at the same time open the outlet cock of the cylinder.

5 The filtration time is measured from this moment until the vacuum breaks after complete filtration of the 2000 ml slurry. The vacuum gauge should remain steady during the whole period of filtration.

Filtration Testing – Filt (A/C) Alternative Procedure

Mixes 5% slurries (20:1 water:solids).

Test E **For one grade of fibre**	**Test F** **For blends of 80 per cent chrysotile and 20 per cent amosite or blue**
1 3300 ml process water	1 3300 ml process water
2 25 gm fibre	2 20 gm chrysotile asbestos
3 141 gm cement	3 5 gm amosite or blue asbestos
	4 141 gm cement

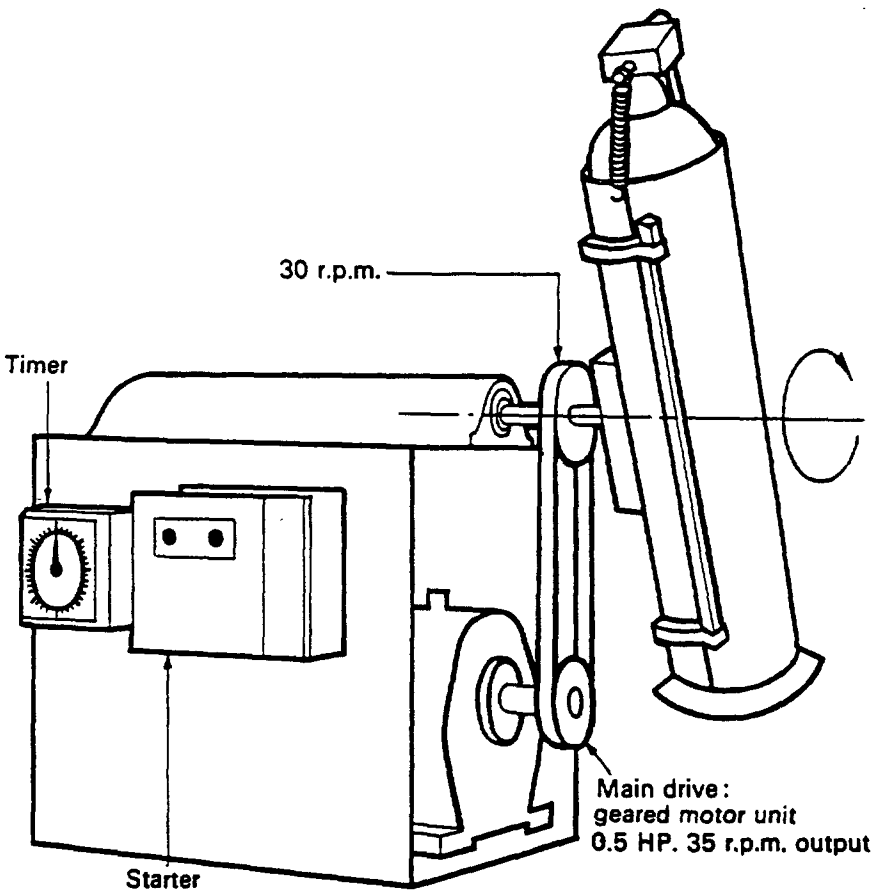
1 Use the board making apparatus for mixing and for the filtration test.

2 Put the components of the mix into the mixer in the order given above, and mix for one minute.

3 Meanwhile, cover the screen of the vacuum filter box with a moistened filter paper, and start the vacuum pump. (The pump should be pre-adjusted to give a vacuum at 5" ± 1" Hg (125 mm ± 25 mm) with the vacuum line to the filter box closed at the filter box end.)

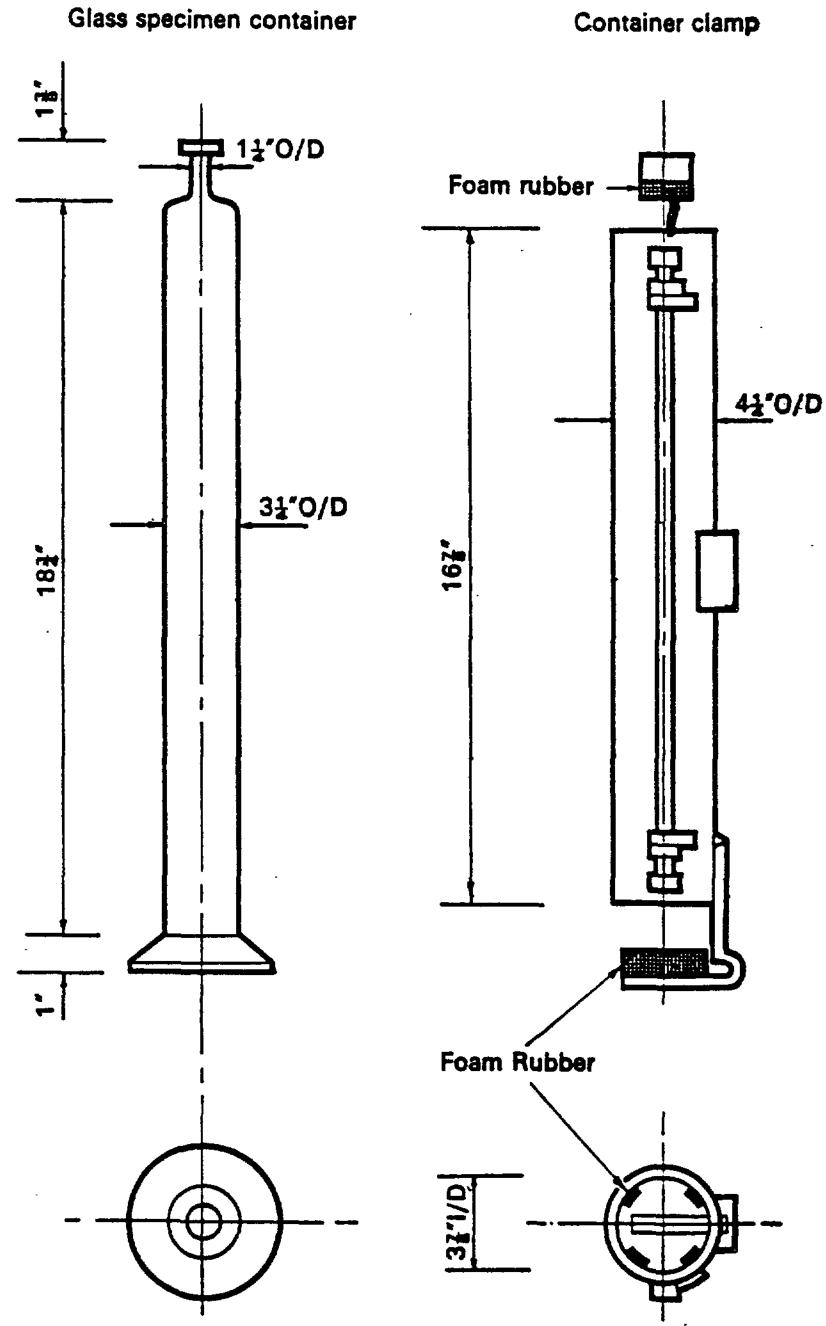
4 Drop the slurry into the filter box and start the stop clock.

5 The filtration time is measured from this moment until the vacuum breaks after complete filtration of the 3300 ml slurry. The vacuum gauge should remain steady during this operation.



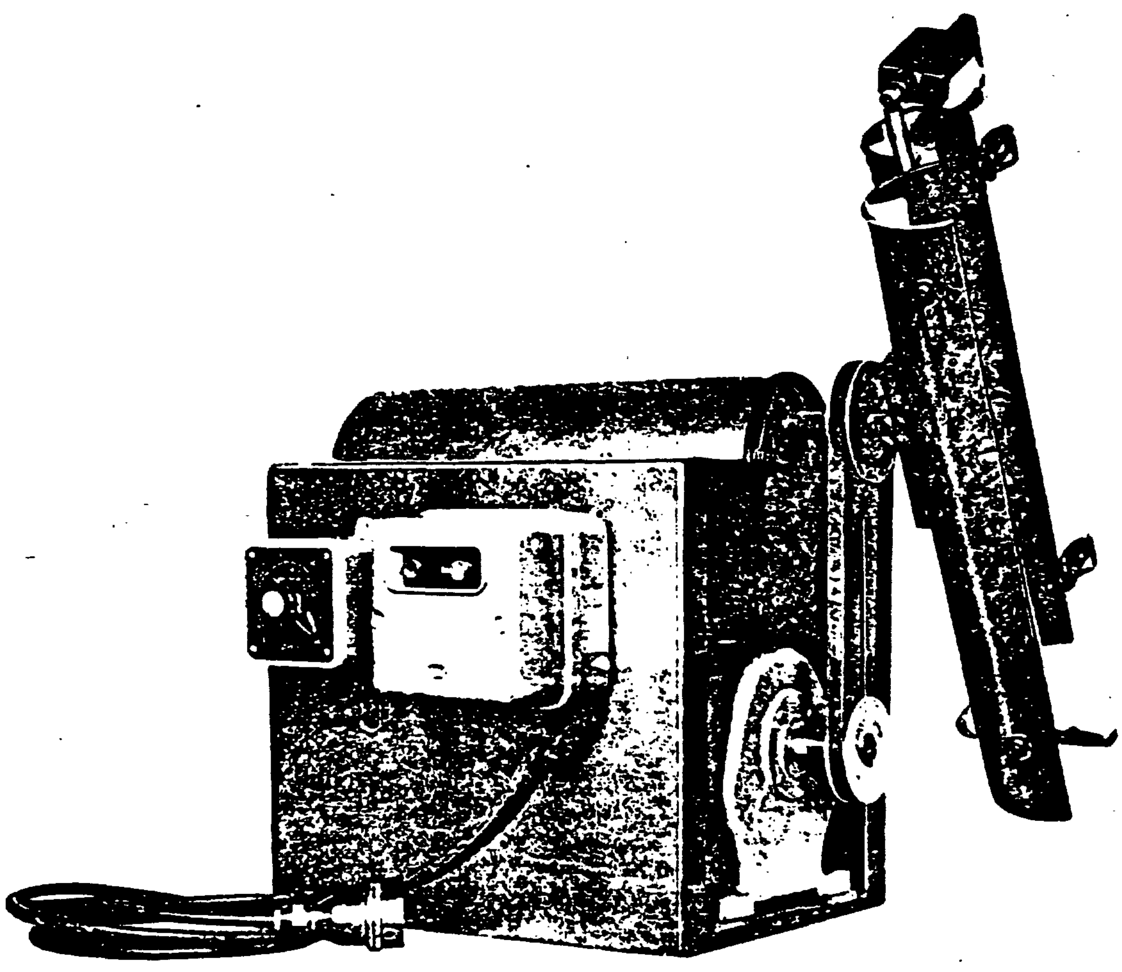
01 040 12[illegible]2

Principle details of mechanical inverter for wet volume test



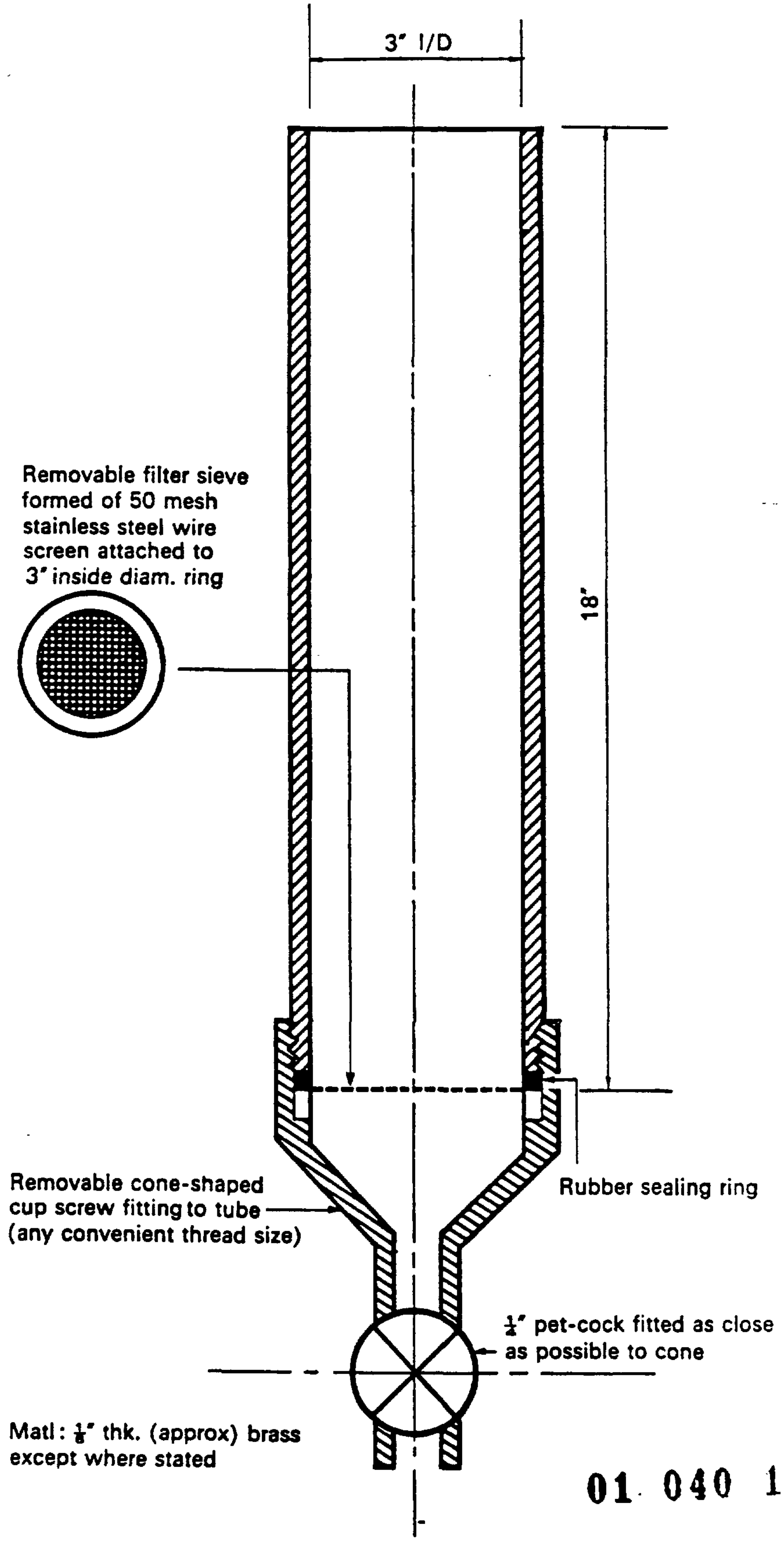
01 040 1293

Details of mechanical inverter for wet volume test



Mechanical inverter for wet volume test

01 040 1294



01 040 1295

Standard filtration tester for asbestos cement slurries

Measurement of Reinforcing Value

There exists a number of laboratory methods for determining this measurement, some of which require the preparation of a steam-autoclaved asbestos-cement-silica test board, and others requiring an air-cured asbestos-cement test board. An air-cure test method is to be preferred because it compares directly with the curing method *generally* found in large scale practice. The main advantage in the steam-autoclave test method is that it provides a rapid turn-over of tests.

The following standardised air-cure test technique combines the best features of a number of methods, and also provides an alternative means to that given in subsection 4·1 of measuring the filtration properties of fibres in asbestos-cement slurries.

This test aims at making a number of test boards from each sample of fibre, over a range of cured and finished densities of about 1.4 to 1.75 (i.e. 85 to 110 lb/cu ft), all having a furnish of 10% of fibre. The moduli of rupture (MOR) of these boards are determined by means of a suitable tensometer, and a mean MOR at a density of 1.6 is calculated. The reinforcing value of the fibre then becomes a measure of MOR, under fixed conditions of density and fibre content. The detailed working of this method may be considerably narrowed down so that the reinforcing value of asbestos blends may be determined at densities near to 1.6 (100 lb/cu ft).

Equipment

1 Board Making Apparatus (see diagrams on pages 4·2/5, 4·2/6) comprising:

a 5 litre mixing vessel with 1/10 hp mixer complete with special impeller, and with delivery trough for mix.

b Vacuum filter box to make 8" x 8" test boards.

c A vacuum pump capable of carrying water vapour. Suitable pumps, as recommended on page 4·1/1 for filtration measurement are the Watson-Marlowe Pump Model HSHR, and the Mono Pump Model M13. The latter pump must be provided with a separate input water bleed, as this type of pump cannot be allowed to run dry.

d Board breaking test machine. Hounsfield Tensometer (page 4·2/9) equipped with breaking jaws for either 1" or 3" wide specimens; or similar type of transverse testing machine, such as the Zwick tester.

2 Small press with 10" x 10" platens, about 4" daylight, capable of total working pressure of 40 to 50 tons, manually or mechanically pumped.

3 Humidity chamber, effective internal dimensions 2' x 1' x 1' to operate at 90 to 95% RH at normal temperatures. Water trough, similar dimensions to humidity chamber.

Materials

1 Cement
It is preferable to obtain small quantities, say 100 lb at a time, direct from the manufacturers. The cement should be stored in 20 lb air-tight tins, to reduce to a minimum the degree to which it air sets. The cement should be regarded as a standard material. It should be of uniform chemical composition from batch to batch, and if at all possible, arrangements should be made to have the cement ground or blended to a standard specific surface area, preferably 3000 ± 100 cm²/gm.

2 Filter papers
No 1 Whatman paper (or nearest available) cut into 8" x 8" squares.

Method a Preparation of the Asbestos Fibre

The many types of mill used to process asbestos fibre have effects on the fibres which vary between the extremes of disintegration (or shortening) and true fiberisation (or opening). The ideal mill fiberises rather than disintegrates asbestos fibre, but there are few laboratory mills which will satisfactorily fiberise all types of fibre. The practical disadvantage here lies in the small diameter of these mills in relation to the length of fibre, and this tends to bring about a shortening of fibres superimposed on excessive fiberisation. This effect is accentuated with mills having screens in the exit port.

Laboratory mills such as the Christie & Norris, Entoleter, BOP are generally satisfactory only for the shortest grades of fibre. The laboratory Pallmann Mill is suitable for all medium and short grades as used in the asbestos-cement industry, and can be adjusted to produce degrees of fiberisation similar to those given by larger mills of the same type. Ball mills and rod mills have been recommended for processing chrysotile fibres on the laboratory scale, but this method of processing does not give the best reinforcement results with amphibole fibres.

When processing fibres in the laboratory for the asbestos-cement reinforcement test, a laboratory mill should be chosen and adjusted to produce a fibre having characteristics related to those produced on the large scale. McNett classification and measurement of degree of openness would be sufficient to characterise a fibre. It is also preferable to have in the laboratory several standard fibres as processed and used on the large scale, to which laboratory tests can be referred.

b Process Water

As in the wet bulk volume and filtration tests, all the water used in the reinforcement test should be process water filtered from the asbestos-cement slurries used in board preparation, and re-circulated into the test. Filtrates from the slurries should be pumped into a closed polythene vessel and retained for future use.

Preparation and Curing of the Boards

Prepare 3 to 5 boards for each sample of fibre using for each board:

3300 ml process water
480 gm cement (90%)
53 gm asbestos fibre (10%)

2 Place 3000 ml water in the mixing vessel, add the asbestos fibre and allow to mix for one minute; then sprinkle the cement in the vessel, and mix a further five minutes.

3 Place an 8" square of dampened filter paper on the screen of the vacuum filter box. Start the vacuum pump, remove the rubber bung from the bottom of the mixing vessel, and allow the contents to drop into the vacuum box. Wash the remnants of fibre and cement from the vessel, using a further 300 ml of water.

When all the water has filtered off, smooth down the edges and surface of the board, pressing down the surface with a suitable implement to encourage further drainage.

Shut off the vacuum pump, drain the vacuum box, then invert it to remove the test board.

The filtration time of the slurry may be measured, in seconds, starting at the point when the contents of the mixing vessel are dropped into the filter box, and finishing when the vacuum breaks in the filter box. Filtration times measured under these conditions of test are closely related to those determined in the filtration test (alternative procedure, page 4·1/5) the results being greater than those determined in the latter test by a constant amount due to the greater thickness of filter paper

01 040 1297

4 Transfer the boards one by one to the press. The boards should be pressed between several layers of filter paper backed on both sides by a wire screen to allow escape of surplus water (see page 4·2/6). Press each board at a successively higher pressure in the range 20 to 35 tons total pressure. Some initial experiments may be necessary, the requirement being to produce a series of boards at various finished densities in the range of density of 1.4 to 1.75.

5 Cure the Boards
a For 24 hours in the humidity chamber.
b For 6 days by total immersion in water.
Dry the cured boards at 100°C temperature for at least 16 hours.

Testing the Boards Two methods are possible here, depending on the test equipment used. The boards may be cut into a number of 6" x 1" strips, discarding the edges, for breaking on the Hounsfield Tensometer; or 8" x 3" strips again discarding the edges, for the Zwick Tester. If the latter method is chosen, then it is preferable to prepare in the first instance duplicate boards at each density (making 6 to 10 boards in all).

A diamond or carbide-tipped wheel should be used for cutting the finished boards, but if such is not available, it is advantageous to cut the boards on a band-saw, when they are partially cured after 24 hours in the humidity chamber.

1 Measure the MOR of the test strips, using the tensometer, and make an average of all the results obtained for each board. Retain part of each test strip for density measurement.

2 Density measurements may be made in two ways:
a take pieces of each test strip after breaking in the tensometer, cut them down to a suitable size, say 1" x 3" and grind the edges and faces smooth. Accurately measure the dimensions of these strips, determine their volume, weigh them and thus determine their density, in gm/cc units; take an average density for the board.

b as in (a) take pieces of the test strips cut down to 1" x 3" size, and without any further preparation, weigh the strips in air and by total immersion in mercury. This latter method is rapid and less tedious than (a), but requires a balance with a special device for weighing in mercury. Details of this device and method may be obtained if required from Cape Asbestos Fibres Limited.

3 Make a graph of MOR against density for the average measurements obtained on the test boards. With reasonable care in preparation of the boards, the points obtained will fall in an approximate straight line (see specimen graph on page 4·2/7). Determine from this line the MOR at a density of 1.6 (i.e. 100 lb/cu ft).

This MOR represents the reinforcing value of the fibre examined. The reinforcing value may be converted into arbitrary units, using for this basis a figure of 100 for a fibre giving an MOR of 4000 lb/sq in at a board density of 1.6 and a raw materials fibre content of 10%. By putting:

$$\frac{\text{test board MOR at density 1.6, fibre content 10\%}}{4000} \times 100$$

a scale of values for various fibres can be drawn up.

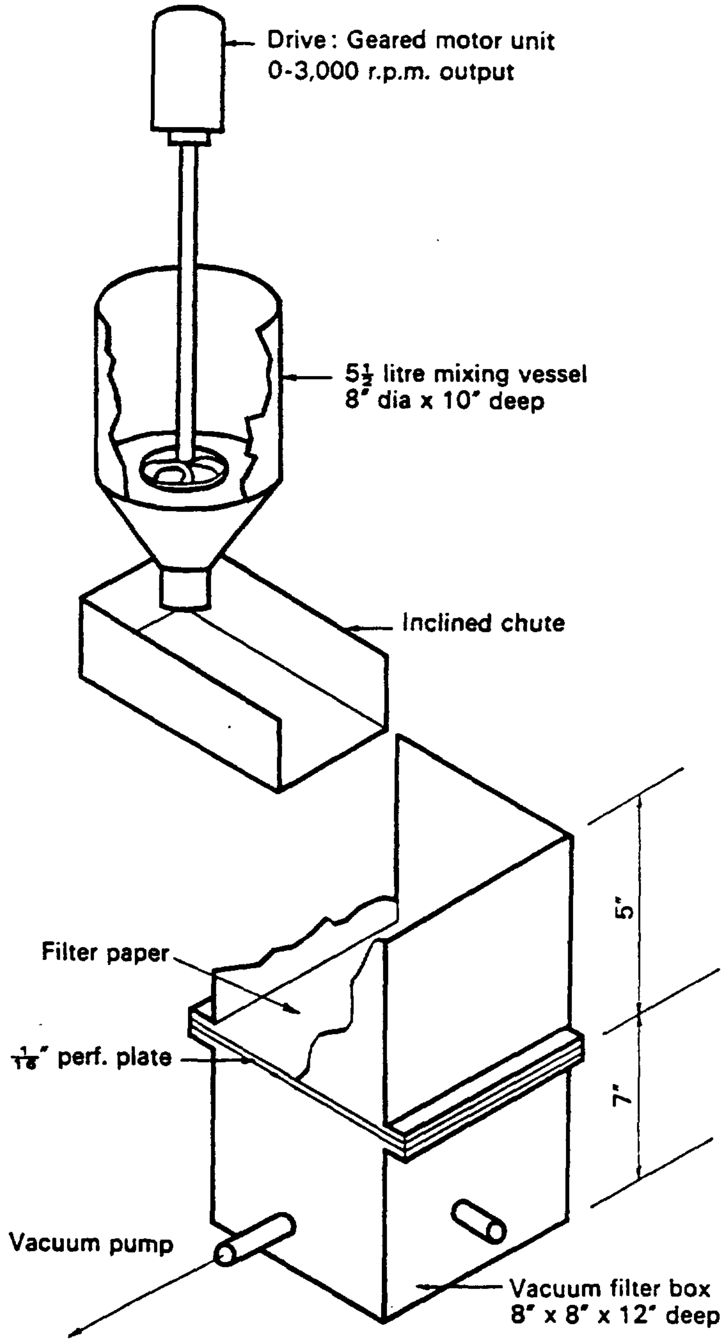
01 040 1238

Testing the Reinforcing Value of Blends

Reinforcing values increase with increasing fibre contents up to a limit of about 18%. The above method assumes a standard furnish of 10%, but where manufacturing processes require furnishes of other amounts, say 15% as in typical a/c pipe manufacture, then it may also be desirable to make laboratory tests under similar conditions. This, moreover, leads to the more realistic applications of this test in the determination of the reinforcing properties of blends of asbestos. In such investigations the combinations of asbestos in both types and proportions are innumerable, and it is recommended that a standardised procedure along the following lines be adopted.

Choose a suitable chrysotile, for example a 5R, and let this make an arbitrary furnish of say 15% in the asbestos-cement mix. Substitute in this furnish parts of amosite or blue asbestos so that the furnish is then made up of 12% chrysotile and 3% amosite or blue asbestos. Test boards may then be made up from these blends, varying only the type of amosite or blue asbestos.

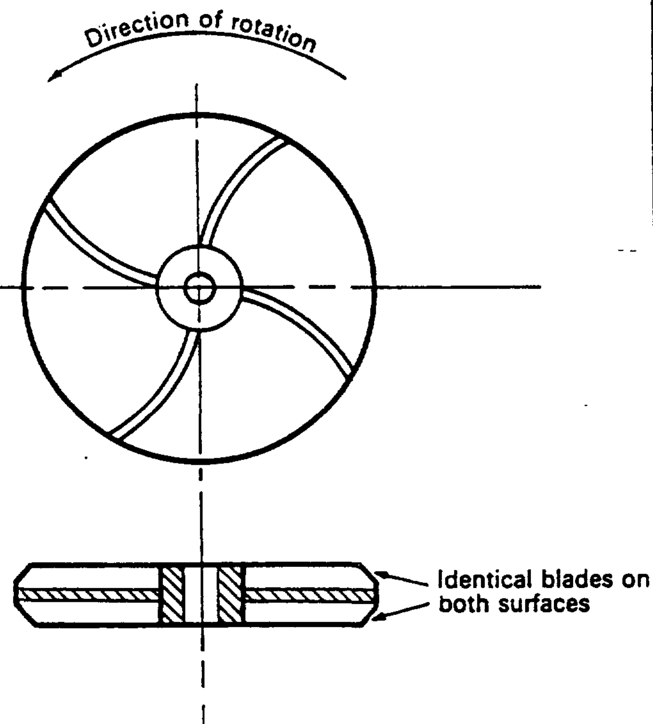
Having established that such furnishes give an enhanced reinforcing value, it is possible to extend the principle of test to ascertain economic blends of fibre. For example if a 15% furnish provides a reinforcing strength greater than the control blend, it should be possible to find a lower percentage furnish which will give the same reinforcement as the control. This then enables the establishment of blends of lower cost than the control blend.



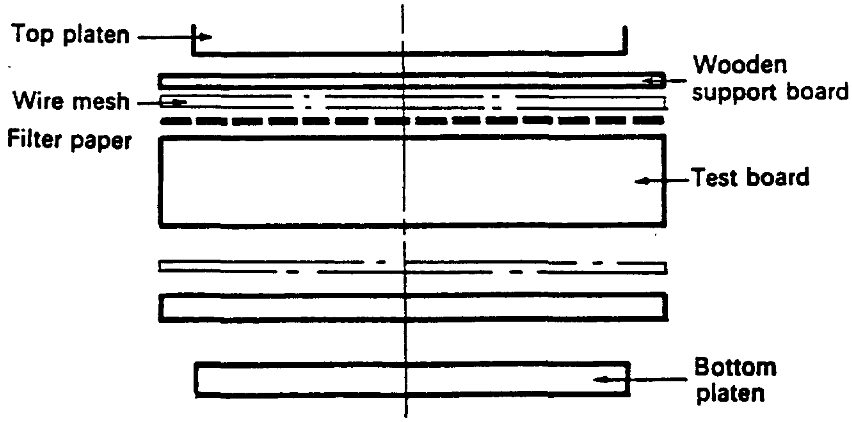
General arrangement of board making apparatus

01 040. 13[illegible]0

detail of impeller

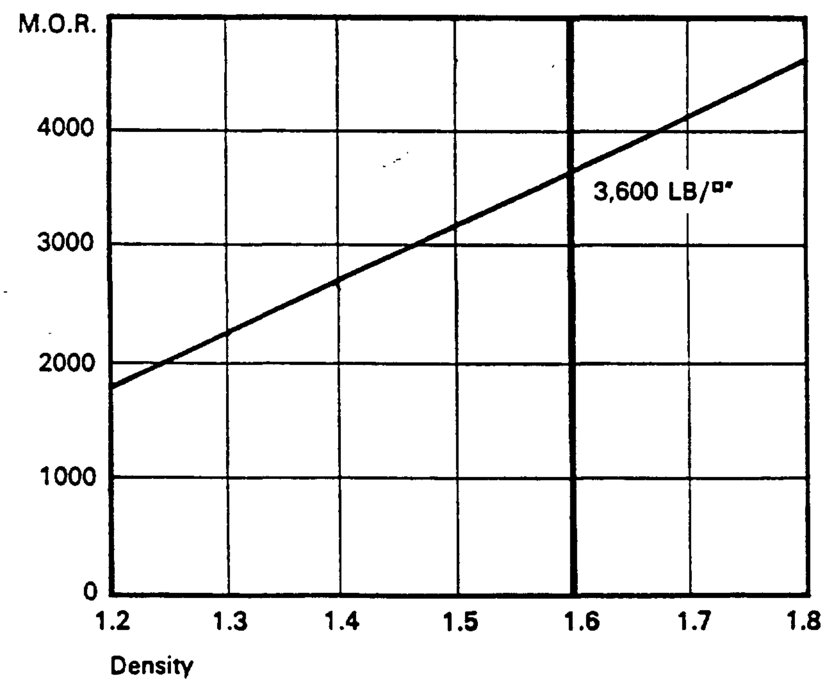


detail of pressing stack



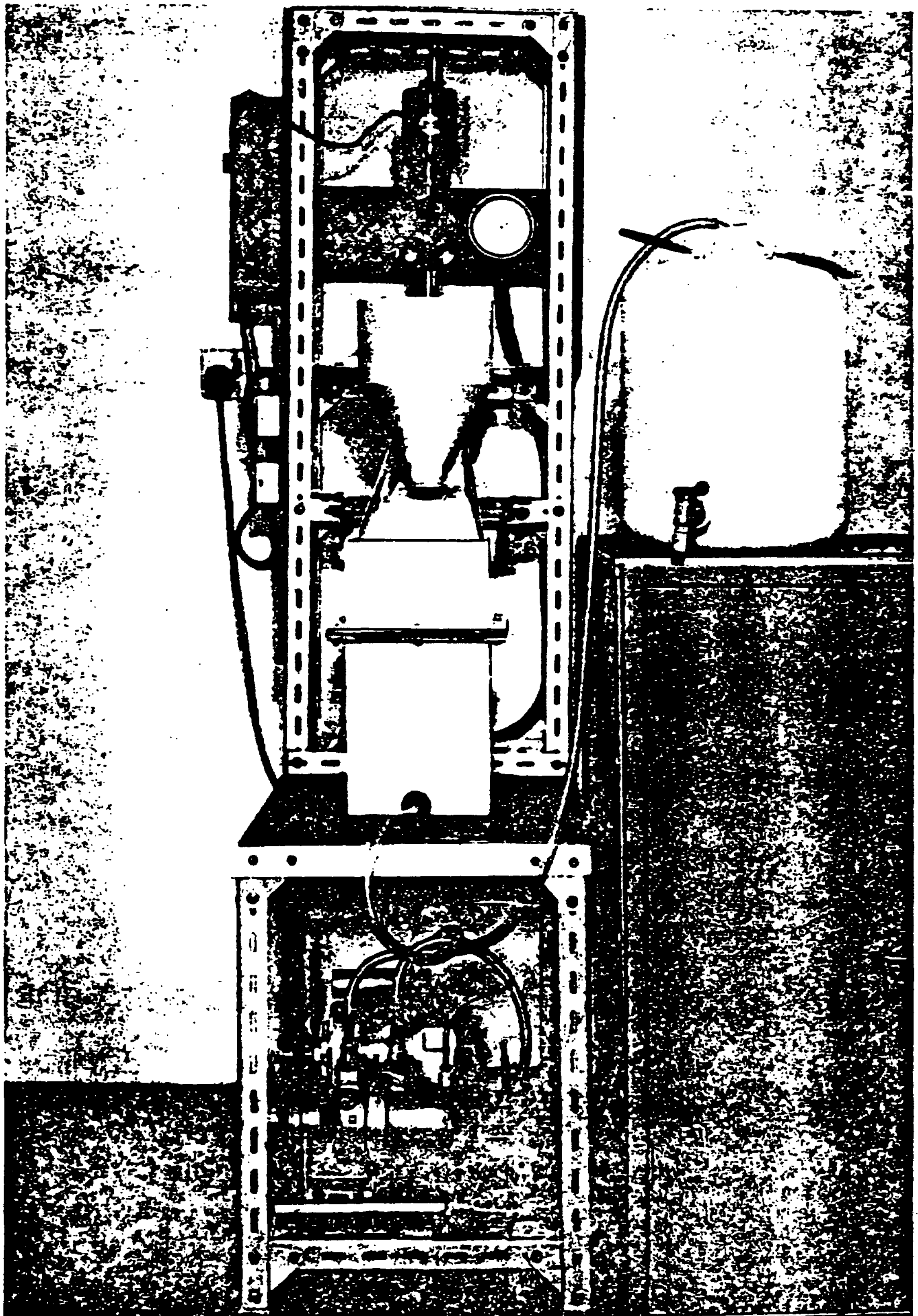
Board making apparatus

01 040 1301



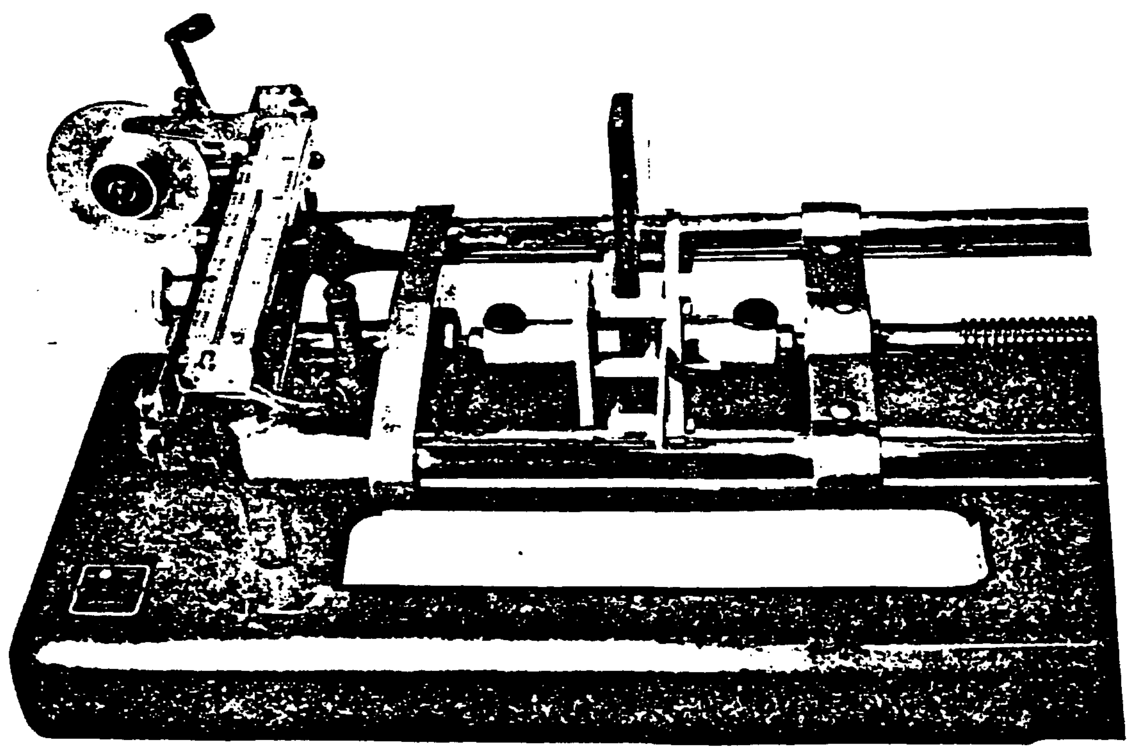
01 040 1302

Plot of M.O.R. of test boards against their density, at constant fibre content



01 040 1303

Board making apparatus



Hounsfield tensometer with sample in test position

81 040 1304

Section 5
CHEMICAL TESTS

01 040 1305

Moisture and Ignition Loss

The moisture content and ignition loss of asbestos fibre are not often required as essential properties in relation to a manufacturing process, but may be needed to meet a contract specification. Although well recognised laboratory procedures for determining these properties exist, there are certain characteristics about asbestos which necessitate special attention to techniques.

Firstly, asbestos fibres have high surface area and absorb moisture quickly from the atmosphere. The analytical procedure for determining moisture content must therefore be rapid and with minimum source of errors. Secondly, the ignition loss of amphibole asbestos fibres will not be the same in an oxidising atmosphere as it is in an inert atmosphere. The conditions of measuring ignition loss must therefore be stated.

Determination of Moisture Content

1 A number of proprietary makes of moisture balances are available, and it is recommended that for general purposes, one of these be used.

An exact weight (e.g. 10 gm) of fibre is weighed out and placed on the pan of the balance. The sample is heated by an infra-red lamp and the percentage moisture loss is directly read off the scale.

The disadvantage of this method lies in the inexactness of the temperature of the test; it may be 100°C ± 20°C.

2 Accurate Method

Equipment
- i Temperature controlled oven, operating at 105°C ± 1°C.
- ii 100 ml capacity glass weighing bottles, with caps.
- iii Dessicator.
- iv Analytical balance.

Method

1 The weighing bottles should be dried in the oven and kept in the dessicator prior to use.

2 Tare the weighing bottle and cap; fill it loosely with asbestos fibre and re-weigh to obtain the weight of fibre.

3 Dry the filled weighing bottle and cap separately at 105°C for two hours. At the end of this time replace the cap on the bottle and transfer it from the oven to the dessicator.

4 Allow the bottle 15 minutes to cool in the dessicator and then re-weigh it. Calculate the % loss in weight as moisture content.

Determination of Ignition Loss

Equipment

1 A temperature controlled tube furnace fitted with a work tube. The inlet end of the work tube has dual access to a vacuum pump and to the appropriate gas cylinder via a flow meter. The outlet end has a vacuum-type glass one-way tap, leading to atmosphere.
A diagram of a suitable apparatus is shown on page 5·1/3.

2 Combustion boats, approximately 10 cm long x 1 cm wide x ½ cm deep.

3 Aluminium oxide powder.

4 Analytical balance.

Method 1 Place a thin layer of aluminium oxide powder in the bottom of a combustion boat. (This will prevent fused asbestos sticking to the boat on completion of the test.) Weigh the boat, and then weigh into it approximately 2 gm of the sample of asbestos.

2 Push the boat to the centre of the furnace work tube, close the work tube by inserting the bung A and closing down the tap B. Set tap C to vacuum and outgas the work tube for 30 minutes.

3 Set tap C to the gas cylinder (oxygen or nitrogen). Open the gas cylinder valve gently and observe the gas flow. This will start rapidly and then begin to fall off as the work tube fills with gas. As soon as this occurs open tap B. Adjust the gas flow to about 75 ml/min.

4 Start the furnace up and raise the temperature to 1000°C, holding it for two hours. Allow the temperature to fall to about 200°C, then shut off the gas flow, take out bung A and withdraw the combustion boat. Place the boat in a dessicator, and reweigh it when cool.

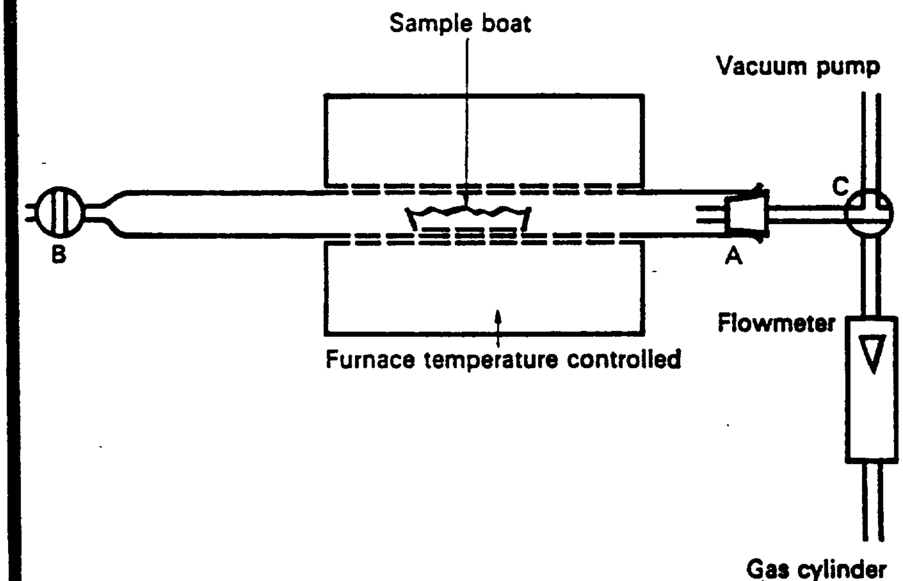
5 Calculate the % weight loss as ignition loss.

Interpretation of Results of Ignition Loss Test

Amphibole asbestos fibres have an ignition loss of 2 to 3% due to loss of combined water, when the test is made in an inert atmosphere (nitrogen). In an oxidising atmosphere this loss of combined water is offset by a gain in weight of the fibre due to its oxidation. The oxidation process is completed only at temperatures above 900°C, therefore the test temperature of 1000°C must be adhered to. The net loss under oxidising conditions will generally be up to 0.5%. If the ignition loss test is made by conventional means, say in a covered crucible in a muffle furnace, there may be restricted access of air to the sample and a result will be obtained which may be intermediate between those found in inert atmosphere and pure oxidising conditions. A similar effect may be found if the sample is not out-gassed before making a test in an inert atmosphere. Results will only be repeatable when the conditions described in the method above are strictly observed.

Chrysotile fibres have ignition losses of about 13% independently of the surrounding atmosphere, and at temperatures in excess of 800°C.

It must be emphasised that a statement of ignition loss of asbestos fibres must include the conditions of test. These should state: temperature, inert or oxidising atmosphere and duration of ignition temperature.



Ignition loss apparatus

Acid Loss and Extractable Materials

The acid resistance of asbestos fibres, particularly blue asbestos, provides one of their most important chemical properties. As these fibres find use in chemical resistant plastic laminates and in battery boxes, a standard acid loss test is a prerequisite in determining the most suitable grade of fibre. A knowledge of the acid extractable metals calcium, magnesium, iron and manganese is also important, manganese being particularly so in relation to battery box manufacture.

Equipment The test is made under reflux using:

1 A 500 ml round bottomed flask.
2 A Liebig condenser fitted in the flask.
3 A heated sand bath or electro-mantle to heat the flask and contents.
4 An analytical balance, dessicator and drying oven (105°C), Buchner flask, sintered glass crucibles (No 1 porosity).

Method Either of two procedures may be adopted:

1 A standard battery acid test, boiling the sample under reflux for one hour with 40% H_2SO_4 (SG 1.250).

2 Exhaustive tests in which samples from the test batch of fibre are refluxed for $\frac{1}{4}$ hr, $\frac{1}{2}$ hr, 1 hr, 2 hr, 4 hr and 8 hr periods. The types and concentrations of the acids used are at the discretion of the user.

The technique for all these tests is identical:

1 Exactly 3 gm of dried fibre is placed in the flask with 150 ml of the required acid. It is advisable to add also a few large glass beads to minimise bumping when the test is commenced. Fit up the apparatus and bring the contents of the flask to the boil. The start of the test period is taken when boiling commences.

2 When the test period is over, the contents of the flask are filtered over a tared coarse sintered glass crucible (No 1 porosity), mounted over a Buchner filter flask. The fibres retained in the crucible are washed with distilled water, to remove all traces of acid. The filtrates are to be retained.

3 The crucible is dried at 105°C and weighed back.

Results The weight loss is then calculated as a % of the original weight taken.

For a battery box fibre this % weight loss is the final test figure. When exhaustive tests on a fibre have been made, the observed weight losses are plotted on a graph against corresponding test periods. The graph shows both rate of weight loss and ultimate weight loss (or ultimate acid resistance).

Notes 1 Exhaustive tests on fibres may be made with HCl, H_2SO_4, HNO_3, CH_3COOH, H_3PO_4, and concentrations of these may be varied from 1% to 40% as required. For comparative purposes 20% HCl should be used as a basis, as this acid has the most destructive effect on asbestos fibres.

2 Concentrations:
20% HCl: Dilute 480 ml 'Analar' concentrated acid to 1 litre.
40% H_2SO_4: Dilute 222 ml 'Analar' concentrated acid to 1 litre.

Extractable Matter The filtrates from the acid loss test, which have been retained in the Buchner flask, are transferred to a 1 litre beaker, for quantitative examination of Ca, Mg, Fe and Mn. Bromine water is added to oxidise any ferrous ions present to the ferric state and the solution boiled down to 150 ml.

A few grammes of NH_4Cl are added to the solution and the ferric iron is then double precipitated with ammonium hydroxide. The suspension is filtered hot and the filtrate collected in a standard flask and made up to 500 ml. This solution contains the Mg and Ca ions which are determined volumetrically with EDTA.

The ferric hydroxide precipitate (after having been washed with a 1% solution of NH_4NO_3 containing a few drops of concentrated ammonium hydroxide—the washings being added to the Ca/Mg solution) is transferred with the filter paper to a beaker containing dilute H_2SO_4. This is boiled gently to dissolve up the Fe^{+++} and to disintegrate the filter paper. The macerated filter paper is filtered off and the solution made up to 250 ml in a standard flask and the ferric iron determined volumetrically with mercurous nitrate.

Alternatively, after boiling and dilution, if the iron is present in suitable quantities, then the ferric iron solution containing the filter paper suspension can be titrated in toto against mercurous nitrate.

Manganese is determined (in cases where the extract does *not* contain HCl) by making the solution obtained after filtration of the fibre up to a known volume of 500 ml and pipetting off 100 ml for the Mn determination. The remaining 400 ml is then used for determining the Ca, Mg and Fe content as described above.

To the 100 ml of solution sufficient phosphoric acid is added to just decolourise the iron salts, then one gram of potassium periodate is added and the solution heated to boiling – it is kept gently boiling for five minutes. After making up to a suitable volume it is determined colorimetrically. With acid loss tests carried out using HCl a more involved procedure is necessary, as all chloride ions must be removed as they will interfere with the Mn determination.

The 100 ml portion is evaporated to dryness and a few cc of concentrated H_2SO_4 added to the residue to remove all chloride. The extract will fume vigorously, heating being continued until the H_2SO_4 has been reduced to at least half its volume to ensure that all chloride has been removed.

The concentrated extract is then diluted and the manganese determined on this solution as before.

Section 9
GENERAL INFORMATION

01 040 1311

A Laboratory for Fibre Testing

A small asbestos testing laboratory, suitable for both routine and investigational work requires 500 to 600 sq ft of space, and should comprise the following sections.

1 A dry testing section, containing the Quebec Standard Testing Machine, the Blaine Dyckerhoff (or similar) air permeability apparatus, a laboratory fibre mill, and a fibre sorting bench; also Rotap Sieve Shaker (if required).

Two weighing scales will be needed; a large pan scale, capacity up to 5 Kg, scale both in Kg and lb, with subdivisions to gm and oz, accuracy about 5 gm or $\frac{1}{5}$ oz, for use with the Canadian Box Test; a small pan scale, capacity up to 200 gm accurate to 0.1 gm for use with the air permeability apparatus.

This section should be adequately dust exhausted and if possible partitioned off from the rest of the laboratory. Dust exhaust hoods should be sited over the Quebec Standard Testing Machine, the fibre mill, the sorting bench, and the sieve shaker.

2 A wet-testing section, containing the McNett classifier, the reinforcing value test equipment, filtration and wet volume testing equipment. All these will require water supplies and a large sink should be provided. A large oven, capacity about 3 cu ft fitted with four perforated metal shelves will be needed for drying McNett samples and test boards.

Two weighing scales will be needed; a small pan scale, capacity up to 500 gm but accurate to 1/10 gm for use with all tests except the McNett classifier; a laboratory balance, accurate to 1/100 gm for use with the McNett classifier.

3 A bench for miscellaneous tests, including colour matching and length sorting. Glass beakers, measuring cylinders and large Petri dishes are all useful items for the visual examination of small samples of fibre in water. A microscope should be provided for the examination of asbestos fibres and asbestos-cement board. Probably the most useful type of instrument for this purpose is a stereoscopic microscope having several magnifications up to x 80.

4 Fibre storage shelves. These should allow for:

a Storage of bulk samples for testing.

b Storage of small envelope or box samples of all fibres tested, so that a permanent index of these may be built up.

The estimated total cost of the test equipment for such a laboratory will be over £3,000, about half of which will be accounted for by the Quebec Standard Testing Machine and the McNett classifier. Benches, storage shelves, dust exhaust equipment and services may account for a further £1,000, but as much of this will be built locally, as will some of the test equipment, overall cost of the laboratory will vary somewhat from place to place.

Suppliers of Asbestos Testing Apparatus

1 The Quebec Standard Asbestos Testing Machine
Drawings only: National Research Council of Canada, Publication No NRC 3470, 'Specifications and Drawings for Quebec Standard Asbestos Testing Machine, Model No 2 1938'.

Complete Machine: Lynn MacLeod Engineering Supplies Limited, Thetford Mines, Quebec, Canada.

2 The Bauer McNett Classifier No 203A
Bauer Brothers Company, Springfield, Ohio.
H. E. Messmer Limited, 144c Offord Road, London N1, England.

3 The Suter-Webb Comb Sorter
Alfred Suter Company, 200 Fifth Avenue, New York, USA.

4 The Blaine Dyckerhoff Air Permeability Apparatus
Chemisches Laboratorium fur Tonindustrie,
Stammhaus, Berlin (West), den Berlin-Reinickendorf 1,
Kopenhagener Strasse 60-74c, West Germany.

5 The Rigden Apparatus
Griffin and George Limited, Ealing Road, Alperton, Middlesex, England.
Cape Asbestos Fibres Limited, 114 Park Street, London W1, England.

6 Universal Air Permeability Cells
Cape Asbestos Fibres Limited, 114 Park Street, London W1, England.

7 Vacuum Pumps
Mono Pumps Limited, Mono House, Sekforde Street, London EC1, England.
Watson Marlow Air Pumps Company, Marlow, Buckinghamshire, England.

8 Inverter
Cape Asbestos Fibres Limited, 114 Park Street, London W1, England.

9 Tensometers
Tensometer Limited, 81 Morland Road, Croydon, Surrey.
Zwick & Company KG, Einsingen Bei Ulm-Donau, Germany.

10 Laboratory Mill
Ludwig Pallmann Limited, Zweibrucken Pfals, Germany.

11 Rotap Sieve Shaker
International Combustion Products Limited, 19 Woburn Place, London WC1, England.

PART - II

CHRYSOTILE ASBESTOS

01 040 1314

SECTION - 4

MOODY FIBRE FLUFFER

01 040 1315

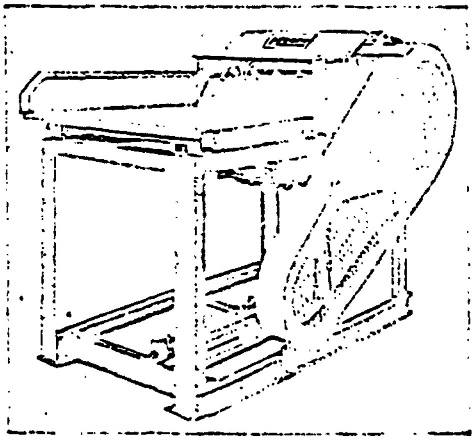
PART II -- CHRYSOTILE ASBESTOS

SECTION 4 -- MOODY FIBRE FLUFFER

The Moody Fibre Fluffer re-opens pressure packed asbestos fibre, which now arrives at Berlin in paper bags and which is chrysotile asbestos. However, Cape is installing some bagging equipment on a trial basis for pressure packing amosite in the future. All of the grades from shorts in 7D grade up are restored to their fluffy pre-packaged condition. Whether this is done as efficiently and to this maximum degree by wet milling through the Bauer Mill is probmatical? At 15 ton capacity this is sufficiently great to allow fitting into the Kaylo batch mixing operation. The merit of such a piece of equipment opening of chrysotile dry can be measured by the result of opening chrysotile through the Pallman Mill and whether or not settings for openings have to be changed on the Pallman between amosite and chrysotile asbestos fibres.

MOODY Fibre Fluffer re-opens Pressure Packed Asbestos Fibre

...all grades of pressure packed asbestos from shorts 7-R to spinning fibre 3-R restored to pre-packaged fluffy condition — free from lumps and mats. Compact, simple to operate — fits into any production line. Up to 15 ton capacity per hour.



Partial list of users

United States
Alcatraz Co. Inc.
American Brake
American Smelting
Armstrong Cork Co.
Auto Specialties
Battenfeld Grease
Durex Plastics
Eaton Mfg. Co.
Flintkote Co.
Grizzly Mfg. Div.
Henry, W. W. Co.
Hooker Chemical Co.
Inland Mfg. Div
Johns-Manville
Linde Air Products
Marshall-Eclipse Div. of Bendix
National Brick Co.
National Gypsum
Nicolet Industries, Hamilton, Ohio
Nicolet Industries, Norristown, Pa.
Philip Carey Co.
Supradur Mfg. Corp.
Thermoid Co.
Union Asbestos
U. S. Gypsum
Worldbestos

Canada
Asbestos Corp.
Asbestonos Corp.
Atlas Asbestos
Canadian Johns-Manville
Cassiar Asbestos
Husky Oil
Lake Asbestos

Elsewhere
Beral-Bremsbelag Kg., West Germany
Everitube, France
Hellenic Building Materials, Greece
Industria de Asbestos Dominican Republic
Israel Brake Lining, Israel
J. D. Jones, India
Pacmac Machinery, Philippines
Turner Bros., England

Full details and literature on request

P.O. BOX 10, MOUNT ROYAL P.O. MONTREAL 16, QUE.

MATTHEW MOODY
DIVISION CANADIAN BOWL-MOR COMPANY LTD.
Head Office & Plant: Terrebonne, P.Q. • Branch Offices: Montreal & Toronto

01 040 1317

SECTION – 5

MILLING ASBESTOS

01 040 1318

SECTION 5 -- MILLING ASBESTOS

This is an article on the preparation of chrysotile asbestos from the mine to the shipping bag. It was written by J. C. Kelleher, of the Johns-Manville Corporation, who was the General Sales Manager of their Asbestos Fibers Division operating their Thetford, Quebec mines. At one time the Kaylo Division bought all of their chrysotile asbestos from this source. The switch to other producers of chrysotile asbestos came about several years ago, when the J-M chrysotile was discovered to contain the highest chloride content. This was inconsistent to our attempt to lower the chloride content of all Kaylo end products.

The terms 'crudy' and 'open' are defined regarding the type of asbestos bundles, where the former is coarse or relatively thick and as 'open' when the fibers are finely divided. Packaging in compressed paper bags has been adopted 100 percent for grades used in manufacture of calcium silicate insulation, since this article was written.

MILLING ASBESTOS

Reprinted from "ASBESTOS"
Philadelphia, Pa.

Price - 25c per copy

MILLING ASBESTOS

By J. C. Kelleher[1]

Asbestos owes its place of importance in industry to a unique combination of qualities. It is the only known material which combines the fibrous characteristics of an organic material, such as wool or cotton, with the resistance to heat, wear and time, of a mineral, such as granite.

Production of asbestos requires two major steps, mining and milling. Mining consists of removing the fibre bearing ore from the mine and delivering it to the mill, and is therefore like many other mining or quarrying operations. Milling covers the steps necessary in removing the fibre from the ore, and the cleaning, grading, and bagging of it for shipment. Asbestos milling is like no other type of mineral recovery and therefore requires special machinery and mill design.

We shall discuss the milling process, principally as it refers to the production of Chrysotile fibre, the major asbestos of use in industry. As much as 480,000 tons of fibre have been milled in Canada in a single year.

To understand the milling process, it is necessary to visualize the objective and the characteristics of the ore.

Since the value of asbestos fibre depends largely on the fibre length, every effort is made to prevent reduction of length, that is, the cutting of the fibre during the milling operation. This objective is carried out in the design and operation of all mill equipment.

The fibre itself is an integral part of the rock or ore. It has the same density and chemical make-up and is of equal hardness. Fibre occurs in veins of varying widths, the width of the vein corresponding to the length of the fibre. Veins may vary from two inches in width down to 1/32 of an inch. The average width of fibre veins is well below 1/2 inch. The direction of fibre length is at right angles to the plane of the vein. Fibre in mill rock usually

[1] Manager, Asbestos Fibre Distributors, Division of Johns-Manville Sales Corporation.

runs from three to ten percent of the total rock fed to the mill.

CRUSHING AND SCREENING

Briefly stated, the entire milling operation consists of extracting the fibre from the rock by repetitive crushings of the ore, at each crushing removing as much free fibre as possible by air-suction or aspiration and screening the freed fibre, to drop out sand, rock and dust. The standard dry separation of fibre from rock is based on

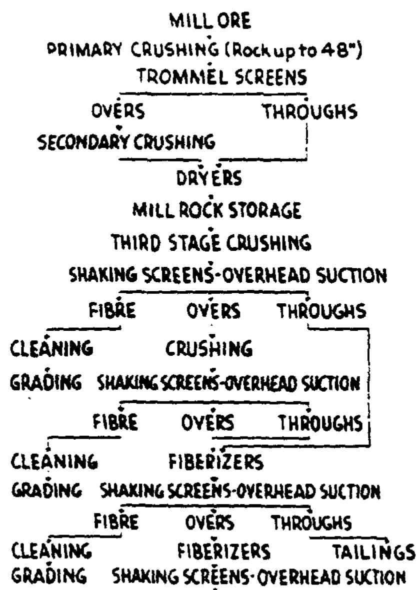
A typical sample of rich ore, showing cross vein fibre formation

the principal that fibre which has been partially opened or fiberized in crushers is lighter in density and offers more resistance to air flow than unopened fibre or rock, and can be lifted by a light air current which will not lift the rock particles. Russian mines have taken advantage of this difference in density of open fibre and rock, and separate them by letting the material flow by gravity down an inclined chute. The heavier rock particles are thrown farther from the end of the chute than the lighter fibre, thus obtaining a rough classification.

Various combinations of equipment have been installed over the years to obtain a combination of high quality fibre and economic operation. The accompanying chart (see page 4) shows the sequence of major operations common to practically all mills. It does not purport to show the full complexity of a complete mill flow line.

Rock or ore from the mine is fed to primary crushers from a storage bin large enough to assure ample feed for the mill. The primary crusher, usually of the jaw type, is capable of taking rock up to 48 inches in size, weighing up to a ton or more. The jaws are set to crush to approximately six inches in width at discharge.

Crushed rock is carried to trommel screens—large revolving cylinders with various size openings, which separate the rock too large to be fed to the dryers. The larger rock, over four inches, is fed to a secondary stage of crushing, usually a gyratory or cone type crusher, before joining the screened rock and passing on conveyor belts to dryer bins.



Typical mill flow sheet
Showing essential operations.

At this point in the mill flow the rock must be dried, as, depending on the season and weather, the mill ore contains varying amounts of moisture; snow and ice often enter the mill with the ore in winter. Efficient milling operation requires completely dry ore.

Drying is accomplished in either stack or rotary dryers varying from 50 to 60 feet in length and 5 to 7 feet in diameter. In either case the rock is cascaded thru a current of hot air generated by oil or coal furnaces, the rock being in contact with the heated air from a few seconds to twelve minutes, depending on the amount of moisture, the type of dryer, the temperature of the dryer, and the rate of feed. Drying temperatures range from 200 deg. F. to 1000 deg. F.

01 040 1323

Rock from the dryers is conveyed to a large, dry, rock storage room, or bins where the latent heat in the ore completes the drying process. The storage bins act as a reservoir of rock to assure a constant flow of mill feed.

The necessity of tremendous rock storage capacity is readily apparent, when we consider that mills consume as high as 300 tons of ore per hour or 6000 tons in a 20 hour day.

A large dry storage of ore eliminates variations in mill feed due to changes in the ore from hour to hour. Many days' supply is piled in layers, which tends to average the mass when a supply is withdrawn.

Ore from the storage bins running up to two to three inches in size is put thru a third stage of crushing in crushers of the gyratory or cone type which further crush the rock and free the fibre.

The product of the third crushing stage is fed to heavy shaking screens equipped with powerful air suction hoods, where the first step of fibre removal occurs. The shaking or bumping action of the screens, obtained by an eccentric drive mechanism separates the light, partially opened fibre from the heavier rock and sand particles. The ore and fibre mass passes down the screen aided by the shaking motion, and under the suction hood where the free fibre is lifted by air suction and the rock passes over the end of the screen. The undersize material passes thru the screen and to fiberizers for further treatment.

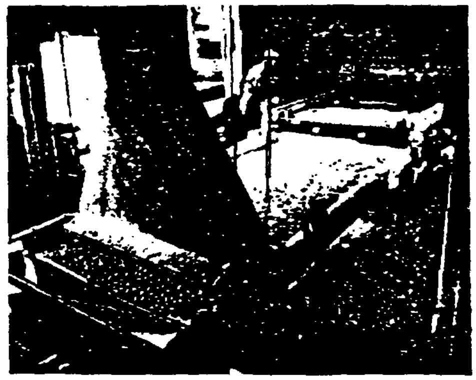
The freed fibre is fed to duplex (two level) shaking screens, equipped with suction hoods, where it is separated into long, medium and short fractions. The long fibre remaining on the top screen is picked up by suction and delivered to a fibre collector. The medium length fibre from the lower screen is fed to a single deck shaking screen where it in turn is picked up by suction and delivered to a collector for its particular grade or length. The short fibre passing the lower screen is conveyed to bins for further grinding and cleaning for special short grades. The rock, passing over the ends of the heavy shaking screens, is carried to a fourth and last stage of crushing, where it is reduced to approximately one-quarter inch in size and again passed over shaking screens with suction for fibre removal. The fibre is discharged to collectors for the various lengths of fibre. The rock, which remains after the fourth stage of crushing, i. e., material passing over the ends of the screens, and the undersize from the first or rock screening operations, are fed to fiberizers, not crushers, for further separation.

Here we should point out the difference between a crushing and fiberizing action. The crushers break the rock by pinching or compressing it. The fiberizer, which consists of high speed hammers in motion, breaks the rock by blow or impact. The falling rock is struck by revolving hammers with a top speed of 10,000 feet per minute. In either case, fibre is released. The impact break is more severe and is not usually used until the longer, more valuable fibres have been freed.

The product of the fiberizers, like that from the crushing operations, is fed to shaking screens where again the fibre is collected by suction and carried to fibre collectors for different lengths of fibre.

The steps of fiberizing, screening and suction are continuous thruout the complete milling process, and the three operations together represent the major elements of asbestos milling.

At each suction-screening operation, part of the fibre is collected and part passes on for collection from subsequent screens. The number of screening and suction operations necessary can be visualized when we realize that a normal sized mill may contain hundreds of screens housed in large five or six story mill buildings. The complexity of the detailed flow of material thru the complete mill, including the many repetitive operations, is entirely too involved for an ordinary discussion. Many variations in a flow sheet are necessary due to the wide variations in the ore itself. We have referred several times to fibre being separated from the rock on shaking screens by means of suction hoods. The accompanying



Shaking Screen with suction hood Note fibre free ore after it passes under hood

Courtesy The Ruberoid Co.

picture clearly shows a suction hood over a shaking screen. It is best described as an oversize vacuum cleaner, which sucks up the light fibre and some dust and rejects the heavier pieces of unopened fibre and rock.

The undersize material or waste from the screening operations, when it has been considered sufficiently free of fibre, is conveyed to tailing dumps. Since the tailings or rejected rock equals 90% of the original ore fed to the mill, waste dumps loom large in the landscape of the asbestos mining country. In recent years the recovery of short fibres included in the tailings and the potential recovery of the high metallic content, have focused attention on the value of these mountains of fine gravel.

CLEANING AND GRADING

No discussion of milling asbestos should omit mention of the disposition of the vast volume of fines, i. e., extremely fine, short fibres and pulverized rock created in the treatment of the ore. The many millions of cubic feet of air being handled hourly by the air collecting system, are heavily laden with fines. This must be deposited without being ejected to the atmosphere, to the detriment of the surrounding community. This objective is accomplished by discharging the fan exhausts into a vast room or chamber known as a float shed. In this space

01 040 1326

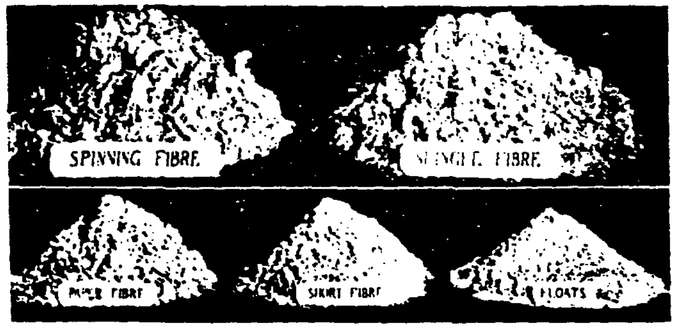
the velocity of the air is dissipated and the fine material settles out. The bin, or shed, is divided into a number of compartments at varying distances from the air inlet. Each compartment collects floats of different ranges of particle size. Asbestos floats, as sold, are a product of one or more of the float bins. The finest particles are prevented from passing out to the atmosphere by such methods as electric precipitation or passage thru canvas filtering bags.

We have considered the removal of fibre from the ore and explained that the suction fans discharged the fibre to collectors for each fibre length grade; it is now necessary to clean, grade, and bag the fibre for shipment.

The fibre collector, a large sheet metal conical cylinder, performs the first step in the cleaning operation. The current of air which carries the fibre and rock dust to the collector, deposits the heavier fibre and carries the dust laden air to the float shed described above. Further cleaning consists of screening the opened fibre over light screens. Here dust and rock falls thru the screen meshes and the fibre is discharged off the end of the screen by suction. Well opened fibre does not screen readily; that is, it tends to cling together, permitting the use of coarse screens which drop out the rock without loss of fibre. Several repetitions of the screening operation may be performed to obtain proper cleaning. A final cleaning operation consists of dropping fibre thru a cyclone or air selector, similar in design to a fibre collector, the heavier rock and unopened fibre falling vertically thru and the lighter fibre being drawn off the side of the collector by suction and again deposited in collectors.

The sequence of the various cleaning operations, screening and air selection, and their tie in with the collecting and grading operations, vary in different mills and even within a given mill depending on the type and grade of fibre being produced. We have merely described the steps of cleaning as tho they occurred progressively, as well they might, in a simple mill layout.

Grading fibre means classifying it according to



Courtesy Canadian J-M Co. Ltd.

Typical samples of milled fibres in major group gradings.

length. The value of a given type of fibre depends chiefly on its length. There are five major classifications according to length, namely, and in descending order of length they are: Spinning or Group 3, Shingle or Group 4, Paper or Group 5, Stucco-plaster or Group 6, and Shorts or Group 7. In each Group are a number of grades or subdivisions, all meeting a standard screen test for length. An average mill produces at least twenty-four separate grades.

Obtaining these grades in a mill is accomplished in specially designed graders. They are usually long rotary screens covered with screen wire of various size mesh. Fibre is fed into one end of the slowly turning screen, in which revolving paddles force the fibre thru the screen openings. Short fibres pass thru the fine mesh at the entering end, longer fibre passes thru larger mesh in the second half of the screen length, and the longest materials pass over the end of the screens.

Grades are obtained by experienced operators by combining proper proportions of material from two or more of the various screen sizes. Several grades may be made at the same time on one grader by directing the flow of varying proportions of the different length products of the grader into appropriate collectors.

Careful grading calls for close cooperation between the operating men and the testing men or inspectors, since, depending on the results of frequent tests, the flow of material from the graders can be adjusted to avoid off-grade fibre.

Graded fibre is conveyed to bins above the bagging room from which it passes by gravity thru metal chutes to bagging machines. These machines may be semi-automatic or manually operated. They load the fibre into burlap or jute bags of one hundred pounds net weight, compressing the fibre to reduce the bulk in shipping. All bags are sewn by hand or with portable stitchers before being loaded into freight cars or sent to stock.

Many special grades are made by variations in the regular mill flow line. Large quantities of short fibres are produced by special grinding, screening, and cleaning of the fine undersize products of many of the screening operations. Highly cleaned grades of longer fibres are produced by repeated passages thru series of air selectors, which drop out all heavy particles and remove a major part of the fine dust. When desired, partially opened or Crudy fibres are produced by eliminating the high speed impact fiberizing operations. Where the terms "crudy" and "open" are used in referring to fibre, it can be generally understood that crudy or partially opened fibre is a product of crushing, whereas open fibre is the result of a fiberizing operation.

Asbestos fibre is unique in that it has no definite fibre diameter like hair or cotton. It can be subdivided indefinitely within the limits of the ordinary microscope. Fibres one-eightieth the thickness of a human hair have been measured. Thus, each fibre is in reality a bundle of finer fibres. An opening process is one which tends to subdivide the fibre bundles. Fibre is spoken of as "Crudy" when the fibre bundles are coarse, or relatively thick, and as "Open" when the fibres are finely divided.

Highly opened fibres are obtained for special requirements by adding an extra step of fiberization in specially designed hammer mills.

Blending, or mixing, permits the production of fibres not obtainable in regular mill operations. By this method definite proportions of coarse or fine fibre, short or medium lengths, can be obtained and such features as filtration rate, wet volume, covering capacity, adhesion, absorption, etc., can be controlled.

While crude fibres, that is No. 1 and 2 Crudes, are not products of the milling process as are the milled fibres in Groups 3 to 7, they are the form in which fibre is generally pictured. Crudes are chunks of fibre which have been separated from the rock or ore, and have considerable fibre length. No. 1 Crude runs from ¾ inches up, and No. 2 includes fibres from ⅜ to ¾ inches. Shorter Crudes are classified as No. 3 or Sundry. The Crude fibre is cobbed or chipped from the broken ore in the quarry, cleaned and graded in the cobbing shed and weighed and bagged for shipment.

Asbestos is evaluated and sold by grades, as established by the Quebec Government and classified in the Standard Quebec Asbestos Classification. The detailed screen specification of all grades and the methods of test have been widely published[1], and will not be repeated here. An important step in Asbestos milling, however, is the sampling and testing of fibre according to the Standard Quebec Classification, prior to storing or shipping.

Before fibre bags are closed, composite samples of each shipment are taken by inspectors and tested. The usual method of sampling is to take a "grab" sample from well down in each bag. The samples from each ten or twenty bags are combined to make a test lot. These tests represent a fair average of each car.

The fibre is well mixed, and one pound is screened in the standard testing machine. Lots which meet the test requirements are tagged and sewed for transfer to stock or to cars. Lots which fail to pass, are sent back to the mill for regrading. In the case of special grades

[1] See reprint "Canadian Chrysotile Asbestos Classification" obtainable from "ASBESTOS", 17 Fl., Inquirer Bldg., Phila. 30, Pa., for 25c.

prepared by additional operations of mixing or extra fiberizing or cleaning, special tests are often made to check them against a particular requirement.

EQUIPMENT

For the sake of clarity, the major steps in Asbestos milling and their relation to one another have been described with a minimum reference to equipment and buildings. The magnitude and complexity of the mills in which the operations occur are a matter of comment and observation by visitors.

An asbestos mill is generally spoken of and guaged in terms of the number of tons of ore per hour which it is capable of processing. Mills vary in size from 50 tons to 300 tons of rock per hour, or from 1,000 to 6,000 tons per day.

N. F. B. Photo

Asbestos mills of the Canadian Johns-Manville Corporation, showing part of the mill buildings.—dust removal, down comers, tailings, conveyor, and 1000 ton loading bin.

Mill buildings vary in size and construction. In general they are all of multi-story, fireproof construction. The multi-story design is followed to take advantage as far as possible, of gravity flow of rock and fibre, material passing from floor to floor by gravity and being returned to the upper floors by conveyor, or suction fans.

The major items of equipment are: crushers, dryers, conveyors, fiberizers, shaking screens, suction hoods, blowers, air collectors, graders, and bagging equipment, with necessary power accessories, ductwork, and storage facilities. The number of units of each type equipment in any mill depends on the tons per hour of ore to be handled, or capacity of the mill.

As far as practical, all equipment is made of metal, wood being eliminated to prevent its getting into the bagged fibre. Wooden housings for screw conveyors and wood chutes are the most troublesome and prevalent sources of contamination.

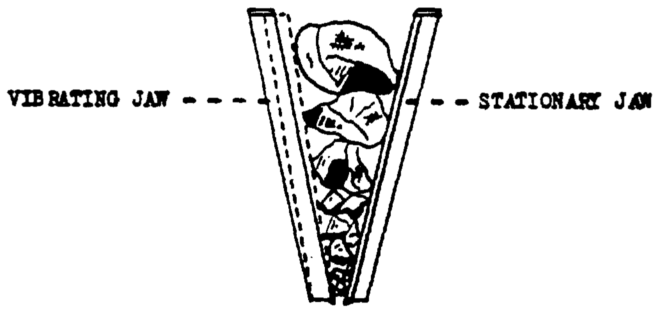
Rock crushers are usually of gyratory or jaw type and descend in size from 6" discharge to 1/4". Fiberizers may vary in design. The general principle is the cracking or disintegration of rock by high speed impact. A horizontal or vertical shaft carrying a row of swinging hammers rotates in a cylindrical metal shell six to eight feet in length and 24 to 30 inches in diameter. The rock enters at one end and is discharged from the opposite end. The shell carries rows of stationary hammers spaced alternately to the swinging hammers. During the passage the rock is subjected to blows from the hammers rotating up to 2000 RPM.

The many screens in a mill are usually of a shaking, rotary or gyrating type. To be effective, the screens must carry only thin layers of material to permit efficient separation of rock and fibre. Thus many thousands of square feet of screen area are necessary to accomodate the mill flow.

Shaking screens are equipped with suction hoods where fibre is to be removed to collectors. Where a simple screening or cleaning operation occurs in a series of screens, many of them do not require the suction hoods. Screens may vary from three to six feet in width and eight to eighteen feet in length.

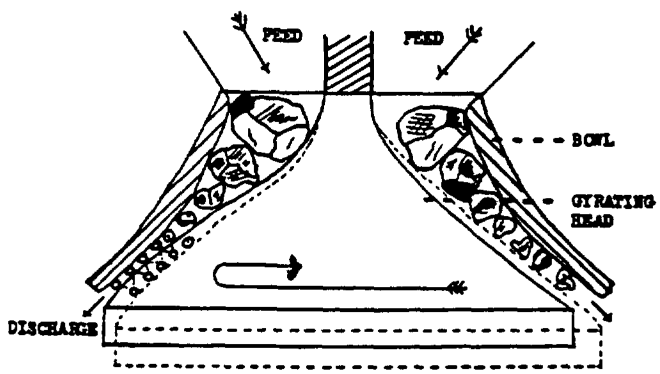
Fibre collectors of large aggregate volume are required to hold the accumulations of fibre in the different stages of milling. The collectors are galvanized iron cylinders, from four to eight feet in diameter, the bottom half conical. Inlet and outlet ducts in the upper half of the collector bring in the fibre and discharge the dust laden air. The fibre which settles, because of its weight, is collected and drawn off from a gate in the cone shaped bottom.

DIAGRAMATIC SECTION OF CRUSHING UNITS
USED IN MILLING ASBESTOS ORE



JAW CRUSHER

The crushing process is accomplished thru reduction by pressure between a vibrating and a stationary jaw with a subsequent freeing movement, at which time the material settles by gravity until caught and subjected to further pressure and then released.



GYRATORY CRUSHER

The ore enters the top and falls on the gyrating head and is crushed between the head and the bowl by the eccentric rotation of the head. The discharge may be set to the size crushing desired.

Grading and bagging equipment has previously been briefly described.

USES OF SPECIFIC GRADES

We have followed fibre production thru the crushing, fiberizing, collecting, cleaning, grading, inspection and bagging operations. In closing, a brief discussion of its major uses may be of interest.

The uses of asbestos are as varied as the physical make-up of the fibre itself. Eliminating crudes, Canadian milled asbestos fibre varies from a fine powder selling at $15 to $20 per ton to a long, silky fibre at over $200 per ton.

The uses of asbestos can most clearly be explained by showing the purposes which the fibres serve rather than listing the products in which they are used. As a reinforcing filler asbestos fibres are used in a wide variety of materials, ranging from plastic molding to asbestos cement shingles and molded brake linings. The major uses include the following:

Long fibres are used as a textile fibre; are felted to make long fibre paper; as a filtration medium; and as a reinforcing filler in asbestos-cement products where great strength is required.

Medium length fibres which include the short spinning, the shingle and the paper grades, are used as a reinforcing filler in asbestos-cement products; as the major component of asbestos paper and millboard; as a reinforcing and binding agent in magnesia and other molded insulation; are felted with cellulose fibre for filtration sheets and pads; as a reinforcing filler in molded friction blocks and brake linings; and as an insulating mass in sprayed insulations.

Short Fibres and Floats are used as a self binding insulating cement; as a filler and reinforcement in all types of asphalt paints, putties and compounds; as a filler and reinforcement in plaster and stucco; as a filler and reinforcement in asphalt tile flooring; and as an insulating space filler. Floats and Shorts also find use as a mineral reinforcing filler in plastics; as a filler in lubricating grease; and as a silicic flux in the welding industry.

The unique combination of qualities which make asbestos alone the suitable material for these many uses, is its fibrous form (like cotton or wool) and its inorganic stone-like composition. It is fibrous, strong, will not burn. and forever resists weather. It has the workability of an animal or vegetable mineral with the fire and weather resistance of a granite block.

Printed in the United States
January 1946

SECTION – 6

RECOVERY OF

RAW ASBESTOS

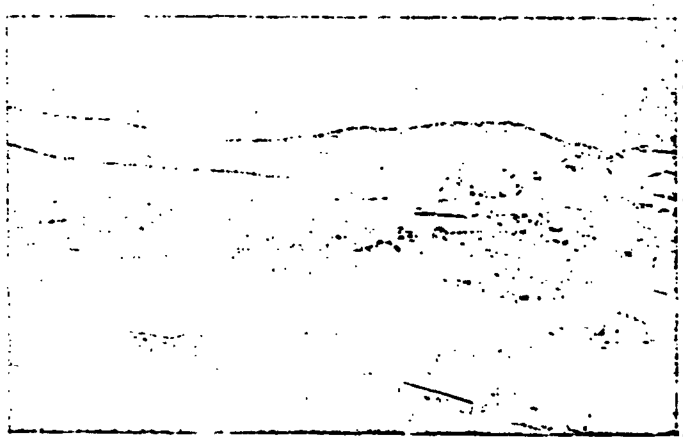
01 040 1335

SECTION 6 -- RECOVERY OF RAW ASBESTOS

Roland Starkey's write up of raw asbestos recovery is of processing the African chrysotile. Turner and Newall, Ltd. are insulation manufacturers in Britain, the chief competitor of Cape Asbestos, whose insulation runs from 85 percent magnesia to calcium silicates in the high temperature field. At the time this article was written some hand pickers were used, because of cheap labor, as against the completely mechanized milling of the Canadian Mines. The African chrysotile tonnage is considerably below the Canadian annual production and their shipping cost to the United States offsets their lower labor and the Canadian mechanization reduces milling costs of their fiber so that the North American chrysotile dominates the large percentage of the Unites States market.

RECOVERY OF RAW ASBESTOS

At The Havelock Mine



By Roland Starkey M. Inst. M. M. Consulting Engineer,
and Staff of African Associated Mines, Limited

Reprinted from May 1947 "ASBESTOS"
Philadelphia, Pa.

RECOVERY OF RAW ASBESTOS

Methods Used at Havelock Mine

By Roland Starkey M. Inst. M. M. Consulting Engineer, and Staff of African Associated Mines, Limited

Production of chrysotile asbestos from the Havelock Mine began in June, 1939 and the milling methods adopted were the result of a considerable amount of experience and research by technicians of Turner & Newall, Ltd., both from their mines in Africa and from their factories in the United Kingdom.

The Havelock Mine is situated in Swaziland a few miles over the Eastern border of the Transvaal. It is owned by New Amianthus Mines, Ltd., a subsidiary company of Turner & Newall, Ltd., of Rochdale, England.

About one quarter of the ore delivered to the mill bins is derived from opencast quarrying operations and the remaining three quarters is broken in underground sub-level caving stopes.

The first operation in the mill is of sizing and hand sorting. The rate of flow from the mill bins is 110 tons per hour and a rotating ring grizzley gives a +4 inch product; the "throughs" pass to trommels clad with steel punched-plate with circular holes of 2½ inch diameter. Fibre bearing rock present in the +4 inch, and —4 inch +2½ inch products, is picked off sorting conveyor belts by hand and the remaining barren waste rock is disposed of forthwith via waste bin and dump haulage. This sorting operation yields a product known as Hand Cobbed Fibre constituting approximately 3% of the original feed; the coarse waste discard to dump amounts to 50%.

The —2½ inch product from trommelling contains moisture varying from 4% to a maximum of 33%, the average content being from 8% to 9%, and before further treatment can take place it is necessary to arrange to dry this material. A type of tower dryer has been evolved, designed to remove excess moisture without subjecting the asbestos to severe overheating or to undue mechanical attrition, both of which would tend to destroy the delicate fibres. The tower dryer is essentially a vertical shell 40 feet high and 6 feet in diameter containing a system of baffles. The moist ore showers down the dryer from top to bottom against the flow of hot furnace gases from a thermostatically-controlled, automatic coal-fired stoker. The contained moisture in the discharge is approximately 2 to 3% and the temperature 180° F.

A further trommelling process now separates the —½ inch element of the dried material, the +½ inch —2½ inch element being presented in a uniform stream to vacuum air separating nozzles causing the loose fibre to be removed and deposited in a form of cyclone settler. The loose fibre recovered at this stage amounts to 2% of the original feed, while the —½ inch material constitutes 22%. This leaves 23% of the original feed in the form of +½ inch —2½ inch material, which is reduced to a 3 ft. short head Symons cone crusher. The loose fibre just referred to and the hand cobbed fibre previously noted receive separate treatment in order to preserve the long fibres present in the original ore. Drying of these two materials is completed in a steam dryer consisting of successive floors of pivotable steel plates along which steam pipes are conducted. The drying takes place on these floors, the material being passed from one floor to the next below at appropriate intervals of time, a thoro turning over being effected at each transfer.

From this point onwards the fibre recovery process consists essentially of a series of stage crushings followed by screening and vacuum air separation of the released fibre. The initial reduction of the lumps of hand cobbed fibre is by means of a 16" x 10" jaw crusher and subsequent crushings are in pan rolls. This crushing machine comprises two edge runners revolving in an annular dished pan which rotates in a horizontal plane. The crushing takes place between the edge runners, which together weigh 4000 pounds, and the pan which rotates at 35 r. p. m., the crushed material being discharged by means of a suitably arranged scraper. This type of crusher has been found to be very effective in separating fibre from containing rock without damaging the fibre down to limiting particle sizes of from .05 inch to .10 inch. The screening apparatus consists of inclined trommels of 3 feet diameter and 7'6" length, clad with wire screening cloth, the clear aperture being reduced at each successive crushing stage. The free fibre in the end discharge of these trommels passes over a reciprocating light sheet metal table to a revolving screen. At an appropriate distance, to effect separation of loose fibre from rock and grit, is located the usual vacuum nozzle thru which the fibre is lifted and subsequently deposited in cyclone settlers of the centrifugal type. Pan rolls crushing, screening, and air separation process is applied also to the —½ inch material and the crushed product from the Symons cone crusher.

As a result of these processes two types of material are segregated, (a) fibrous products from cyclone settlers, known as concentrates, and (b) sized gritty materials from 0.10 inch to 0.03 inch particles size, some of which are sent to waste dump and the remainder have sufficient fibre content to warrant further milling.

Dealing first with the concentrates, which are only roughly classified in respect of average fibre length and which contain a proportion of fine dust, it is necessary to provide a screening (trommelling) plant in which there is a much more searching classification into fibre length groups and a practically complete elimination of fine dust. The result is classified fibre in four grades. The next process has a two-fold object, (a) to eliminate fractures in the individual strands of fibre, and (b) to eliminate the hard bundles or faggots of fibre aggregates. The former purpose ensures that the marketable product shall have true fibre lengths between predetermined limits and the latter secures a product of uniform texture. Previous attempts to achieve these aims were generally incompletely successful because of the difficulty in providing a selective treatment whereby fibres already opened up and free from fractures were not subjected to further treatment tending to destroy the fibre altogether. The principle of the machine now in use involves two elements, first an absolutely uniform feed at a predetermined rate, and secondly, introduction of this uniform layer of fibre into a swiftly moving air stream which passes thru a series of streamlined chambers in each of which revolves a horizontal shaft at high speed. The shafts are provided with a large number of beater arms, ½ inch in diameter, radially thru the shaft and projecting about 4½ inches on each side of the shaft. The direction of rotation of the shaft is opposed to the flow of the fibre-air stream. Fibre particles impinge upon these rods and the force of the blow is naturally proportional to the mass of the fibre aggregate. The light elements of opened fibre pass on unmolested, whereas the more compact bundles receive sharp blows which open them and at the same time break down fractured elements into true unfractured strands of fibre. After passage thru these conditioning machines the asbestos is removed from the air stream in the usual cyclone settler and passes thru trommels clad with the appropriate screening to eliminate short length fibre resulting from the conditioning process just described. The discharge from the trommels (plus product) is bagged in 10 ounce hessian bags containing 125 lbs. net asbestos weight under registered marks HVL/2 (spinning grade), HVL/3, 4 and 5 (shingle grades).

In the preliminary stages noted above, mention was made of gritty elements containing sufficient fibre to justify further treatment. Recovery from these materials is effected in a type of conditioning machine in which the rate of flow is regulated to achieve separation of fibre from adhering waste rock particles—a concentrate results which is incorporated in the flow in the same way as concentrates from other sources.

Finer elements still—down to 0.03 inch particle size—are subjected to a screening process in which a gyratory action is imparted to the horizontal screening surface giving selective treatment to the fibrous elements, opening them up and enabling the vacuum separating action to become operative. The limit to which the ultimate fibre recovery can be pursued is, of course, an economic one in which factors of cost of crushing and treatment have to be offset against net revenue from the salable product after making allowances for transport charges to the customer.

The rate of marketable asbestos production is approximately 26,000 tons per annum.

This article is a companion (or supplement) to Milling Asbestos by J. C. Kelleher, which was published in "ASBESTOS" during 1945 and is also available in reprint form (at 25c per copy):

Printed in U. S. A.

Price - 25c per copy

SECTION – 7

CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION

01 040 1343

SECTION 7 -- CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION

Explained in this section are the lists of standard grades of Canadian asbestos mines products as supervised by the Minister of Mines of Quebec province, with a guaranteed minimum shipping test of the grades. An explanation of the Quebec Asbestos Mining Association is included, as well as its screen sizes and operation.

January 1, 1949

CANADIAN CHRYSOTILE ASBESTOS CLASSIFICATION

(List of Standard Grades set up by the Committee on Uniform Classification and Grading of Asbestos Mines Products. This committee was formed in 1931 at the instigation of the Minister of Mines of the Province of Quebec, and the list of grades has been revised from time to time. Latest revision December 1942)

The asbestos mines products are divided into two classes: "Crude Asbestos" and "Milled Asbestos," respectively, defined as follows:

"*Crude Asbestos*" consists of the hand-selected cross-vein material essentially in its native or unfiberized form.

"*Milled Asbestos*" consists of all grades produced by mechanical treatment of asbestos ore.

"Crude Asbestos" and "Milled Asbestos" are subdivided into groups designated and defined below.

Classification of the "Milled Asbestos" grades, in groups Nos. 3 to 7, inclusive, unless otherwise specified is based on the Quebec Standard Testing Machine (see illustration).

"*Shipping Test*" is the average for each carload or smaller shipment, of tests of representative samples taken at the time of shipping.

"*Guaranteed Minimum Shipping Test*" is that below which the actual shipping test shall not fall.

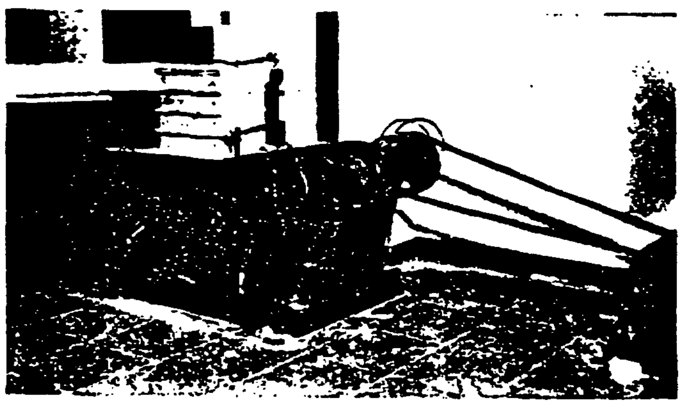
GROUP No. 1	CRUDE No. 1	Consists basically of crude ¾ inch staple and longer
GROUP No. 2	CRUDE No. 2	Consists basically of crude ⅜ inch staple up to ¾ inch
CRUDE RUN-OF-MINE		Consists basically of unsorted crudes
CRUDES SUNDRY		Consists of crudes other than above specified

GROUP No. 3

Standard Designation of Grades	Guaranteed Minimum Shipping Test
3F	7 — 7 — 1.5 — 0.5
3K	4 — 7 — 4 — 1
3R	2 — 8 — 4 — 2
3T	1 — 9 — 4 — 2
3Z	0 — 8 — 6 — 2

01 040 1345

Standard Designation of Grades		Guaranteed Minimum Shipping Test
GROUP No. 4		
	4H	0 — 5 — 8 — 3
	4K	0 — 4 — 9 — 3
	4M	0 — 4 — 8 — 4
	4R	0 — 3 — 9 — 4
	4T	0 — 2 — 10 — 4
	4Z	0 — 1.5 — 9.5 — 5
GROUP No. 5		
	5D	0 — 0.5 — 10.5 — 5
	5K	0 — 0 — 12 — 4
	5M	0 — 0 — 11 — 5
	5R	0 — 0 — 10 — 6
GROUP No. 6		
	6D	0 — 0 — 7 — 9
GROUP No. 7	The affix "F" designates "Floats" in all subsections of Group No. 7	
	7D	0 — 0 — 5 — 11
	7F	0 — 0 — 4 — 12
	7H	0 — 0 — 3 — 13
	7K	0 — 0 — 2 — 14
	7M	0 — 0 — 1 — 15
	7R	0 — 0 — 0 — 16
	7T	0 — 0 — 0 — 16
GROUP No. 8	8S	Under 75 pounds per cubic foot loose measure.
GROUP No. 9	9T	Over 75 pounds per cubic foot loose measure.



Quebec Standard Asbestos Testing Machine, Model No. 2

01 040 1346

QUEBEC ASBESTOS MINING ASSOCIATION [1]

(APPROVED METHOD OF TESTING ASBESTOS FIBRES)

¶1. Only the Quebec Standard Testing Machine Model No. 2 shall be used for the purpose of testing asbestos fibres.

¶2. The machine shall be manufactured, installed and operated according to the specifications issued by the National Research Council, and shall be kept in proper adjustment and in good working condition at all times.

¶3. The method of taking samples for testing shall be as follows: When testing Group 3 fibres, a composite sample shall be made up from each and every lot of 100 bags included in the number to be tested. Each composite sample shall be made up by taking a handful (about 4 ounces) from every fifth bag of the 100; that is to say, 20 handfuls are taken from each lot of 100 bags.

¶4. In the case of Group 4, 5, or 7 fibres, a composite sample shall be made up from each and every lot of 200 bags included in the number to be tested, and each composite sample shall be made up by taking a handful (about 4 ounces) from every tenth bag of the 200; that is to say, 20 handfuls are taken from each lot of 200 bags.

¶5. In every case the handful of fibre shall be taken from well inside the interior of the bag.

¶6. Each composite sample so made up shall first be allowed to approximate average work-room temperature and humidity, and then shall be thoroly mixed on a smooth topped table while passing it thru the hands with a gentle rubbing action in order to break up and separate all clots and lumps. It then shall be divided into halves, quarters, etc., as necessary, and a representative one pound lot shall be weighed accurately and placed in the testing machine.

[1]Formerly Quebec Asbestos Producers' Association

01 040 1347

QUEBEC STANDARD TESTING MACHINE AND ITS OPERATION

The Quebec Standard Asbestos Testing Machine (see illustration) consists of a nest of 4 boxes, measuring 24½"x14¾", resting on a table which is driven by an eccentric with 25/32" throw and 1 9/16" travel. The boxes, which are superimposed one above the other, are numbered from the top down—1, 2, 3 and 4. The bottoms of boxes Nos. 1, 2 and 3 are made of brass screen of the following specifications:

Box No.	Screen opening	Diameter of Wire
1	0.500"	0.105"
2	0.187"	0.063" (4 mesh)
3	0.053"	0.047" (10 mesh)

4—Receptacle for the fines which fall thru the other three boxes.

To make a test, 16 oz. of asbestos is placed on the uppermost tray (No. 1) which is then covered and tightly clamped. The machine is started and by means of an automatic device is kept going until exactly 600 revolutions have been made. (The speed of rotation is 300 r.p.m. in the old model No. 1 machine, and 328 r.p.m. in the new model No. 2 machine.) At the end of this time the asbestos which remains on each tray (box) is weighed. This gives the grade of asbestos fibre; the longest fibre naturally stays on the screen with the largest opening, whereas shorter fibre, according to its length, remains on screens (or trays) 2 or 3, or drops into the pan (lowest tray). The more fibre retained on the first screen, and the less fibre falling into the pan, the higher the grade and therefore the greater its value.

If, for instance, a customer buys 3K fibre of the specification 4-7-4-1, it means that in a sample of 16 oz., representing the average of the lot shipped, 4 oz. will remain on the top screen, 7 on the second and 4 on the third, while 1 oz. will go thru all the screens into the pan. It is evident that the figures of the test represent the proportion in ounces of the different lengths of fibre in a pound of asbestos.

The product known as "Crude Asbestos" consists of veins of asbestos, of the cross-fibre type, the length of which is ⅜" and longer; No. 1 Crude being material ¾" or longer and No. 2 Crude ⅜" to ¾". Crude asbestos is not graded on the Quebec Standard Asbestos Testing Machine.

From "Asbestos" Philadelphia, Pa.

Price—25c

(Printed in United States of America)

SECTION – 8

THE ASBESTOS FACTBOOK

PART III --

AMOSITE AND CHRYSOTILE ASBESTOS

SECTION 8 -- THE ASBESTOS FACTBOOK

This section's article deals with the theory of the origin of asbestos, its mining locations, its uses in various products, typical analysis of Canadian chrysotile (Blue and Amosite) and various qualities of each. This is a general information section.

THE ASBESTOS FACTBOOK

Wherein is given in compact form much information concerning asbestos — that amazing, versatile non-metallic mineral.

"ASBESTOS," Philadelphia, Pa.

Second Edition—Feb. 1st, 1944

FOREWORD

In the compilation of this small book we have taken information from many sources, and have been helped by various executives in the Asbestos Industry. It is impossible to list them all, but to all of them our sincere appreciation is extended.

The Asbestos Factbook is for those who need, for one reason or another the main facts on asbestos without hunting thru many volumes. Those preparing luncheon talks may find it useful; teachers will welcome it; it can be used to answer the many inquiries received by "ASBESTOS" and by members of the Asbestos Industry for general information about the wonderful non-metallic mineral—Asbestos.

THE ORIGIN OF ASBESTOS

(Extracted from "The Origin of Asbestos"[1] published in "ASBESTOS," July, 1940)

Chemical and mineralogical studies clearly show that asbestos fibre is not of vegetable or animal origin, but entirely of mineral origin. Taking as an example the chrysotile asbestos mined in Canada, the observed facts lead to the following explanation of its formation.

In the greenstone region of Canada, covering hundreds of square miles, the present surface rock was at one time thousands of feet below its present elevation, and under very great pressure due to the weight of the overlying rock and soil. This rock is a variety of olivine called peridotite and is composed of iron, magnesia and silica. In certain extensive areas this rock was acted on by hot ground waters, under high pressure, and carrying dissolved salts and carbon dioxide. The pressure is easily understood when it is realized that the rock was very far below the earth's surface, and the high temperature is explained by the fact that the temperature of the earth increases about 1°F. for every fifty feet of depth. From depth alone, this would give a temperature increase of at least 20°F. for every

[1]By M. F. Smith, Research Chemist, The Philip Carey Mfg. Co.

1000 feet, not to mention the hot intrusive rocks also present. These ground waters gradually changed the original rock from the iron-containing peridotite to the magnesia-silica-water ($3MgO \cdot 2SiO_2 \cdot 2H_2O$) mineral, serpentine. During the alteration the volume of the rock increased, causing innumerable cracks, small and large. These cracks were filled with the hot ground waters, chiefly derived from the slow infiltration of rain or surface waters. This underground water circulated thru the cracks in the rock, descending slowly thru the smaller openings in the rocks and ascending thru the larger openings and cracks. This water at high temperature and containing carbon dioxide under pressure is a very good rock solvent. The water rising in the larger cracks loses pressure and slowly cools, losing some of its solvent power and throwing out a small amount of the dissolved rock. This material deposits on the sides of the crack in the rock thru which the water is flowing, and if suitable mineralizers are present, such as dissolved salts and carbon dioxide, tends to form regular crystal shapes, depositing the molecules in a regular rather than a haphazard manner. Rock salt gives cubes; diamond forms in octahedrons; graphite in six sided plates, gold in octahedrons or cubes. Asbestos forms in easily separable, closely packed filaments, which when teased apart give the workable form in which asbestos is marketed and used.

The theory for the formation of asbestos fibre as given in the foregoing is held by many experts, but may be and is contested in some of its minor details by others, based on slightly different conditions present where they made their observations. In most cases the difference of opinion relates to such details as to how the waters were heated, and what the mineralizers were rather than to the whole of the theory. What has been said above about Canadian asbestos fibre formation holds also for the Vermont chrysotile fibre, Arizona, Russian, Cyprus and South African chrysotile fibre, as well as for some of the other non-chrysotile types.

TERSE ASBESTOS FACTS

¶ "Asbestos" is not the name of a distinct mineral species, but is a commercial term applied to fibrous varieties of several minerals differing widely in composition, the fibres being diverse in strength, flexibility and consequent usefulness.

¶ The properties of asbestos that give it commercial value are fibrous structure and fire resistance.

¶ Grading of asbestos is on the basis of length rather than quality. Fibres of the same *quality* range in price according to length.

¶ The three varieties of asbestos most used commercially are Chrysotile, Amosite and Crocidolite (blue) the bulk of world production and use, both long and short fibres, is Chrysotile.

¶ The earliest use of asbestos known to the world was over 2000 years ago by the Romans for the wrapping of their dead.

¶ Canadian Asbestos (chrysotile variety) was first "discovered" near St. Joseph, Que., in 1860; the deposits at Thetford and Coleraine were found in 1877; but, according to the story of Benjamin Franklin's purse[1], asbestos was actually known in Canada, probably by the Indians, as early as 1724.

¶ Blue asbestos was discovered near the Orange River, South Africa, in 1816; the name "crocidolite," meaning "flakey" or "woolly" stone, was applied to it in 1831; exploitation of the material began in 1893.

¶ Amosite (in Central Transvaal) was first known in 1907; the name was given to it in 1918, being taken from the initials of the company most interested in its production—Asbestos Mines of South Africa. Commercial production started in 1916.

¶ Rhodesia first reported production of asbestos (chrysotile variety) in 1908—55 tons.

[1]See March, 1939, "ASBESTOS," page 2, for this story.

¶ Asbestos in itself does not have low heat conductivity. Its extensive use for heat insulation is because of its fireproof qualities; the porous structure or aircell content of asbestos insulation materials accounts for their insulation value.

¶ Italy is called the cradle of the Asbestos Industry because the mining of asbestos and the manufacture of its products began on an industrial scale in that country.

¶ Asbestos was found in the Ural District (Russia) between 1710 and 1720.

¶ Asbestos was discovered in Vermont in 1824, but production was first recorded in 1908.

¶ A patent on engine packing using asbestos was granted as early as 1857 to Richard Lloyd, of England.

¶ Insulation containing asbestos was first used in 1866; it was made of asbestos fibre and silicate of soda and was in sectional form.

¶ Great Britain's asbestos manufacturing industry began in 1871 in a factory founded by the Patent Asbestos Manufacture Limited, of Glasgow, Scotland.

¶ The first known attempt to make asbestos paper was in 1765; it was first made in the United States about 1878.

¶ Cape Asbestos Company were the original spinners of crocidolite or blue asbestos—as early as 1895.

¶ Ludwig Hatschek, an Austrian, invented asbestos-cement shingles in 1900; they were introduced into the United States in 1905 by the Keasbey & Mattison Company.

¶ Asbestos-cement pipe was first used for carrying corrosive salt water for street cleaning and fire-fighting in an Italian seacoast town.

¶ Patents on asbestos-cement pipe were granted in Italy in 1913; the manufacture of such pipe began by Eternit Pietra Artificiale in Genoa, Italy, in 1915; it was introduced into the United States by Johns-Manville in 1929 and the first shipment made by J-M in 1930.

¶ Arizona asbestos is important for electrical insulation because of its low iron content.

¶ Crocidolite and Amosite asbestos are highly acid resistant, making them valuable for use in chemical plants.

¶ Amosite asbestos was first spun in England in 1924 by the Cape Asbestos Company. The pioneer in the spinning of Amosite was S. Weingarten, of South Africa, who spun Amosite yarns as early as 1909.

¶ Asbestos was first used in brake lining in 1906.

¶ A capital investment of $22,000,000 is represented in the asbestos mining and milling industry in Canada.

¶ The United States is the largest consumer of asbestos in the world.

ASBESTOS IS FOUND:

The four largest asbestos producing countries are Canada, Russia, Southern Rhodesia (Africa) and the Union of South Africa. Next in importance are the United States, Cyprus, Italy and Finland.

In spite of the fact that asbestos is found in practically all countries, its occurrence in *satisfactory quality and economic quantity* is not common. Altho deposits are continually being reported, there are very few which upon examination are found to warrant the expense necessary for development. The following tabulation forms an index to the varieties of asbestos produced in the various countries or localities.

AFRICA:

Southern Rhodesia (chrysotile of excellent quality).
Swaziland (chrysotile of excellent quality).
Union of South Africa—Transvaal produces amosite, blue and chrysotile. Cape Province produces the well-known Cape Blue exclusively and extensively. Other occurrences of asbestos (chrysotile) have been reported from Natal.

AUSTRIA:

Short fibered amphibole known as "micro-asbestos" used, in combination with concrete or asphalt, for road surfacing.

AUSTRALIA:

Chrysotile of various qualities and lengths is found in Western Australia, South Australia, Queensland and New South Wales. Blue asbestos is found in South Australia; the deposits of blue in Western Australia are being developed at the present time.

CANADA:

Chrysotile variety, found principally in the provinces of Quebec and Ontario. Asbestos Mines in Quebec are the best known in the world. Canadian quality and grading are considered as standard the world over.

CHINA:

Deposits of chrysotile worked to some extent in a number of provinces, the most important being in Chihli (Hopeh) Province and Manchuria.

CYPRUS:

Good quality of chrysotile; most of the production is of "shingle stock" grade or lower.

FINLAND:

Produces fair quantities of short anthophyllite.

INDIA:

Produces both amphibole and chrysotile to some extent. The chrysotile is of excellent quality and low iron content.

ITALY:

Chrysotile of fair grade and tremolite of excellent quality are produced. Mining and manufacture of asbestos on an industrial scale first began in Italy.

RUSSIA:

Very extensive deposits of good grade chrysotile are found in the Ural Mountains and have been extensively developed by the U. S. S. R., altho quite large production was recorded previously.

SOUTH AMERICA:

Deposits of chrysotile in Venezuela are the most important from a commercial standpoint. Other deposits, some chrysotile and some amphibole, are reported in Argentina, Brazil, Chile and Bolivia. Very long blue asbestos, not strong enough for spinning, is found in Bolivia. So far no commercial use has been found for it.

UNITED STATES:

Arizona Mines produce an excellent long fibre chrysotile, valuable for electrical work because of its freedom from iron.

California has deposits of short chrysotile, not being worked to any extent at present. Tremolite asbestos is also being produced in commercial quantities for Gooch Crucible use.

Georgia has been the most consistent producer of amphibole (anthophyllite) asbestos of any of the states. Large deposits are found in Sall Mountain (near Gainesville) and at Hollywood.

Maryland has a deposit of anthophyllite and tremolite, from which filter fibres are made.

Vermont produces good grades of chrysotile ranging from shingle stocks to shorts.

Wyoming, Montana and New York have deposits of good chrysotile asbestos also, but these have not been worked.

Deposits of amphibole (principally anthophyllite) which are being worked to some small extent are found in North Carolina, Idaho, Wyoming, Montana, Oregon and Alaska.

Deposits have also been reported in Maine, New York, Pennsylvania, Virginia, Texas, Michigan, Connecticut, South Carolina, South Dakota, Wisconsin.

OTHER COUNTRIES:

Occurrences of asbestos of various types, principally chrysotile or anthophyllite, have been reported from time to time from Albania, Algeria, Bulgaria, Chosen (Korea), Czechoslovakia, Corsica, Cuba, France, Germany, Ireland, Japan, Mexico, Madagascar, Newfoundland, New Zealand, Philippine Islands, Portugal, Spain, Switzerland, Spitzbergen, Syria, Turkey and Turkish Armenia.

THE USES OF ASBESTOS AND ASBESTOS PRODUCTS

In presenting this list of uses of asbestos and asbestos products, we have included only the basic and more important uses—those which consume the largest volume of asbestos (or the product made therefrom) or those which require small quantities of material but perform a very valuable function.

We have not tried to include in this list the end use of every item, that is the place where the asbestos or asbestos product is used, or the purpose for which it is used, except where that place or purpose is most important, or unique. For instance, asbestos blankets are used for fire fighting in hotels, department stores, laundries, dry cleaning establishments, at airplane hangars, by fire departments; the one designation "Asbestos blankets for fire fighting" covers a multitude of what might be regarded as the "Uses of Asbestos Cloth" if the list were carried out to the *nth* degree.

There are also innumerable uses of asbestos and asbestos products which may be extremely interesting but are unimportant from the viewpoints mentioned. Most of these have been published at some time or other in "ASBESTOS" and a complete list, so far as is known, is kept on file.

As an illustration, a certain actor's pockets were made of asbestos cloth[1], but we do not consider "asbestos pockets" sufficiently important to include in this printed list.

(Several uses have been added in this 2nd Edition.)

—:—

USES OF RAW ASBESTOS

- Yarn
- Thread
- Wick packing
- Rope packing
- Felt
- Paper (plain and corrugated)
- Rollboard
- Millboard
- Insulating wire
- 85% Magnesia pipe covering, blocks and locomotive lagging
- High temperature insulation (moulded) (various types)
- Compressed sheet packing
- Compound for encasing of motor windings
- Moulded composition for electrical and other purposes

[1]See page 18, January, 1930, "ASBESTOS."

(Uses of Raw Asbestos — Continued)

Moulded brake lining and brake blocks
Automobile bodies and railway sleepers (moulded composition)
Filler in Plastics
Flooring
Pottery and sculpture
Asbestos Cement Products, viz:
- Shingles, siding, tile
- Wall tile and flat sheets
- Corrugated roofing and sheathing
- Decorative panels
- Insulated board
- Floor tile backing
- Pipes
- Miscellaneous articles, such as ventilators, flower pots, louvres, etc.

Asbestos cement for insulation of boilers
Roofing cement
Furnace cement
Plaster and stucco
Paints, varnishes and fillers
Sprayed asbestos (acoustical)
Filling for asbestos mattress insulation
Insulation of batteries (loose fibre)
Insulation of walls and floors (loose fibre)
Insulation in underground conduits (loose fibre)
In foundations to resist shock
Packing for explosives or other materials
Wadding in cartridges and timing devices
Filter fibres and filter pads
Platinized asbestos fibre for filtering
Coating for welding rods
In cheese making (on which to place spores)
Pavement in sewer pipe

USES OF ASBESTOS YARN

Cloth
Tape, electrical and other
Brake lining
Clutch facings
Packing—valve stem, braided and other
Gaskets and gasket cloth
Tubing
Wick for oil burning apparatus
Rope
Twine or sewing thread
Stocking for lead cable
Electric fixture wire covering

(Uses of Asbestos Yarn — Continued)

Electric cable covering
Tying gas mantles
For spark plugs
Edges for hair felting

USES OF ASBESTOS CLOTH

Packing—sheet, high pressure, folded or wound
Brake lining, folded and stitched
Clutch facings
Gaskets
Asbestos insulation mattresses
Substitute for canvas on insulation where temperatures are high
Clothing, viz:
- Suits
- Helmets
- Gloves and mittens
- Aprons
- Leggings
- Berets

Tapestry
Hangings for firestops
Blankets for fire fighting
Blankets in electrolyzer cells
Bags and diaphragms (in oxygen producing)
Mailbags
Awnings
Rugs
Theatre curtains
Theatre scenery
Floor lining in theatres
Portable motion picture booths
Motion picture screen
In acoustical treatment
In acetylene welding
Gun grips
Asbestos faced wipers in commutators
Facing for dryer felt
Filtering (fruit juices, acids, etc.)
Filter in dust collectors
Oil filter sack (in automobiles)
Protectors for gas bags in balloons
Oven insulation
Lining in motors
Lining of laboratories, cooling chambers and other rooms
Lining of automobile footboards

(Uses of Asbestos Cloth — Continued)

- Padding for laundry presses and mangles
- Padding prison cells
- Wrapping oil tanks and oil lines in engines
- Umbrellas and shields (protecting firemen)
- In various medical test apparatus
- Sand bags (for pressing hats)
- Conveyor belting
- In hay curing to preserve aroma and color
- In cheese making to control temperature
- Insulation against noise and vibration (especially in airplanes)
- Fittings for airplanes

USES OF ASBESTOS FELT

- In acoustical work
- Protection of underground pipes
- On paper machines
- Noise insulation
- Padding in pianos

USES OF ASBESTOS TAPE

- Wick for oil burning apparatus
- Belts for conveying hot glass or other articles
- Pull strings for ovens
- Insulating locomotive steam pipes at bends, etc.
- Insulating armatures
- Winding coils
- Winding buss bars
- Insulating underground cables
- Laboratory uses, such as insulation for flasks, test tubes, retorts; tie straps in diffusing materials
- In glass manufacture for wrapping tines of forks to take bottles from ovens; reinforcing paddles for stirring molten glass

USES OF WICK PACKING

- As packing
- For wiping of wire, armor plate or galvanized materials

USES OF ASBESTOS PAPER

- Air cell and other pipe coverings
- Boiler jackets
- Asbestos felt roofing
- Asbestos built-up roofing
- Asbestos protected metal roofing
- Gaskets, plain and metallic
- Wick in oil burning apparatus
- Tubes in electrical industry
- Wrapping of electrical wire
- Wrapping of hot air pipes
- Linings of
    - Stoves
    - Heaters

(Uses of Asbestos Paper — Continued)

Linings of
- Filing cabinets
- Cartridges
- Soldiers' helmets
- Carpets
- Auto mufflers
- Radiator covers
- Drum controllers
- Cookers
- Electric appliances
- Armored car roofs
- Auto floorboards

In enameling ovens to catch drip
Insulation of ovens and dry kilns
Diaphragm in electrolytic cell
Tank covers
Reinforcing aluminum foil for insulation
Filtering
In window glass machinery to guide hot sheets; to shield hot glass from flying fragments
In welding and other processes for protection from heat
In annealing (crumbled paper)
In chemistry and physics in many various ways
Reinforced with cotton thread for automobile tops
Covering of rockwool blankets which must be sewed
Wrapping of wires and cables
Insulating exhausts on automobiles
Baking sheets
Table pads and mats
Construction of air ducts or lining of paper ducts

USES OF ASBESTOS MILLBOARD

Linings of
- Stoves and heaters
- Safes
- Garages
- Motion picture booths
- Electric switch boxes
- Dry cleaning machines
- Garbage incinerators
- Hoods of automobiles
- Bottoms of brooder stoves
- Ovens and dry kilns

As fireproof wallboard
Ceiling over boilers, smoke stacks, etc., for fire protection
Gaskets, plain and metallic

(Uses of Asbestos Millboard — Continued)

Paddles in glass mills
Washers in electrical apparatus
Tent shields and stove pipe rings
In metal clad doors (between outside metal and wood core)
Table pads and mats
Stove mats

USES OF ASBESTOS-CEMENT FLAT SHEETS AND WALLBOARD

Interior sheathing (of factories, refrigerator rooms, etc.)
Partitions, movable and fixed
Exterior sheathing (half-timber effect)
Brick-type siding
Portable buildings
Roofs and sides of small buildings
Semi-portable motion picture booths
Fireproof layer on insulated board
Fire protection around engines
Lining of fireless cookers
Backing for dies (in moulding glass)
Brake shoes for elevators
Hoods over machines or vats (from which vapor rises)
Mounting of test instruments and gauges
Laboratory table tops
Switch boards
Cabinets and panel box work
Insulators between phases and on arc deflectors
Electric motor casings
Spark arresters
Miscellaneous uses in electrical apparatus
Lining for bleaching and other tanks and vats
Backgrounds and cut-outs for window displays
Blackout or bombproof board

USES OF ASBESTOS CEMENT PIPES

For carrying of water, sewage, gas and special liquids
As gas vent pipes
Conduits for electric light wires, etc.
Purlins, rafters, trusses, etc., for wartime buildings

USES OF ASBESTOS COMPOSITION MATERIAL

Insulation compounds
Heater cord insulation
Electric wire insulation
Lamp sockets, rheostat backings, switch parts, arc deflectors, resistance mountings and other electrical uses

[1]Of many types.

(Uses of Asbestos Composition Material — Continued)

Underground insulation
Flooring
Phonograph records, buttons and other small objects made of plastic
Sealing of percussion caps in large cells

USES OF VARIOUS ASBESTOS PRODUCTS IN MOVIES

To localize fires in location
To protect nearby buildings when fires are set
For wall sections in sets to prevent reverberations
Firebox in fireplaces
Insulation of camera booths against sound
Blinders or ears for lights or sun arcs
Dressing winter scenes as snow
Dust on cobwebs, old wine kegs, etc.
Noise insulation
Insulation for maintaining even temperature

•

TYPICAL ANALYSES

	Chrysotile[1]	Blue	Amosite
Silica (SiO_2)	39.05	51.1	50.24
Alumina (Al_2O_3)	3.67	...	....
Ferric oxide (Fe_2O_3)	2.41	...	7.80
Ferrous oxide (FeO)		35.8	32.00
Magnesia (MgO)	40.07	2.3	3.96
Lime (CaO)	....	....	....
Sodium oxide (Na_2O)	....	6.9	2.12
Combined water (H_2O)	14.48	3.9	3.00
	99.68	100.0	99.12

[1]Canadian (Thetford)

QUALITIES OF ASBESTOS

Durability — Resists	Weather Corrosion Fire Heat Acid Vermin Fungi-growth
Insulates against	Vibration Electricity Sound
Binds	Fillers Magnesia Cement Rubber
Filters	Acids Alkalies
Attracts	Sludge Dust

Printed in the United States
Price — 10c per copy

PART – III

AMOSITE & CHRYSOTILE ASBESTOS

01 040 1367

SECTION- 9

ASBESTOS, A MINERAL OF UNPARALLED PROPERTIES

01 040 1368

SECTION 9 -- ASBESTOS, A MINERAL OF UNPARALLELED PROPERTIES

Section 9 contains concise information on:

A. Properties of asbestos fibers.

B. Solubility of Asbestos.

1. Chrysotile is readily attacked by acids.
2. Amphibole is fairly acid resistant.

C. Effect of heat on asbestos.

1. Chrysotile shows small ignition losses below 700° F and a rapid increase in loss at 1000° F and above.
2. Amphiboles show small ignition losses since they contain only small percentages of water of crystallization.

D. Effect of heat on tensile strength.

1. High temperatures and lengths of exposure decrease the strength of chrysotile fibers. At temperatures above 1000° F, the strength decreases rapidly.

E. Comparison of surface area of fibers.

F. Comparison of fiber diameters.

G. Photomicrographs of chrysotile.

1. Harsh chrysotile fibers.
2. Semi-harsh chrysotile fibers.
   (a) The harsh fiber has a straight or needle like structure.
3. Soft chrysotile fiber.
   (a) The soft, silky, chrysotile fiber is wavy.

H. Electron micrographs of asbestos.

1. Chrysotile from Arizona.
2. Amosite from South Africa.
3. Anthophyllite from Georgia.
4. Crocidolite Blue from South Africa.
5. Crocidolite Blue from Bolivia.
6. Tremolite from California.
7. Actinolite from Canada.

Asbestos, A Mineral of Unparalleled Properties

By M. S. BADOLLET*

(Annual General Meeting, Quebec City, Que., April, 1951)
(Transactions, Volume LIV, 1951, pp. 151-160)

Introduction

THE DEMAND for general knowledge on asbestos fibres has increased considerably in recent years. A few publications have printed data showing some of the physical and chemical properties of asbestos, but in many cases this information is difficult to find and is seldom available when needed.

During the past ten years, Johns-Manville have received many inquiries on the physical and chemical properties of asbestos fibres. Fortunately, we had some of the information in our files, and we willingly supplied the data.

To help relieve this need, we have tried to present briefly in this paper some of the interesting and outstanding properties of asbestos. This information was obtained over a period of years by search of the literature and by experimental investigations.

Properties of Asbestos Fibres

Table I (1, 2) presents, in convenient form for easy comparison, data on the principal properties of the several varieties of commercial 'asbestos' — actinolite, amosite, anthophyllite, chrysotile, crocidolite, and tremolite. Under each variety of fibre is a brief statement describing the properties in terms of structure, mineral association, origin, etc. Some of the more important data in Table I are expanded and presented in Table II (3).

Solubility of Asbestos

A report (4, 5) discussing the effects of acids and caustic on asbestos fibres was published in Germany in 1927. Re-published several times, it appears to be the only information available on the subject.

When, several years ago, it became necessary to obtain technical data, not available in the literature, on the solubility of commercial grades of asbestos, tests were arranged following the plan adopted by the author of the original article (4).

Samples were obtained of actinolite from Canada, amosite from Africa, anthophyllite from Georgia, chrysotile from Canada, crocidolite from Africa, and tremolite from California. These samples represented fibres obtainable in commercial quantities. They contained some mineral impurities and thus their degree of solubility was not identical with that of hand-picked, high-grade crudes from these localities.

The acids used in these tests were hydrochloric, acetic, phosphoric, and sulphuric. All were diluted to a 25 per cent acid solution, by weight.

*Research Center, Johns-Manville Corporation, Manville, N.J.
(1) For references, see end of paper.

TABLE II.— PHYSICAL PROPERTIES OF ASBESTOS

	CHRYSOTILE	AMOSITE	ANTHOPHYLLITE	CROCIDOLITE	TREMOLITE	ACTINOLITE
Specific heat B.t.u./lb./°F.	0.266	0.193	0.210	0.201	0.212	0.217
Tensile strength, lb./sq. in.	80,000 100,000	16,000 90,000	4,000 & less	100,000 300,000	1,000 8,000	1,000 & less
Temp. at max. ignition loss, °F.	1,800	1,600 to 1,800	1,300	1,200	1,800	——
Filtration properties	Slow	Fast	Medium	Fast	Medium	Medium
Electric charge	Pos.	Neg.	Neg.	Neg.	Neg.	Neg.
Fusion point, °F.	2,770	2,550	2,675	2,180	2,400	2,540
Spinnability	Very good	Fair	Poor	Fair	Poor	Poor
Resistance to acids & alkalies	Poor	Good	Very good	Good	Good	Fair
Magnetite content	0-5.2	0	0	3.0-5.9	0	——
Mineral impurities present	Iron, chrome, nickel, lime	Iron	Iron	Iron	Lime	Lime, iron
Flexibility	High	Good	Poor	Good	Poor	Poor
Resistance to heat	Good, Brittle at high temp.	Good, Brittle at high temp.	Very good	Poor, fuses	Fair to good	——
Ionizable salts, micro-mhos (Relative elec. conductance)	1.82	1.34	0.58	0.84	——	——
Colour	Green, grey to white	Yellowish-brown	Yellowish-brown, Sometimes almost white	Blue	White	Greenish

TABLE I.- PROPERTIES OF ASBESTOS FIBRES

	ACTINOLITE	AMOSITE (FERRO ANTHOPHYLLITE)	ANTHOPHYLLITE	CHRYSOTILE	CROCIDOLITE	TREMOLITE
STRUCTURE	RETICULATED LONG PRISMATIC CRYSTALS AND FIBRES	LAMELLAR, COARSE TO FINE FIBROUS AND ASBESTIFORM	LAMELLAR, FIBROUS ASBESTIFORM	IN VEINS OF SERPENTINE, ETC.	FIBROUS IN IRON STONES	LONG, PRISMATIC AND FIBROUS AGGREGATES
MINERAL ASSOCIATION	IN LIMESTONE AND IN CRYSTALLINE SCHISTS	IN CRYSTALLINE SCHISTS ETC.	IN CRYSTALLINE SCHISTS AND GNEISSES	IN ALTERED PERIDOTITE ADJACENT TO SERPENTINE & LIMESTONE NEAR CONTACT WITH BASIC IGNEOUS ROCKS	IRON RICH SILICIOUS ARGILLITE IN QUARTZOSE SCHISTS	IN MG LIMESTONES AS ALTERATION PROD. OF HIGHLY MAGNESIAN ROCKS. METAMORPHIC AND [illegible]LOUS ROCKS.
ORIGIN	RESULTS OF CONTACT METAMORPHISM	METAMORPHIC	METAMORPHIC, USUALLY FROM OLIVINE	ALTERATION & METAMORPHISM OF BASIC IGNEOUS ROCKS RICH IN MAGNESIAN SILICATE	REGIONAL METAMORPHISM	METAMORPHIC
VEINING	SLIP OR MASS FIBRE	CROSS FIBRE	SLIP, MASS FIBRE UNORIENTED AND INTERLACING	CROSS AND SLIP FIBRES	CROSS FIBRE	SLIP OR MASS FIBRE
ESSENTIAL COMPOSITION	CA, MG, FE, SILICATE WATER UP TO 5%	SILICATE OF FE AND MG HIGHER IRON THAN ANTHOPHYLLITE	MG SILICATE WITH IRON	HYDROUS SILICATES OF MAGNESIA	SILICATE OF NA AND FE WITH SOME WATER	CA & MG SILICATE WITH SOME WATER
THEORETICAL FORMULA	$Ca(Mg.Fe)_3(SiO_3)_4 \times H_2O$	$(Fe.Mg)SiO_3$ 1.5% H_2O	$(Mg.Fe)_7Si_8O_{22}(OH)_2$	$3MgO.\ 2SiO_2 2H_2O$	$Na\ Fe\ (SiO_3)_2 FeSiO_3 \times H_2O$	$Ca_2Mg_5Si_8O_{22}(OH)_2$
CRYSTAL STRUCTURE	LONG & THIN COLUMNAR TO FIBROUS	PRISMATIC, LAMELLAR TO FIBROUS	PRISMATIC, LAMELLAR TO FIBROUS	FIBROUS AND ASBESTIFORM	FIBROUS	LONG & THIN COLUMNAR TO FIBROUS
CRYSTAL SYSTEM	MONOCLINIC	ORTHORHOMBIC *	ORTHORHOMBIC	MONOCLINIC (PSEUDO-ORTHORHOMBIC?)	MONOCLINIC	MONOCLINIC
COLOR	GREENISH	ASH GRAY, GREENISH, OR BROWN	GRAYISH WHITE, BROWN, GRAY OR GREEN	WHITE, GRAY, GREEN, YELLOWISH	LAVENDER, BLUE, GREENISH	GRAY-WHITE, GREENISH, YELLOWISH, BLUISH
LUSTRE	SILKY	VITREOUS, SOMEWHAT PEARLY	VITREOUS TO PEARLY	SILKY	SILKY TO DULL	SILKY
HARDNESS	6±	5.5—6.0	5.5—6.0	2.5—4.0	4	5.5
SPECIFIC GRAVITY	3.0—3.2	3.1—3.25	2.85—3.1	2.4—2.6	3.2—3.3	2.9—3.2
CLEAVAGE	110 PERFECT	110 PERFECT	110 PERFECT	010 PERFECT	110 PERFECT	110 PERFECT
OPTICAL PROPERTIES	BIAXIAL NEGATIVE EXTINCTION INCLINED	BIAXIAL & POSITIVE EXTINCTION PARALLEL	BIAXIAL POSITIVE EXTINCTION PARALLEL	BIAXIAL POSITIVE EXTINCTION PARALLEL	BIAXIAL ± EXTINCTION INCLINED	BIAXIAL NEGATIVE EXTINCTION INCLINED
REFRACTIVE INDEX	1.63± WEAKLY PLEOCHROIC	1.64±	1.61±	1.50 — 1.55	1.7 PLEOCHROIC	1.61±
FUSIBILITY	FUSIBLE AT 4	FUSIBLE AT 6; LOSES WATER AT MODERATE TEMPERATURES	INFUSIBLE OR DIFFICULTLY FUSIBLE	FUSIBLE AT 6	FUSIBLE AT 3	FUSIBLE AT 4
FLEXIBILITY	BRITTLE AND NONFLEXIBLE	GOOD, LESS THAN CRYSOTILE	VERY BRITTLE, NON-FLEXIBLE	VERY FLEXIBLE	FAIR TO GOOD	GENERALLY BRITTLE, SOMETIMES FLEXIBLE
LENGTH	SHORT TO LONG	2" TO 11" VARIES	SHORT	SHORT TO LONG	SHORT TO LONG	SHORT TO LONG
TEXTURE	HARSH	COARSE BUT SOMEWHAT PLIABLE	HARSH	SOFT TO HARSH, ALSO SILKY	SOFT TO HARSH	GENERALLY HARSH, SOMETIMES SOFT
TENSILE STRENGTH	VERY WEAK	FAIR, LESS THAN CHRYSOTILE	VERY WEAK	VERY GOOD	VERY GOOD. HIGHEST OF ALL VARIETIES	WEAK.
ACID RESISTANCE	RELATIVELY INSOLUBLE IN HCl	FAIRLY RESISTANT TO ACIDS	FAIRLY RESISTANT TO ACIDS	SOLUBLE UP TO APPROXIMATELY 57%.	FAIRLY RESISTANT TO ACIDS	FAIRLY RESISTANT TO ACIDS
SPINNABILITY	POOR	FAIR	POOR	BEST	FAIR	GENERALLY POOR. SOME ARE SPINNABLE

* Recent studies claim the crystal structure is monoclinic.

[illegible] per cent [illegible], by weight.

Each fibre sample, consisting of 10 grams, was accurately weighed and placed in a flask containing 500 c.c. of the 25 per cent acid or caustic solution.

Two sets of tests were conducted, one at room temperature (26°C.) for indefinite periods, the other at boiling temperature in a reflux condenser for two hours. At the end of each test, the fibres were removed from the solutions, washed free from acids or caustic, dried, and weighed.

Table III shows the solubilities of these particular asbestos fibres in the four acids used and in caustic soda.

The action of boiling acids on asbestos fibres is severe, with chrysotile the most soluble. Acetic acid was not so effective as the mineral acids in dissolving chrysotile, and caustic had even less action on this mineral.

After chrysotile fibres had lost 55 per cent of their weight, examination showed the fibre structure to be almost all silica, brittle, and very fragile.

The high solubility values for actinolite are, it is believed, due to the presence of soluble minerals as impurities in the commercial product used by industry.

Anthophyllite seemed to resist acid action better than any other variety, with crocidolite second best, tremolite third, and amosite fourth.

All these solubilities would vary depending upon the source of the fibre and whether the samples represented pieces of 'crudes', or milled fibres as purchased on the market.

The action of acids and caustic at room temperature is slower than at boiling temperatures, but if the fibres are kept immersed in the solvent for a sufficient length of time, the solubilities finally reach the values obtained at boiling temperatures.

The tests at room temperature were conducted for periods of 24 hours, 192 hours, 360 hours, and 528 hours. After each time period, the fibres were removed, washed, and weighed, and the solubility calculated. The fibres were then replaced in fresh solutions of acid or caustic to begin the next cycle.

For convenience, only the solubility data for 528 hours are given in Table III since at this point most of the fibres apparently reached their maximum solubility, and this was approximately equal to the solubility after a two-hour treatment in boiling acids or caustic.

Such information is invaluable to a manufacturer desiring to produce an asbestos product which will be exposed to conditions similar to those in the tests. The most resistant fibre, if available in commercial quantities, naturally will be selected for the product.

	HCl	CH_3COOH	H_3PO_4	H_2SO_4	NaOH
Actinolite	20.31	12.22	20.19	20.33	9.25
Amosite	12.84	2.63	11.67	11.35	6.97
Anthophyllite	2.66	0.60	3.16	2.73	1.22
Chrysotile	55.69	23.42	55.18	55.75	0.99
Crocidolite	4.38	0.91	4.37	3.69	1.35
Tremolite	4.77	1.99	4.99	4.58	1.60

Per Cent Loss in Weight. Room Temperature 26°C. for 528 Hours
25% Acid or Caustic

	HCl	CH_3COOH	H_3PO_4	H_2SO_4	NaOH
Actinolite	22.55	12.14	20.10	20.60	9.43
Amosite	12.00	3.08	11.83	11.71	6.32
Anthophyllite	2.13	1.04	3.29	2.90	1.77
Chrysotile	56.00	24.04	56.45	56.00	1.03
Crocidolite	3.14	1.02	3.91	3.48	1.20
Tremolite	4.22	1.41	4.89	4.74	1.65

Effect of Heat on Asbestos

Since asbestos fibres frequently are exposed to elevated temperatures, it is necessary to determine which fibre most satisfactorily meets the demands.

With this in mind, the same fibres as used in the solubility tests were subjected to two hours' exposure at temperatures varying from 400°F. to 1,800°F., and the weight loss measured. The samples, after drying to eliminate surface moisture, were

Table IV.— Effect of Temperature on Loss in Weight of Asbestos Fibres

Temp. °F.	Time	Loss in Weight				
		Amosite %	Anthophyllite %	Chrysotile %	Crocidolite %	Tremolite %
400	2 hr.	0.23	0.05	0.30	0.08	0.04
600	"	0.57	0.24	0.85	0.25	0.08
700	"	0.80	0.30	1.73	0.49	0.13
800	"	0.98	0.38	2.17	0.73	0.22
900	"	1.07	0.41	2.53	0.83	0.26
1,000	"	1.16	0.44	3.99	0.85	0.29
1,100	"	1.36	0.52	10.33	1.00	0.37
1,200	"	1.39	0.54	12.73	1.04	0.37
1,400	"	1.43	0.54	13.43	1.03	0.47
1,500	"	—	0.64	—	—	0.56
1,600	"	1.52	1.12	13.62	0.93*	0.67
[illegible]	"	—	1.73	—	—	1.40
1,800	"	1.53	2.39	13.77	0.77*	2.18

*Iron changing in weight due to oxidation.

01 040 1372

weighed, placed in a muffle where temperature was maintained automatically, removed after a two-hour exposure, cooled to room temperature in a desiccator, and re-weighed. The percentages of loss in weight are presented in Table IV.

Generally speaking, the amphibole fibres such as anthophyllite and tremolite resisted the heat fairly well at temperatures below 700°F. The chrysotile fibre, on the other hand, began to show a suddenly increased weight loss at 700°F., and a rapid increase above 1,000°F.

At higher temperatures, all fibres began to change in physical characteristics, but the amphiboles did not disintegrate so rapidly as the chrysotile fibres. The crocidolite fibre at 1,600°F. and higher showed a definite oxidation of iron and became brittle.

Chemical analysis of chrysotile fibres showed that the ignition loss values varied with the mineral impurity present. Therefore, it was decided to determine the nature of these impurities and their effect on ignition loss values.

A series of chrysotile asbestos fibres from Arizona, Australia, Rhodesia, Russia, and Canada were selected. These fibres were individually tested by placing a sample in an ultimate analysis train, with heating units electrically controlled.

The air taken into the combustion chamber was dried by passing it through sulphuric acid and absorbing the water and carbon dioxide with magnesium perchlorate, $Mg(ClO_4)_2$, and ascarite.

The temperature of the combustion unit was accurately determined by a chromelalumel thermocouple connected on one end to a potentiometer, and on the other to the side of the asbestos sample in the combustion tube.

Any gases, such as water and carbon dioxide, driven off the asbestos sample were weighed after being recovered in a second absorbing train containing $Mg(ClO_4)_2$ and ascarite in two different *U* tubes.

Prior to the test, the combustion train was purged for half an hour at 220°F. with dry air. Then the temperature was raised by 1,000°F. and the absorbed gases weighed. Later, the test was repeated by raising the temperatures to 1,800°F. and weighing the absorbed gases.

The data shown in Table V give the percentages of water and carbon dioxide driven off each fibre at the two temperatures.

The Arizona fibre had a high ignition loss at 1,800°F. This loss consisted of 12.89 per cent water and 1.91 per cent carbon dioxide. At 1,000°F., 0.54 per cent carbon dioxide was expelled from the sample. Calculated as $MgCO_3$, this indicates the presence of 1.03 per cent $MgCO_3$. As the temperature was raised to 1,800°F., additional quantities of carbon dioxide were driven off, which, assumed as having been combined with CaO, would represent 3.11 per cent $CaCO_3$, indicating that the Arizona fibre tested contained a high percentage of calcium carbonate.

These calculations of CO_2 as representing $MgCO_3$ and $CaCO_3$, respectively, are based upon the dissociation temperatures of these compounds. Magnesium carbonate dissociates at temperatures below 1,000°F., and calcium carbonate at a temperature of approximately 1,630°F.; a temperature of 1,800°F. for one hour, therefore, should be sufficient to drive off all the CO_2.

The Australian fibre contained 12.48 per cent H_2O and 0.96 per cent CO_2; loss in weight on ignition was 13.33 per cent. Recalculation of the carbon dioxide as carbonates indicated that this fibre contained 1.26 per cent $MgCO_3$ and 0.68 per cent $CaCO_3$ as impurities.

The Canadian fibre identified as *"A"* shows a water content of 14.23 per cent, which is higher than the theoretical amount of water in the asbestos molecule. X-ray diffraction patterns of this fibre show the presence of brucite, $Mg(OH)_2$, which would break down and produce water during the heating period, accounting for the high water content of the fibre. The magnesium carbonate is calculated at 1.62 per cent and calcium carbonate at 0.27 per cent.

The Rhodesian fibre contained a much higher percentage of magnesium carbonate than any of the other fibres tested — 4.85 per cent. The calculated amount of calcium carbonate is 0.79 per cent.

The Canadian fibre identified as *"B"* resembles the *"A"* sample in having a water content higher than that of pure serpentine, and here again the X-ray diffraction pattern showed the presence of admixed brucite. The magnesium carbonate content was calculated to be 0.86 per cent, and calcium carbonate, 0.07 per cent.

The Russian fibre is a harsh chrysotile having a low water content (11.74 per cent at 1,800°F.). The presence of 1.47 per cent mag-

TABLE V.— COMBUSTION ANALYSIS OF CHRYSOTILE ASBESTOS

Source of Fibre	Temperature °F.	Per Cent H_2O	Per Cent CO_2	Total Per Cent H_2O+CO_2	Per Cent Ignition Loss of Fibre	Carbon Dioxide Calculated in Terms of Percentage of	
						$MgCO_3$	$CaCO_3$
Arizona............	1,000	3.37	0.54	3.91	3.87	1.03	
"	1,800	12.89	1.91	14.80	14.80	1.03	3.11
Australian..........	1,000	1.50	0.66	2.16	2.06	1.26	
"	1,800	12.48	0.96	13.44	13.33	1.26	0.68
Canadian (A).......	1,000	5.47	0.85	6.32	6.23	1.62	
"	1,800	14.23	0.97	15.25	15.17	1.62	0.27
Rhodesian..........	1,000	1.82	2.54	4.36	4.28	4.85	
"	1,800	12.00	2.89	14.89	14.84	4.85	0.79
Canadian (B).......	1,000	3.75	0.45	4.20	4.14	0.86	
"	1,800	13.31	0.48	13.79	13.75	0.86	0.07
Russian...........	1,000	1.98	0.77	2.75	[illegible]	1.47	
"	1,800	11.74	1.06	12.80	[illegible]	1.47	0.66
Canadian (C).......	1,000	2.25	[illegible]	2.72	2.66	0.90	
"	1,800	11.93	[illegible]	12.44	12.40	0.90	0.09

01 040 1373

nesium carbonate and 0.66 per cent calcium carbonate was indicated.

Canadian fibre identified as "C" is a semi-harsh fibre with a low water content (11.93 per cent). The total amount of CO_2 driven off is small and is calculated as representing 0.90 per cent $MgCO_3$ and 0.09 per cent $CaCO_3$.

From these data it can be seen how readily ordinary ignition-loss figures can be misunderstood if the presence of mineral impurity is not taken into account. For example, most ignition-loss tests on chrysotile asbestos are made to determine molecular water content. If the fibre contains impurities such as brucite, magnesium carbonate, or calcium carbonate, an error is introduced into the calculations and the fibre is shown to have an ignition loss greater than the theoretical quantity of molecular water. This could be a serious error in determining the asbestos content of an asbestos textile, from which the organic fibre is burned purposely and a correction factor is applied for the molecular water content of the asbestos.

Effect of Heat on Tensile Strength

A piece of Canadian crude was set aside and a number of small fibre bundles, approximating 20 to 30 microns in cross-section, were selected and heat-treated at different temperatures in an automatic controlled muffle.

The original fibre bundles had a tensile strength of 131,000 lb./sq. in.

Four sets of fibre bundles were heated for 3-minute periods at temperatures of 600°F., 800°F., 1,000°F., and 1,200°F. The effects on the tensile strengths of the fibres are shown in Table VI.

Table VI.— Effect of Heat on Tensile Strength of Canadian Chrysotile Crude

	Tensile Strength (lb./sq. in.)	Per Cent of Original Tensile Strength
Original crude—No heat	131,000	—
Heated 3 min. at 600°F.	120,000	91.6
" " " " 800°F.	96,000	73.3
" " " " 1,000°F.	78,000	59.5
" " " " 1,200°F.	42,000	32.0

At temperatures higher than 1,200°F., the fibre bundles were too brittle to handle and were considered rather weak.

The same fibre, when heated for one hour at the temperature stated, had a tensile strength as follows: 400°F., 129,000 lb./sq. in.; 600°F., 100,000 lb./sq. in.; 1,200°F., less than 2,000 lb./sq. in.

These data show that temperatures and times of exposure affect the tensile strength of chrysotile fibres, especially at 1,000°F. and higher, where the strength begins to decrease rapidly.

Tensile Strengths of Various Materials

Reference has been made on several occasions to the fact that asbestos fibres are strong. As an interesting comparison, data have been selected showing the approximate tensile strengths of such materials as iron, steel, cotton, rock wool, glass, and several varieties of asbestos.

Table VII.— Comparison of Tensile Strengths of Various Materials

Type of Material	Tensile Strength (Lb./Sq. In.)
Ingot iron	45,000
Wrought iron	48,000
Carbon steel	155,000
Ni-Cr steel	243,000
Piano steel wire	300,000
Cotton fibre	73,000 to 89,000
Rock wool	60,000
Glass fibre	100,000 to 200,000
Chrysotile asbestos	80,000 to 100,000
Crocidolite asbestos	100,000 to 300,000
Amosite asbestos	16,000 to 90,000
Tremolite asbestos	1,000 to 8,000

The values given in Table VII are approximate and are cited solely for the purpose of illustrating the comparative strengths of some materials used in industry. It will be noted that chrysotile and crocidolite asbestos fibres are exceptionally strong and are comparable in that respect to glass and to some grades of steel.

The tensile strength values for the asbestos fibres are based upon breaking loads applied to fibre bundles measuring approximately 20 microns in cross-section.

Comparison of Surface Area of Fibres

It is a recognized fact that asbestos fibres appear as bundles consisting of many thousands of individual fibrils not visible to the eye. This would indicate that asbestos should have a great surface area when fully opened.

Table VIII.— Comparison of the Surface Area of Various Fibres

Type of Fibre	Surface-Area by N_2 Adsorption (Sq. Cm./Gram)
Nylon	3,100
Acetate rayon	3,800
Cotton	7,200
Silk	7,600
Wool	9,600
Viscose rayon	9,800
Asbestos (Chrysotile)	130,000 to 220,000

The data in Table VIII show the surface areas of nylon, rayon, cotton, silk, wool, and chrysotile asbestos. The values for asbestos are so large in comparison with the other fibres tested that it seems hardly possible that they could have such great surface area.

The large surface area value of asbestos is a very important factor. It gives wide coverage and at the same time furnishes strength to asbestos products.

Comparison of Fibre Diameters

The approximate diameter of fibres of various types has been measured and recalculated in terms of the number of fibres or fibrils required to equal one linear inch. The results are interesting and they show that a very large number of asbestos fibrils is required to make a linear inch. Table IX gives approximate data for fibres of hair, ramie, wool, cotton, rayon, nylon, glass, rock wool, and asbestos. The extremely small cross-section of asbestos fibres as compared with others will be noted.

TABLE IX.— COMPARISON OF APPROXIMATE FIBRE DIAMETERS

TYPE OF FIBRE	FIBRE DIAMETER IN INCHES	FIBRILS IN ONE LINEAR INCH
Human hair	0.00158	630
Ramie	0.000985	1,015
Wool	0.0008 to 0.0011	910 to 1,250
Cotton	0.0004	2,500
Rayons	0.0003	3,300
Nylon	0.0003	3,300
Glass	0.00026	3,840
Rock wool	0.000142 to 0.000284	3,520 to 7,040
Asbestos (Chrysotile)	0.000000706 to 0.00000118	850,000 to 1,400,000

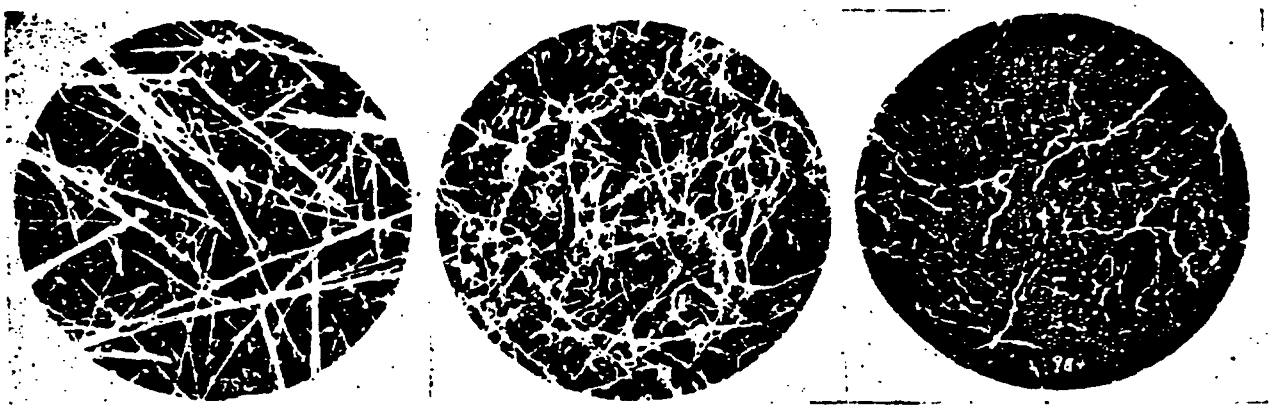
method of investigation is of considerable interest.

On a number of occasions we have had the opportunity of examining asbestos fibre under the electron microscope through the courtesy and co-operation of Dr. James Hillier*. The several varieties of fibres studied and discussed in this paper were submitted to the RCA Laboratory to be photographed at two different magnifications to show the structure of the fibrils.

Chrysotile

The soft Arizona chrysotile at a 4,000 magnification shows fibre bundles which appear wavy with frayed ends (see Figure 2)‡.

The same fibre at a magnification of 35,000 shows bundles in which the



Harsh type — Semi-harsh type — Soft type

Figure 1.—Photomicrographs of chrysotile asbestos. x 100.

fibres appear as hollow tubes (Figure 3). This feature was first reported by Dr. Hillier in April, 1949 (6), using a magnification of 94,000, and it has since been reported by Bates, Sand, and Mink (7), of Pennsylvania State College. Our measurement of the thin fibrils indicated a cross-section in the range of 214 to 284 A† units, while Dr. Hillier reported fibril diameters of 180 A units. This would account for the fact that soft chrysotile fibres have large surface areas and show a preference to open lengthwise if properly fiberized.

PHOTOMICROGRAPHS OF CHRYSOTILE

Three samples of chrysotile were selected, representing three different degrees of texture. Each of these three fibres, mounted on a cover glass, was placed under a microscope and photographed at 100 magnifications. They are shown in Figure 1.

The *harsh* chrysotile fibre at this magnification resembles the structure of splinters and has a needle-like structure. The fibres are springy, bulky, fast-filtering, and usually not so high in tensile strength as soft, silky fibres. This type of fibre will break quickly under flexing action.

The *semi-harsh* fibre appears partially as a harsh, and partially as a soft, fibre. The fibres have lost most of the needle-like structure and appear as thick, wavy bundles. It is difficult to show in a picture that they are different from soft fibres. Chemically, they are the same as the latter, but the measurements show quite different physical properties. Such physical tests as filtration, willowing, surface area, bulk, and strength will bring out the true properties of this fibre and show how it differs from the soft, silky chrysotile.

The *soft* fibres appear as thin threads which are very soft, not bulky, slow-filtering, and extremely strong. As noted above, they have the same chemical composition as the semi-harsh fibres, but quite different physical characters.

The soft, silky chrysotile fibres make up the bulk of asbestos used in industry. They are available in large quantity and usually are cheaper than the semi-harsh or harsh fibres.

ELECTRON MICROGRAPHS OF ASBESTOS

The electron microscope is a valuable tool for examining materials which are difficult to see by ordinary microscopic means. Since asbestos exists in thin cross-sections, this

Amosite

The amosite from South Africa, at a magnification of 4,000, shows

*RCA Laboratories, Princeton, N.J.
‡In this and all succeeding Figures showing electron micrographs, the magnification has been reduced from that stated in the text. The caption below each Figure gives the magnification as thus reduced.
†Angstrom.

Figure 2.—Electro micrograph, chrysotile asbestos. x 1,733.

Figure 3.—Electron micrograph, chrysotile asbestos. x 15,200.

straight bundles criss-crossing the field (Figure 4).

The same fibre at 35.000 magnification shows rather thick bundles that still remain straight and indicate a plane of cleavage that is clean-cut and abrupt (Figure 5). Whenever a small fibril is split from a small bundle, its cross-section appears to be approximately 300 A units. However, only a few small bundles appear in this picture. while chrysotile fibre, on the other hand, apparently breaks down lengthwise easily and shows numerous small fibrils within the range of 300 A units and less.

The fact that amosite fibre tends to remain as large, thick bundles may well account for its freeness in filtration, small surface area, and bulky appearance.

Anthophyllite

At a 4,000 magnification, anthophyllite fibres appear as a mixture of thick and thin bundles which show clean, even breaks at the ends (Figure 6).

At a 35.000 magnification, some fibrils appear thin and flexible while others are stubby, thick bundles (Figure 7). The cross-section of the thin flexible fibrils is equal to, and possibly smaller than, that of chrysotile fibrils, placing them at approximately 200 A units. It is to be noted that no hollow-tube structure appears within these thin fibrils.

This particular sample of anthophyllite is soft, not strong, and breaks easily during processing.

The mineral impurities in the fibre are visible as plates in the electron micrographs.

This fibre is found in Georgia as a mass fibre, and considerable nonfibrous material is associated with the recovered fibre.

Crocidolite

The crocidolite used in this investigation was the typical blue fibre from South Africa.

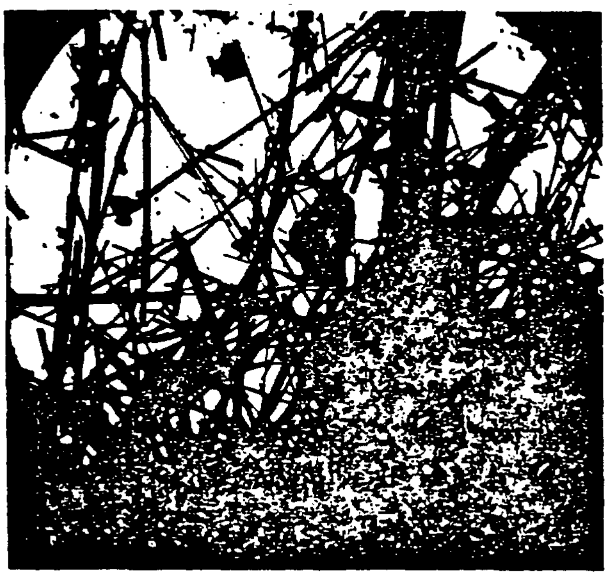


Figure 4.—Electron micrograph, amosite asbestos. x 1,733.

Figure 5.—Electron micrograph, amosite asbestos. x 15,200.

Figure 6.—Electron micrograph, anthophyllite asbestos. x 1,733.

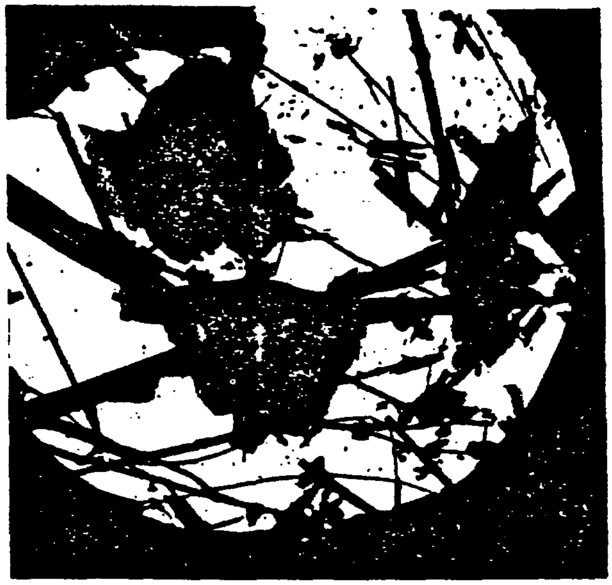


Figure 7.—Electron micrograph, anthophyllite asbestos. x 15,200.

At a 4,000 magnification, the fibre appears as straight, stiff, brittle bundles, and in most cases the ends show clean breaks (Figure 8).

At a 35,000 magnification, the bundles appear fairly thick, but there is evidence that slender fibrils of approximately 300 A units exist (Figure 9), though they are few and far apart. The brittle nature of the fibre probably prevents individual fibrils from splitting off lengthwise, and consequently all that is seen is the large bundles.

Bolivian Blue.

Bolivian blue asbestos is a type of crocidolite fibre which differs somewhat from normal African crocidolite in chemical composition. It is a soft, silky fibre, not very strong and easily pulverized.

At a 4,000 magnification the fibre bundles are clean, tightly bound, and show evidence of brittleness (Figure 10).

At a 35,000 magnification, the bundles still appear clean and tightly held together (Figure 11). An examination of the few bundles in the field indicates that, if the bundles are properly opened, they will show fibrils of approximately 300 A units.

Tremolite

The tremolite under investigation is from California and is considered of good quality.

At a 4,000 magnification, the cross-section of the bundles varies from thick to thin (Figure 12). The bundles do not appear to be held tightly together and they show a tendency to fray out.

Examination of the bundles at 35,000 magnification shows evidence of individual fibrils existing at approximately 300 A units (Figure 13).

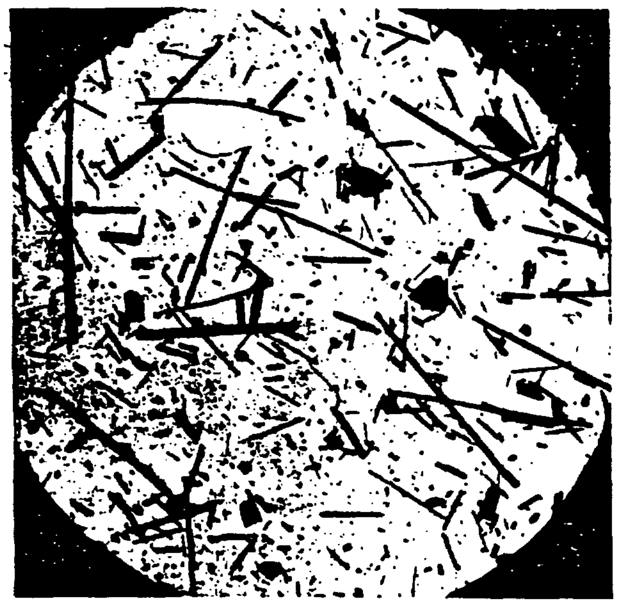


Figure 8.—Electron micrograph, crocidolite asbestos. x 1,733

Figure 9.—Electron micrograph, crocidolite asbestos. x 15,200.

Figure 10.—Electron micrograph, Bolivian blue asbestos. x 1,733.

Figure 11.—Electron micrograph, Bolivian blue asbestos. x 15,200.

Actinolite

The sample of actinolite was obtained from Canada. Previous tests showed high solubility, indicating the presence of impurities.

The electron micrograph at 4,000 magnification verifies this fact as it shows only a few fibre bundles, with a high percentage of plate-like minerals present (Figure 14).

Sampling this grade of actinolite for electron microscope studies is a considerable problem and many examinations would be required to obtain a satisfactory field. However, it was recognized that this sample was a milled commercial product and the pictures do show the true nature of the material.

At a 35,000 magnification, only one large, thick bundle appears in the picture. There is a suggestion of breaks along the end, but there is no indication as to the size of the individual fibril (Figure 15).

CONCLUSION

The various properties of the six varieties of asbestos investigated are given in convenient table form to serve as a quick reference.

Solubility data of the six varieties of asbestos show that chrysotile asbestos is readily attacked by acids and that the amphibole fibres are fairly acid-resistant.

The effect of heat on the different varieties of asbestos varies. Chrysotile shows small ignition losses at temperatures below 700°F. and a rapid increase in loss at 1,000°F. and above. The amphiboles show small ignition losses since they contain only small percentages of water of crystallization.

Ignition losses also indicate the presence of water and carbon dioxide. Some chrysotile fibres show the presence of brucite, magnesium

Figure 12.—Electron micrograph, tremolite asbestos. x 1,733.

Figure 13.—Electron micrograph, tremolite asbestos. x 15,200.

01 040 1378

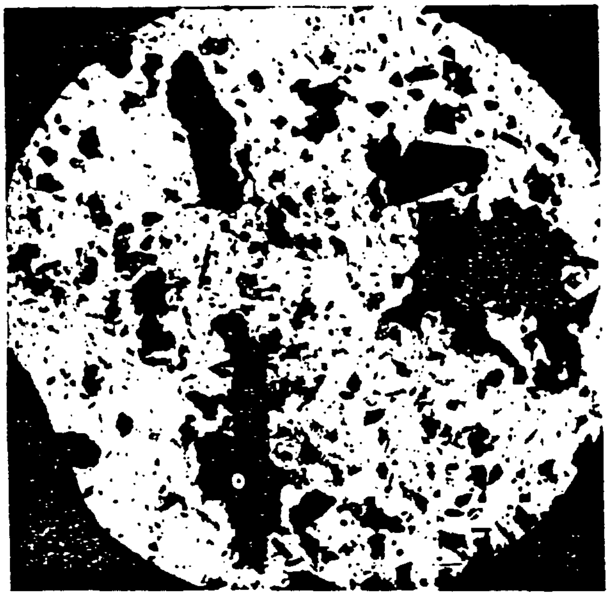


Figure 14.—Electron micrograph, actinolite asbestos. x 1,733.

Figure 15.—Electron micrograph, actinolite asbestos. x 15,200.

carbonate, and calcium carbonate; therefore, great care should be taken in interpreting ignition-loss data.

High temperatures and lengths of exposure decrease the tensile strength of chrysotile fibres. At temperatures above 1,000°F., the strength decreases rapidly.

Charts are presented to show that asbestos fibres have great tensile strength and large surface areas.

Photomicrographs at 100 magnification show that the soft, silky, chrysotile fibre is wavy, whereas the harsh fibre has a straight or needle-like structure.

The electron micrographs of the six varieties of asbestos at 4,000 and 35,000 magnifications show the fibre bundles, individual fibrils, and their approximate cross-sections, and may help to explain some of the physical properties of asbestos fibres used in commercial products.

ACKNOWLEDGMENTS

The author wishes to thank Dr. James Hillier and the RCA Laboratory for their help in producing the electron micrographs of the six varieties of asbestos described in this paper.

REFERENCES

1. CUMMINS, A. B., unpublished paper.
2. ROGERS, A. F., and KERR, P. F., *Optical Mineralogy*, 1942, pp. 277, 282, 289, and 363.
3. CASEY. R. S., *Materials of Construction;* Indust. and Eng. Chem., Vol. 40, Oct., 1948, p. 1793, also pp. 1837-1850.
4. NO AUTHOR, *Acid Resistance of Asbestos*; Gummi Zeitung, May, 1927, p. 1861.
5. NO AUTHOR, *Acid Resistance of Spinnable Types of Asbestos;* Asbestos, 1931, pp. 22-24.
6. TURKEVICH, J., and HILLIER, J., *Electron Microscopy of Colloidal Systems;* Anal. Chem., Vol. 21, April, 1949; pp. 480-481.
7. BATES, T. F., SAND, L. B., and MINK, J. F., *Tubular Crystals of Chrysotile Asbestos;* Science, May 12, 1950, p. 512

(*Reprinted from The Canadian Mining and Metallurgical Bulletin, April,* 1951)