

PLAINTIFF'S
EXHIBIT

JM 1027

MINERAL WOOL - HISTORY OF

INSULATIONS - MINERAL WOOL

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Research and Engineering
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MEMORANDUM FOR FILE:

History of Mineral Wool and
Development of Spinning Process

Mineral Wool is a generic term encompassing various wool-like products composed of staple fibers produced from molten rock, slag, glass and similar substances. Although the origin of mineral wool as a commercial product has been obscured by conflicting statements in the literature as to the date of first commercial production, it is probable that in the United States regular production of this material was begun before 1875.*

On May 31, 1870 United States Pat. No. 103,650 (Attachment 1) was issued to the administrators of John Player of Philadelphia, Pa., for a "method of producing mineral-wool," or "vitreous fiber" from the "slag or scoria at blast-furnaces and glass-works" by melting the slag or scoria in a "cupola or furnace" from which it is allowed to flow "in a small stream", and then directing a blast or jet of air or steam "onto" the stream to sub-divide it "into exceedingly fine filaments or fibers". Alternatively, it was stated, "the blast or jet might be applied to the slag as it runs from an ordinary blast-furnace and thus save the reheating of the slag, and this would, perhaps, constitute the simplest application of the invention."

*Only the literature (including patents) in the files of the Patent Department and in the Research and Engineering Center Library has been reviewed. This literature is extensive but not complete and while entirely satisfactory for the purposes of this memorandum, may not be sufficient to provide a completely accurate history of the early development of mineral wool.

In the Journal of the Franklin Institute*, Vol. LXII, No. 6, December, 1871, it is stated, at page 38:

"At the last meeting of the Franklin Institute Mr. Coleman Sellers exhibited a sample of a material which we believe is now for the first time about to be manufactured and applied to useful purposes in the art.

"The product possesses a general resemblance to cotton wool, for which it may doubtless in certain cases be substituted with advantage, but on closer examination seems more like a spun glass, which in reality it is. It is formed by allowing a jet of steam to escape through a stream of liquid slag, by which it is blown into the finest threads, sometimes two or three feet in length."

It was then suggested that the properties of mineral wool "would seem to fit it very well for a non-conducting casing to steam boilers and pipe, an application for which it is at present being tested."

Several early articles, for example an article by C. Baatsch in the Scientific American Supplement of September 10, 1881, and an article by A. D. Elbers in the Engineering and Mining Journal of August 26, 1899, page 248, state that the first commercial production of mineral wool in the United States took place in 1875 at an iron works blast-furnace located in Orange County, New York and was later

*Complete title - "Journal of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts."

produced at an iron works blast furnace located at Stanhope, New Jersey. There is some evidence, however, indicating that regular commercial production began at the Stanhope blast furnace several years prior to 1875. A pamphlet published by the National Mineral Wool Association in about 1940, entitled "For One Hundred Years PERFORMANCE", Vol. 2, No. 1, states that in 1870 the New York Steam Company was insulating steam lines in New York with mineral wool. A subsidiary of the New York Steam Company was at that time operating the blast furnace at Stanhope and the present-day management of this subsidiary, the name of which is now "United States Mineral Wool Company", states that old records which were made available temporarily to the National Mineral Wool Association in 1940, but which may recently have been destroyed by fire, establish that mineral wool has been produced regularly at Stanhope since 1869.

Numerous references in the literature indicate that the product had previously been manufactured in Great Britain and in Germany, although it is not clear in which country such production first occurred. It is also reported that in about 1836 (although various dates are given), a United States expedition, while visiting the volcano Kilauea in Hawaii, observed that the material believed by natives to be the hair of a goddess, was in fact rock wool produced by steam escaping through the molten lava in the volcano. Tests and experiments following the expedition are said to have resulted in a suggestion that rock wool might be produced commercially by pouring molten rock into the path of a steam jet. If this proposal was ever made, it is clear that neither Player nor the U. S. Patent Office had any knowledge of it, since Player was required by law to make an oath in essence the same as that required of U. S. inventors today and the Patent Office at that time was required by law to examine applications for novelty.

Regardless of its origins, mineral wool clearly was an established product in the United States by the middle 1880's. According to the Scientific American, Architects and Builders Edition, April 1887, page 73, and Stone Magazine of November, 1888, mineral wool was then widely used as an insulation for houses. In his article in the Engineering and Mining Journal of August 6, 1899, Elbers reveals the methods employed, in commercial production of the product. He discloses that in 1881 at the Stanhope, N. J. iron works, mineral wool was produced by steam fiberization of the molten material issuing from the slag taps of the blast furnace. He states:

"A few years later the Stanhope furnace went out of blast, and since then mineral wool has been made there from slag taken from the cinder bank and re-melted in cupola furnaces especially constructed for that purpose. Though this method was at first only adopted as a make-shift it was soon found that the wool made from re-melted slag contained considerably less sulphur than that made from the direct process; and the latter has since been practically abandoned in this country."

Elbers also indicates that three cupolas, of the type to which he had referred, could produce 48,000 lbs. of mineral wool per day, which at an assumed recovery of about 70% would indicate a cupola melt rate in the neighborhood of 1,000 lbs. per hour. He also states that up to 1899 use of mineral wool in the United States had not exceeded about 7,000 short tons yearly.*

In 1897 the General Insulating and Manufacturing Co. began the

*In this memorandum "ton" means short ton - 2,000 pounds.

manufacture of rock wool at Alexandria, Indiana, by melting argillaceous limestone in a cupola and fiberizing the molten rock by means of a steam blast. Mr. C. C. Hall, the Manager of the original Gimco operation, some years later formed the Banner Rock Products Company which produced rock wool at Alexandria by the same method.

Statistics available in Information Circular No. 6142 of the Department of Commerce, Bureau of Mines, entitled "Mineral Wool", dated June, 1929, written by J. R. Thoenen (Attachment 2) indicates that from 1900 through 1911 the production of mineral wool in the United States averaged about 7600 tons per year. At the production rates indicated by Elbers, about 4 cupolas operating generally on a six-day week would produce this amount, but it is clear that during these years there must have been several more than four cupolas in operation, since in each of the years 1902 and 1909, about 11,000 tons were produced.

In December, 1928 and February, 1929, Thoenen visited each of the eight mineral wool plants then operating in the United States. These plants included a total of 28 cupolas or furnaces, the majority of which were melting rock. The melting capacity of the cupolas or furnaces was substantially the same as in 1899 - about 1,000 lbs. per hour. As shown by Thoenen's report, the only fiberization process in commercial use in the United States in 1929 was the same process which had been suggested by Player in 1870; namely, melting rock or slag in a cupola, pouring the molten rock or slag from the cupola in a stream, and fiberizing the stream by shredding it with a steam or air blast.

Fiberization of mineral wool by methods other than steam or air blasts had been described in patents from time to time between 1870 and

1929, but by far the majority of patents issued during this period relating to production of mineral wool disclosed fiberization by steam or air jets and it seems rather clear from the literature that none of the other methods was ever used successfully in a commercial operation. The following is a list of the U. S. Patents, in addition to Player, having filing dates prior to 1929 which clearly disclose a method of producing mineral wool:

<u>Inventor</u>	<u>Pat. No.</u>	<u>Issue Date</u>
Elbers	180,570	August 1, 1876
Elbers	191,524	June 5, 1877
Burns	299,111	May 27, 1884
Kennedy et al	328,226	Oct. 14, 1885
Parrott	396,050	Jan. 8, 1889
Kennedy	436,244	Sept. 9, 1890
Parkison	779,307	Jan. 3, 1905
Fay	1,242,537	Oct. 9, 1917
Fay	1,256,541	Feb. 19, 1918
Koberle	1,650,136	Nov. 22, 1927
Jackson	1,769,181	July 1, 1930 (filed 1926)
Mottwieler	1,818,346	Aug. 11, 1931 (filed 1927)
Powell et al	1,837,836	Dec. 22, 1931 (filed 1928)

Elbers Patent No. 180,570 (Attachment 3) discloses a paddle wheel arrangement which he proposed for production of mineral wool but which undoubtedly would produce primarily, if not entirely, granules or shot. It is apparent from the literature of the latter 19th Century that such an arrangement was never used for production of mineral wool.

Burns discloses pressure extrusion of molten iron or glass slag through a bushing having a multiplicity of orifices. Jackson (Attachment 4) discloses forming fibers by flinging molten material from the circular face of a rotating member to form primary fibers which are reheated and further attenuated by gas and steam blasts. No record can be found of devices of even the general types shown in Burns and Jackson having been used prior to fairly recent times. All of the other patents in the list disclose fiberization solely by fluid jet or blast.

There are a number of patents, exemplified by Passow No. 964,805, July 19, 1910 (Attachment 5) and Lessing No. 998,358, July 18, 1911, (Attachment 6) which show granulation of slag by arrangements similar to those used and proposed for fiberization. Thus, Passow discloses forming granulated or pulverized slag, for use in cement, both by steam or air jet, and by a spinner, onto the top face of which a stream of molten slag is poured. Lessing discloses a plurality of paddle wheel type structures onto one of which a molten stream of slag is poured, the slag being granulated or pulverized by the action of the wheels. Prior to 1929 none of these rotary devices had been found to be suitable for commercial production of mineral wool, although Jackson, 1,769,181 may constitute a suggestion that a spinning disc could be utilized to produce coarse mineral fibers.

Examination of the literature, and particularly of the patents relating to the mineral wool art, indicates that the industry progressed very little if at all from about 1910 until the years just preceding Thoenen's report in the Bureau of Mines Information Circular No. 6142. In the middle 1920's machines were developed for blowing so-called "granulated" or "nodulated" mineral wool into the interior wall spaces

of existing homes, thus greatly expanding the demand for mineral wool in an application to which it was not previously readily adaptable. Somewhat later self-sustaining batts or blankets of mineral wool, needing no other facing material than paper, or the like, were developed, thus greatly increasing the demand for mineral wool as an insulation for new houses. These developments were responsible for a tremendous growth in the mineral wool industry, and while this growth was already under way in 1929, as indicated by the number of cupolas then in operation, in the next ten years the growth of the industry was phenomenal. In Bureau of Mines Information Circular 6984R of June, 1939, again by J. R. Thoenen, (Attachment 7) it is disclosed that there were in that year the equivalent of 160 cupolas in operation in the United States for the manufacture of mineral wool. As might be expected, during a period of such tremendous growth in the industry, there was considerable activity directed toward improvement of production processes, and particularly to improvement of methods of fiberization. It is an interesting fact, however, that although Thoenen, from 1936 through 1938, visited 25 plants having about one-half the total capacity of all the plants for producing mineral wool in the United States and Canada, there had been surprisingly few significant deviations from the general process disclosed by Player nearly 70 years previously. The majority of the melting devices utilized in the period 1936 through 1938 in the plants visited by Thoenen consisted of the standard cupolas of 1,000 lbs. per hour melting capacity which were in use at the turn of the Century, although a few producers were using cupolas and reverberatory furnaces*

*The difference between cupolas and reverberatory furnaces is revealed to some extent on pages 40 and 41 of I.C. 6984R (Attachment 7)

of up to about 2,000 lbs. per hour melting capacity, or slightly more. One cupola was indicated to have a melting capacity of 4.7 tons per hour, which rather clearly indicates that during this period the limit on production rates was not in the cupola but in the fiberizing devices.

For the most part Thoenen found almost no change in the general method of fiberization. In only two of the 25 plants which he visited did the fiberizing mechanism consist of something other than a steam or air jet directed against a stream or streams of molten material. While Thoenen's data indicate some considerable variation, on the average it appears that little progress had been made in regard to the recovery rate; i.e., the percentage of molten material converted into usable wool (fiber plus entrapped unfiberized particles called "shot"). The average appeared to be about 70%, or roughly the same it is believed was attained in the preceding decades.

The plants utilizing something other than fluid jets directed against a molten stream were Nos. 19 and 25. The apparatus utilized in plant No. 19 is disclosed in U. S. Patent to White, No. 2,136,988, November 15, 1938 (Attachment 8). In this arrangement the molten stream is intercepted on the frusto-conical peripheral surface of a disc spinning on a vertical axis, the stream being thereby shattered and cast into the path of several steam jets. In a sense, therefore, this apparatus is a modification of Jackson U. S. Patent No. 1,769,181, (Attachment 4), in that a rotary device serves to convert molten material into a more desirable form for fiberization by fluid jets. It is clear from Thoenen's description of plant 19, however, that this apparatus was wholly impractical in that the recovery rate

averaged only about 11%. Thus one hundred charges of 1175 lbs. of raw material each were sent to the cupola every 24 hours, and from this raw material only 5 to 10 tons of loose wool were produced. Even if 10 tons were the average, the recovery would total only 17%, which is wholly impractical from a commercial point of view. A later arrangement of disc and steam jets which has been proven commercially workable in recent years, is shown in Drill Patent No. 2,328,714, September 7, 1943 (Attachment 9).

The apparatus utilized in plant No. 25 is disclosed in U. S. Patent to Buss, No. 2,153,739, April 11, 1939 (Attachment 10). As described by Thoenen, the production apparatus included relatively small electric furnaces for melting a calcareous shale, apparently on an intermittent basis. When the material was melted the furnace was tipped to pour a molten stream onto an inclined grooved face of a rotor spinning on a vertical axis, fibers being formed by projection of the molten material from the rotor by centrifugal force. Sixty-six percent of the molten material fed onto the rotor was collected for processing through an associated device for removal of shot, it being stated by Thoenen that 360 lbs. of "shot free wool" was thereby recovered from each 1,000 lbs. of molten raw material fed onto the rotor, thus providing an actual recovery of 36%. As indicated below, while there is reason to question Thoenen's statement that "shot free wool" was produced, the production figures which he gives are believed to be approximately correct. It is rather clear that the Buss device was of extremely limited capacity.

Despite the low production rate, the device of Buss used in plant 25 described by Thoenen had accomplished something which had

never been accomplished before with slag or rock wool. As revealed on page 44, at the end of the fourth paragraph, material formed on the spinners was "long, silky fiber with no visible shot."

If Buss was the first on the North American Continent to begin commercial production of fiber directly from a spinning disc, he was not the first to suggest such a possibility. In Whittier Patent No. 2,018,478, October 22, 1935 (Attachment 11) it is disclosed that mineral wool may be produced through the use of a disc spinning either on a vertical axis, in which case the stream of molten material is fed onto the upper circular face, or a disc spinning on a horizontal axis, in which case the molten material is fed onto the cylindrical, peripheral surface. So far as can be determined, however, the apparatus disclosed by Whittier was never used commercially. Devices similar to Buss are disclosed in at least two patents which, although issued subsequent to Buss, were based upon patent applications filed considerably previous to his filing date. Rosengarth and Hager Patent No. 2,234,087, March 4, 1941 (Attachment 12) based upon an application filed in Germany on November 29, 1930, is perhaps the earliest effective disclosure of the formation of fiber directly from a spinning disc. It is reported that the method disclosed in that patent has long been used in Germany under the name of the "Hager process" but it has not been confirmed that such use took place prior to the use of the Buss apparatus in Canada. Harford et al Patent No. 2,156,982, May 2, 1939 (Attachment 13) based on an application filed March 9, 1934, disclosed formation of fiber by projecting molten material over the lip of a shallow cup spinning on a vertical axis, while Thomas Patent No. 2,192,944, March 12, 1940, discloses a similar arrangement

in which the lip of the cup is perforated, as shown in Figure 3, or serrated, as shown in Figure 4. It is not known if any of these devices, other than that disclosed in Buss, was actually used commercially.

There is a critical distinction to be noted between the arrangements shown in Rosengarth et al, Harford, Whittier and Buss, and those shown in Jackson, White and Drill. In the Buss type apparatus the fiber was formed directly from the spinner and the fiber was longer and tougher than fiber produced by fluid jets. In the devices of White and Drill, on the other hand, the fiber was actually produced by fluid jet and, therefore, had substantially the same characteristics as the fiber which had been produced by such jets from the days of Player.

In about 1940 Johns-Manville Corporation was by far the largest producer of mineral wool fiber in the World. It was then operating five plants having about 30% of the total mineral wool plant capacity in the United States. The cupolas in use by Johns-Manville at that time had a capacity of about 1,000 lbs. per hour and fiberization was accomplished entirely by steam jet. A greater and greater percentage of the mineral wool products produced by Johns-Manville in about 1940 were in batt or blanket form which were sold under the trade designation "SUPER-FELT". Steam blown mineral wool had two serious disadvantages for use in these products. First, the fiber was relatively short and in order to attain strength of product it was necessary to use a relatively high percentage of binder. The high percentage of binder, in turn, resulted in a stiffness and lack of resilience in the product. Furthermore, steam blown mineral wool contained a considerable amount of shot of relatively large size which

lowered the insulating value of the product. Also, shot dropped from the product as it was being installed, and particularly when the product was being installed in a ceiling or roof, tended to drop on the workmen installing it. Obviously, the higher the percentage of shot, the poorer the efficiency of the over-all manufacturing operation.

On page 44 of I.C. 6984R (Attachment 7) Thoenen states:

"The ultimate goal of the mineral-wool producer is to blow a shot-free wool. The writer has not yet found any commercial wool that is entirely shot-free. However, samples of specially processed wool were observed in which no shot was visible to the naked eye. Samples of glass wool observed had little if any shot as such, but in several instances the ends of the fibers were enlarged and hook-shaped. On the other hand, picked samples of glass wool showed remarkable length of fiber of uniform diameter and no visible shot or fused ends. Spun rock-wool samples showed long, silky fiber with no visible shot."

and on page 45 he states:

"Failing to prevent the formation of shot, operators have investigated the possibility of its removal from the wool after blowing. Raw wool contains from 10 to 30 percent shot by weight. These shot particles may range from microscopic size up to 1/8 inch or more in diameter. Obviously, caught as they are in the interlaced fibers and in many cases integral with the fiber, their separation is a somewhat difficult problem unless the fibers themselves are ground or broken. The solution of this problem has been the manufacture of granulated wool. In its preparation the raw wool is subjected to severe beating in hammer mills, feed threshers, or other types of granulators. In this process the fibers are broken up until the shot is released and can be separated by screening. Breaking the original fiber length, however, destroys much of the binding power inherent in long, interlaced fibers, which the manufacturers would like to preserve for its greater insulating value."

It is not known upon what test method Thoenen based his statement that raw wool contains 10 to 30% shot by weight, but even a cursory examination of the figures he gives for recovery of granulated wool from loose wool indicates up to 50% by weight of shot removed from loose wool by the granulators and it is well known the finished granulated wool was not completely shot-free. The figures used by Thoenen probably were based on a test method similar, if not the same

as, U. S. Department of Commerce, National Bureau of Standards, Commercial Standard CS 131-46, "Industrial Mineral Wool Products, All Types - Testing and Reporting." In Ceramic Bulletin, Vol. 34, No. 10, 1955 it is stated:

"Trade specifications (CS131-46) limit by definition shot as consisting of material separated from the pulverized fibers by sieving on a 50-mesh sieve, i.e., particles that are greater than 0.3 mm. (300 μ) in diameter. However, such definition is unrealistic in not taking into account finer shot which is also objectionable. For example a commercial refractory fiber, containing only 2 to 3% shot when graded by a test using the 50-mesh sieve, actually was found to contain 30% shot when graded according to a more rigorous test method."

It has been estimated that the average steam blown mineral wool product being produced in about the year 1940 contained a total of about 60-65% shot retained on 325 mesh, about one-half of which, or around 30 to 35% by total weight of the product, was objectionably large (50-mesh or larger). Although this was not a great disadvantage in producing granulated wool where most of the objectionable shot was removed, as indicated above, it was a serious disadvantage in the production of batts and blankets. According to the Encyclopedia of Chemical Technology, Vol. 9, page 126 (copyright 1952 by The Interscience Encyclopedia Inc., of New York) the amount of shot retained on 325 mesh may run as high as 75% in some crude loose wools.

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Apparently, however, the primary improvement desired by Johns-Manville in its mineral wool products in about 1940 was an increase in fiber length so as to enable production of a lower density, lower binder content, more flexible and resilient batt or blanket product. As a result, a so-called "long fiber mineral wool development program" was undertaken, and in 1942, having previously observed the quality of fiber produced by the Buss apparatus, a visit was made

to the plant of Spun Rock Wool Co., Ltd. at Thorold, Ontario, for a discussion with Mr. Buss of the process disclosed in his U. S. Patent No. 2,153,739 (Attachment 10) and in Thoenen's description of plant 25, beginning on page 34 of I.C. 6984R. This visit is described in detail in Memorandum M212*. According to the memorandum the process as then operated yielded about 50% long fiber wool containing about 23% shot (retained on 50-mesh). The wool was quite coarse and brashy by J-M standards but Mr. Buss stated he could make finer fibers. The melt was poured onto the spinner from the furnaces at a rate of about 300 lbs. per hour, so that the actual production rate of usable wool was no more than about 150 lbs. per hour.

At the time of the visit to Buss there was available to Johns-Manville additional prior art relating to devices of the Buss type. Ramseyer Patent No. 2,243,122, May 27, 1941 (Attachment 14) disclosed an apparatus for dividing the melt from the furnace into two pairs of streams which were poured onto spaced, independently operating discs, identical with those shown in the Buss patent and rotating on vertical axes. Davis Patent No. 2,274,130, February 24, 1942 (Attachment 15) disclosed formation of fiber by pouring molten material onto the upper circular face of a rotor spinning on a vertical axis (Fig. 7) and also disclosed formation of fiber by feeding molten material onto

*No copies of J-M Research Center Memoranda or Research Center Reports are attached because (1) data and facts summarized in this memorandum, which are noted as based on Research Center sources, are believed to be completely accurate, and (2) only a very minute portion of the source material is pertinent and the remaining portions contain much technical information which may still be considered confidential. The sources have been identified so that, if necessary, the accuracy of this memorandum may be verified.

the peripheral surfaces of axially spaced rotors rotating on a horizontal axis, blowing means being provided for removal of fiber formed.

In the Summer of 1942 J-M erected a pilot plant unit largely duplicating the Buss equipment but providing a continuous stream of molten material from the cupolette (small cupola) and a moving conveyor for collecting fiber continuously. It was demonstrated that long fibered wool could be made continuously from the standard slag formulations and that a much tougher, more resilient batt or blanket could be formed with such wool. It was also immediately discovered that an essential condition for the production of fiber was the bonding of the molten material to the rotor. The first description of the operation of the pilot plant (Research Report No. 32-371) states:

"The recovery is low when first starting up due to the fact that it takes a little while for the slag to start bonding to the rotor. For the same reason, the recovery drops if the stream spatters or changes position rapidly because it must stay in one position at least 10-15 seconds to form a maximum bond."

In practice most of the material fed onto the rotor was spattered instead of bonded and relatively little fiber was formed. With melting rates varying from 300-700 lbs. per hour from the cupolette, the recovery of usable wool (fiber plus entrapped shot) averaged only 20% or roughly 100 lbs. per hour. Numerous attempts were made to improve the bonding of the molten material to the rotor by varying the shape and number of the grooves on the slag receiving surface, but no substantial improvement was attained.

Apparently for the purpose of facilitating the collection of fiber the rotor was later arranged to spin on a substantially

horizontal axis and the molten stream was fed onto the peripheral surface of the rotor. The modified apparatus is illustrated in U. S. Patent to Powell No. 2,399,383, filed Nov. 18, 1942 (Attachment 16). Runs were made with various rotor shapes and groove designs but the basic problem of promoting sufficient bonding of the molten stream poured onto the rotor remained unsolved. Thus substantially all of the molten material fed onto the surface of the rotor spattered into large globules which were not fiberized and only a small percentage of the molten material bonded to the surface of the rotor and was converted into fiber. It was then determined, at Run 28 (see drawing No. C-272-3 and Table 1 of Research Report No. 32-383) to attempt "to reflect back the slag onto" the rotor by means of steam jets or wooden blocks. These attempts were encouraging but not highly successful.

On Run 35 it was decided "to try mechanical throwback" by use of a 4" rotating disc. The disc was arranged to rotate apparently on substantially a vertical axis and the molten material was fed onto its upper circular face from which it was thrown by centrifugal force against a sharply inclined, grooved, frusto-conical portion of the peripheral surface of the fiberizing rotor which was similar in construction to the rotor of Attachment 15. While the result was considered encouraging, it was found that the disc itself produced a considerable amount of coarse fiber which was a distinct disadvantage. A further attempt was made on Run 36 to utilize a wooden block for casting slag back onto the rotor surface. At Run 37 the first real progress was made, when two similar rotors rotating on substantially parallel axes were arranged with their peripheral surfaces facing each other at the bight between them so that material spattered from the first rotor was intercepted by the second rotor, on which a

portion of the spattered material was retained in the form of a bonded incandescent ring, and the remaining portion of the spattered material was spattered again and cast back onto the initial rotor. Whereas recovery with the single rotor averaged 20% at pouring rates of 300-700 lbs. per hour, the initial runs with the first two rotor units showed a recovery of 40% at the same pouring rate and the recovery increased progressively on subsequent runs. The result of these experiments was the two-rotor unit described in U. S. Patent to Powell No. 2,428,810 (Attachment 17) and after changing to a 44" cupola*, it was demonstrated that this two-rotor system was capable of yielding 50-65% usable wool at melt rates of from 1200-1500 per hour. As described in the patent, the system functioned as follows:

"The molten material impinging on rotor 18 is partially bonded to the rotor in grooves 30, the bonded material forming a relatively permanent non-stripping annular ring or rings 32 (see Fig. 5) revolving with the rotor. Most of the stream, however, is projected by the rotor almost tangentially to the surface thereof, at a greatly accelerated speed and in a slightly spread condition, onto the peripheral surface of the second rotor, as indicated in Fig. 2. The molten material bonds in the grooves of rotor 20 to provide an annular ring 34, the excess unbonded material being projected tangentially back to the first rotor.

"The projection of the unbonded molten material from one rotor to the other may continue to form a third bonded ring-38 on rotor 20, as indicated in Fig. 5, and likewise in some instances may again be projected back onto rotor 18. In each case, the additional ring will be laterally removed from the previous rings due to the relative tilting of the rotors."

*The melting capacity of the production cupolas used by J-M during this period in producing steam blown wool had been increased substantially over the capacity of the cupolas of the 1930's. The 44" cupola was not of production size.

The patent then describes how fibers are formed from the molten incandescent material on the outer surface of rings 32, 34, 36 and 38.

As indicated by the illustration in Fig. 5 and by the description quoted above, Powell apparently believed at the time of filing his patent application that the molten material became bonded in substantially equal quantities to the two rotors, or that under normal circumstances the first rotor would carry two bonded rings to only one for the second rotor. In a later experiment, however, when an attempt was made to fiberize a stream poured at 1600 lbs. per hour, it was found that the second rotor became seriously overheated and produced a much greater amount of fiber than the first rotor, i.e., the rotor onto which the molten material was first dropped. Attempts were made to equalize the production and operating temperatures between the two rotors, in the hope that this would enable fiberization of much larger streams of molten material. Several tests were made with an arrangement in which the stream from the cupola was split and one of the split portions fed onto each of the two rotors. This equalized the production on the two rotors and also eliminated the problem of the second rotor becoming hotter than the first, but there was no improvement in recovery.

The above tests revealed to Powell something of which he obviously had not been aware previously. In Patent No. 2,428,810 he had disclosed that molten material was discharged from the first rotor "at a greatly accelerated speed and in a slightly spread condition" but he did not disclose and apparently did not then know that this condition affected the character of the bond on the second rotor. After the filing of the two-rotor application, however, and

as a result of continued experiment, he came to realize that spreading and accelerating the stream of molten material and projecting it against the peripheral surface of a rotor with a greater force than could be obtained by merely permitting the stream to drop through the atmosphere onto the surface, would result in a greater portion of the stream becoming bonded to the surface. This followed from the fact that the second rotor, in actual practice, contrary to the disclosure in the patent application, had apparently retained on its surface a greater proportion of the material projected onto it from the first rotor than the first rotor was able to retain from the initial molten stream dropped upon it. Powell then conceived that the solution to the problems he had encountered lay in intercepting the molten stream with a device which would act, at least primarily, as a distributor so that onto surfaces which would be relied upon primarily for fiberization the molten material would be projected in a spread and accelerated condition. This distributor was to be critically different from the rotary distributors of White and Drill (Attachments 8 and 9) in that the major function of Powell's distributor was not to be merely to spread the molten stream so that it could be more readily disintegrated by a fluid jet but, in addition to spreading, to accelerate the stream and forceably project it against a fiberizing surface to cause it to bond thereto in an incandescent ring.

At the end of the runs with the 44" cupola, therefore, it was proposed to arrange above the two main fiberizing rotors a small rotor which would function almost entirely as a distributor, rather than as a fiberizer, and would intercept the molten stream, spread and accelerate it and project it with considerable force onto the first of the fiberizing rotors. The initial runs with such an

arrangement produced very encouraging results. Not only was the temperature and production capacity of the fiberizing rotors substantially equalized by this arrangement, but there was every indication that excellent recovery rates could be obtained at higher pouring rates than were possible with the two-rotor arrangement. This new three-rotor arrangement (distributor rotor and two fiberizing rotors) was recommended for further experimental work. By October of 1944, the rate of recovery with the three-rotor unit exceeded 70% at melting rates of about 1800 lbs. per hour. See Run No. 130, Report No. 32-451. Since only a minor amount of fiber was produced by the distributor rotor it is apparent that the increased recovery at higher pouring rates was due entirely to the more efficient bonding of molten material to the fiberizing rotors promoted by the distributor rotor.

In the late Summer of 1944, it had become apparent that the three-rotor spinner would be satisfactory for commercial production of long fibered mineral wool and design work was begun for the eventual moving of the experimental work to the Manville Plant where a full production size cupola (54") was available. Because of War-time restrictions it was not until late in May of 1945 that experimental runs were begun with the unit which was designed for full-scale operations. This design is shown in U. S. Patent to Powell No. 2,520,168 (Attachment 18) based on an application filed September 22, 1944, and in Drawing No. C-467-3 constituting Appendix A to Research Report No. 435-73, August 8, 1947. During experimental runs, data for which appear in Report No. 32-513, December 21, 1945, this three-rotor unit was capable of producing resilient batts of 2.7 lbs. per

cubic foot density with only around 1% binder and a shot content as follows:

<u>Sieve Mesh</u>	<u>Percentage Shot</u>
28	.85
48	3.15
100	8.60
200	13.20
325	7.00
Total	<u>32.8</u>

The above finished product was produced at a rate of 1350 lbs. per hour at a recovery rate of about 70% from a molten stream poured at slightly under 2,000 lbs. per hour. Compared with the steam blown product then being sold by Johns-Manville under the trade designation "SUPER-FELT" the quality of the mineral wool produced on the three-rotor unit was startling. With reference to the spun product, Report No. 32-513 states: "density of the product is roughly one-third less than 'SUPER-FELT' and the area packed in a standard bag has been increased from 40 to 50 square feet". The binder usage in the spun product was less than half the amount of binder used in the steam blown product and the total shot content was about half and the large shot content (plus 50 mesh) was far less than half.

The 3-rotor unit was not capable, however, of fiberizing the full cupola output, which was then in excess of 3,000 lbs. per hour. When attempts were made to run with large fluid streams the spinning capacity of the unit was overloaded frequently. The result of the overloading was that the molten material spattered from the unit to an excessive extent and in some cases spattered into the finished product. The spattering was caused by the distributor rotor and several attempts were made to operate under circumstances where

the molten stream struck the distributor rotor substantially tangentially. Under such a condition the distributor rotor spread and accelerated the stream to a far lesser degree than normally and as a result the unit operated largely as the two-rotor unit had operated with the third rotor (second fiberizing rotor) producing a majority of the fiber.

Because of a long strike at the Manville Plant, it was determined to transfer the spinning development to the plant at Alexandria, Indiana. At the same time it was determined that an attempt should be made to increase the production capacity of the unit. It was recognized that an increase in production capacity would require distributor means which would distribute larger streams without spattering and Powell conceived that one form of such an improved distributor would be a two-rotor distributor in which the second distributor rotor, in addition to its distributing function, would produce a substantial amount of fiber. As a result he designed the four-rotor units shown in U. S. Patent to Powell No. 2,520,169 (Attachment 19) based on an application filed September 29, 1948, and in Drawing No. C-467-3. These four-rotor units accomplished their intended function. The units were able to fiberize the full output of standard production cupolas with recoveries of up to 85%. Although the quality of the fiber was reduced somewhat from that produced by the three-rotor arrangement, the quality was still vastly superior to that of any product which had previously been produced in comparable quantities.

When J-M's mineral wool plants had been converted to the spinning units, the impact on the market was such that J-M's major competitors requested licenses under the J-M patent rights in the United States. These competitors had made attempts to duplicate the spun product but had been able to do so only by adoption of spinners embodying the novel distributor concept of the J-M patents. Effective in the beginning of 1953 all of the major mineral wool producers in the United States were granted licenses under the three and four-rotor patents. Among the licensees were National Gypsum Company, the successor to General Insulating and Manufacturing Company (Gimco), Baldwin-Hill Company and U. S. Mineral Wool Company. The significance of the new process and its impact on the market can be appreciated from an item in "Industrial Heating" for June 1955, page 1268, which describes the conversion by Baldwin-Hill Company from steam blowing to the new spinning process in part as follows:

"Baldwin-Hill Co., Trenton, N. J., has changed over to the spinning process for production of mineral wool fibers with increased tensile strength, improved handleability and lower density than fibers produced by the old method. The improved properties are accomplished with equal or greater efficiency by the new process.

"The new process, which imparts no change in chemical composition of the material, utilizes centrifugal force of spinning cylinders, rather than jets of steam, to form longer, finer mineral wool fibers with greatly reduced percentages of 'shot' or unfiberized material.

"Since longer fibers have greater cohesion, less actual mineral wool material is required to produce blocks, blankets or felts of given thickness and area. Therefore, all spun wool products are lighter in weight and easier to handle than corresponding blown products. For example, industrial felts have been reduced in weight by about 50% and metal-mesh blankets by 33%.

"Shot content of mineral wool formed by steam blowing, as determined by U. S. Commercial Standard CS-131, is on the order of 35% by weight. Identical tests conducted on spun mineral wool indicate shot content averaging less than 5%."

The advance in the art which permitted the product improvement referred to above, is succinctly defined in the broadest claims of U. S. Patent to Powell No. 2,520,168 (Attachment 18), these being claims 3, 5 and 10. Claim 3 is exemplary and reads as follows:

"3. In an apparatus for converting a molten raw material into fibrous form having means for supplying a stream of the material, rotary distributor means in the path of the stream, means for rotating said distributor means to project the main portion of the molten material as a distributed stream moving at a greatly accelerated speed, and rotor means including an unobstructed, molten-material retaining, annular surface, means supporting said rotor means in position to have said annular surface intercept material of said distributed stream, and means for rotating said rotor means to move said annular surface at a speed substantially higher than the speed of the distributed stream."

It will be noted that all that this claim requires is a rotary distributor means for intercepting the molten stream and projecting it at a greatly accelerated speed onto a spinning surface capable of retaining molten material, and traveling at a speed substantially higher than the speed of the distributed stream. Claim 10 eliminates the requirement for the difference in speed between the molten material retaining surface and the distributed stream, but adds the requirement that rotors (plural) be positioned to receive the distributed stream. Claim 5 includes the novel concepts of both of claims 3 and 10. Quite evidently these claims were carefully drawn to clearly distinguish over two-rotor arrangements, such as shown in Powell U. S. Patent No. 2,428,810 which, even if construed to include a distributor, did not include a distributor in either of the

relations just described. It is also evident from these claims that the novel feature of Powell's invention was initial interception of a stream by a rotary device, which could be of any size or shape permitting it to be operated in such a manner that it would function primarily as a distributor rather than as a fiberizer, and projection of the stream from the distributor in a spread and accelerated condition onto one or more fiberizing rotors so as to insure bonding of the molten material to the rotors. Experimental and commercial practice had proven that this novel feature was the primary if not the sole contributing factor to success of the multiple rotor spinning apparatus. Consequently J-M has always taken the position that any spinning apparatus which includes this novel feature is an infringement of at least U. S. Patent No. 2,520,168 and patents based upon it.

The scope attributed to Patent No. 2,520,168 is clearly demonstrated by J-M's experience with one of its licensees in about 1954. This licensee, American Rock Wool Company, had developed a spinner construction which is shown in Tillotson U. S. Patent No. 2,678,466 (Attachment 20). The spinner had been developed to the point of commercialization before Johns-Manville was advised of its existence. The licensee indicated it did not intend to pay royalties for use of this apparatus. J-M's attorneys, as well as independent patent attorneys, considered the Tillotson arrangement without any question to fall within the scope of the broad concepts disclosed and claimed in Powell U. S. Patent No. 2,520,168, and particularly claims 3, 5 and 10. Since claim 3 requires only spreading and accelerating a stream by rotary distributor means, and discharging it onto a rotary

fiberizing surface traveling at a speed substantially higher than the speed of the distributed stream, it was clearly infringed by the Tillotson arrangement, in which the distributor rotor rotates at 200-1200 r.p.m. and the fiberizing rotors rotate at speeds between 2000 and 8000 r.p.m. and have a diameter equal to or greater than the diameter of the distributor rotor. Since claim 10 requires nothing more than rotary distribution to a plurality of fiberizing rotors, it also was clearly infringed by the Tillotson arrangement. Since claim 5 requires merely the combination of the concept of claims 3 and 10, it likewise clearly was infringed. It should be noted that the broad claims of Patent No. 2,520,168 call for the fiberizing rotors to have molten material retaining surfaces but do not specify the means by which such retention is attained. Consequently, the claims are readable on any rotors which do in fact have surfaces to which molten material will bond, as clearly happens in the Tillotson arrangement. Johns-Manville's position with respect to the Tillotson device was not challenged further by the licensee. The device was not used commercially because it was no better than the 4-rotor arrangement disclosed in U. S. Patent No. 2,520,169 and had several disadvantages and either could be used for the same royalty.

We have noted Graybeal U. S. Patent No. 2,774,103 (Attachment 21) which discloses a device in many respects similar to Tillotson but including only four fiberizing rotors. This arrangement likewise is considered by Johns-Manville to be an infringement of U. S. Patent No. 2,520,168, but to our knowledge has not been used commercially.

The applications from which U. S. Patents Nos. 2,520,168 and 2,520,169 matured were combined into a single application and filed in the following countries:

Argentina	{ Pat. No. 77667, Oct. 19, 1950)
Australia	{ Pat. No. 148,033, Sept. 9, 1953)
Brazil	{ Pat. No. 39,987, Jan. 28, 1952)
France	{ Pat. No. 1,018,547, Oct. 15, 1952)
Germany	{ Pat. No. 919,096, July 24, 1954)
Great Britain	{ Pat. No. 673,561, Oct. 1, 1952)
Sweden	{ Pat. No. 137,084, June 5, 1952)

Particularly the application which matured into the Australian patent was extensively prosecuted and, in fact, was opposed by an Australian producer of mineral wool. The basis for the opposition was, in essence, U. S. Patent No. 2,428,810 and Australian Patent No. 135,499 (Attachment 22) published January 15, 1948 and assigned to Insulwool Products Pty., Ltd., as assignee of one C. D. Richardson*. Johns-Manville refused offers of Insulwool to settle the opposition after an informal exchange of evidence and the opposition was dropped by Insulwool. J-M's reasons for refusing to settle were that the two-rotor apparatus used experimentally by Insulwool prior to 1950 did not disclose the novel distribution concepts of U. S. Patent No. 2,520,168, and the Insulwool Australian patent was likewise not pertinent. In this connection our position as outlined to Insulwool was as follows: -

"Insulwool Australian Patent No. 135,499 discloses an arrangement of four rotors, some of which are spaced from adjacent rotors by distances greater than their diameters. The drawing definitely shows streams of molten material being projected

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*Richardson was also granted U. S. Patent No. 2,491,766, Dec. 20, 1949 (Attachment 23) which includes very low speed stream splitting rolls associated with disintegrator rolls similar to those shown in Lessing (Attachment 6). The disclosure of this U. S. patent is less pertinent than the Australian patent.

without bonding from one rotor to another and thus being sub-divided into smaller streams. It is quite apparent that the inventor did not contemplate bonding the molten material to any of the rotor surfaces, and it would also be apparent to any person skilled in the art of mineral wool spinning that the Insulwool arrangement is wholly unworkable. Theoretically, this arrangement might function to shatter the stream of molten material repeatedly by impact until the streams become quite small and solidify in the form of fibers. Thus it is stated in lines 14 and 15 of page 3 that: 'the material projected from the last rotor of the series solidifies and settles in the form of spun fiber' (emphasis added). Those skilled in the art recognize the impossibility of making commercial fiber from such a system. In fact, it is extremely doubtful if any significant quantity of even large diameter fiber could be made from such a system."

Our conclusions were strengthened by the evidence submitted by Insulwool which showed rather clearly that the apparatus of Australian Patent No. 135,499 had never been worked even experimentally.

The concept of utilizing a rotary distributor means to spread and accelerate a molten stream and to project it forcibly onto a molten material retaining fiberizing surface is wholly lacking in the Insulwool patent. It is for this reason that the Australian Patent Office initially allowed the claims after presentation by Johns-Manville of arguments of the type quoted above relative to the Insulwool patent.

The J-M spinning patents were licensed in several of the countries in which filed, the largest operation so licensed being that conducted by Roclaine in France. No attempt has been made to determine the nature of the commercial practices relating to mineral wool in France

in the early 1950's when Roclaine became a licensee, but information relating to practices in Great Britain at that time was included in the available literature. Stillite Products Ltd., an affiliate of Stillite Francaise, which was the predecessor of Francisol, rather clearly employed steam blowing during this period. See, for example, International Chemical Engineering, January, 1951, pages 15 through 18 (Attachment 24) and Chemical and Process Engineering, December, 1956, pages 422 through 425 (Attachment 25). From this it is assumed that the standard process for producing mineral wool throughout Europe at this time also probably was steam blowing. The products produced by Roclaine in accordance with French Patent No. 1,018,547 (Attachment 26) had the same advantages over competitive slag and rock wool products which the products of Johns-Manville and its licensees in America had enjoyed over competitive products, these advantages being set forth in the item from Industrial Heating of June, 1955, quoted extensively above. Francisol and its predecessors, Stillite Francaise, in an attempt to duplicate the Roclaine quality, adopted an apparatus which compares with French Patent No. 1,018,547 (Attachment 26) in the same manner that the Tillotson and Graybeal devices (Attachments 20 and 21) compare with Powell U. S. Patent No. 2,520,168. - -

It is particularly pointed out that in U. S. Patent No. 2,520,168 the distributor roll was provided with means (grooves 26 and 28) so arranged that the main portion of the intercepted molten stream would be "projected at a greatly accelerated speed, as compared to the original gravity flow of the stream, tangentially from the distributor roll through a substantial arc of its rotation, the projected material

impinging upon the peripheral surface of the rotor 30 and to some extent on the peripheral surface of rotor 32 as illustrated in Fig. 2, rotors 30 and 32 forming in effect a substantially unbroken surface to receive the molten material." (emphasis added). Francisol adopted this exact principle, the only difference being one of degree, rather than kind, and lying solely in having extended the distribution to substantially a full arc of 360° of rotation of the rotary distributor and in providing a ring of rotors forming in effect an unbroken surface of commensurate extent to receive the molten material. Francisol obviously had found that not only was it necessary, in producing a long fibered, high quality product like that produced by Roclaine, to use true spinning apparatus in which fiber is produced from bonded rings on the peripheral surfaces of spinning rotors, but had also found it necessary, in order to conduct such spinning efficiently to use Powell's novel concept of rotary means for intercepting the initial molten stream and projecting it in a spread and accelerated condition onto the fiberizing surfaces in order to promote the bonding. Francisol, therefore, adopted the very heart of the Powell invention disclosed and claimed in U. S. Patent No. 2,520,168 and in French Patent No. 1,018,547.

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John A. McKinney

JAMcK:pb
Attachs.

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LIST OF ATTACHMENTS

- ✓ 1. Player, U.S. Pat. No. 103,650, May 31, 1870.
- ✓ 2. U.S. Bureau of Mines Information Circular 6142, June 1929, by J. R. Thoenen.
- ✓ 3. Elbers, U.S. Pat. No. 180,470, August 1, 1876.
- ✓ 4. Jackson, U.S. Pat. No. 1,769,181, July 1, 1930.
- ✓ 5. Passow, U.S. Pat. No. 964,805, July 19, 1910.
- ✓ 6. Lessing, U.S. Pat. No. 998,358, July 18, 1911.
- ✓ 7. U.S. Bureau of Mines Information Circular 6984R, June 1939, by J. R. Thoenen.
- ✓ 8. White, U.S. Pat. No. 2,136,988, November 15, 1938.
- ✓ 9. Drill, U.S. Pat. No. 2,328,714, September 7, 1943.
- ✓ 10. Buss, U.S. Pat. No. 2,153,739, April 11, 1939.
- ✓ 11. Whittier, U.S. Pat. No. 2,018,478, October 22, 1935.
- ✓ 12. Rosengarth, et al., U.S. Pat. No. 2,234,087, March 4, 1941.
- ✓ 13. Harford, et al., U.S. Pat. No. 2,156,982, May 2, 1939.
- ✓ 14. Ramseyer, U.S. Pat. No. 2,243,122, May 27, 1941.
- ✓ 15. Davis, U.S. Pat. No. 2,274,130, February 24, 1942.
- ✓ 16. Powell, U.S. Pat. No. 2,399,383, April 30, 1946.
- ✓ 17. Powell, U.S. Pat. No. 2,428,810, October 14, 1947.
- ✓ 18. Powell, U.S. Pat. No. 2,520,168, August 29, 1950.
- ✓ 19. Powell, U.S. Pat. No. 2,520,169, August 29, 1950.
- ✓ 20. Tillotson, U.S. Pat. No. 2,678,466, May 18, 1954.
- ✓ 21. Graybeal, U.S. Pat. No. 2,774,103, December 18, 1956.
- ✓ 22. Insulwool, etc., Australian No. 135,499, November 28, 1949.
- ✓ 23. Richardson, U.S. Pat. No. 2,491,766, December 20, 1949.
- 24. International Chemical Engineering, January 1951.
- 25. Chemical and Process Engineering, December 1956.
- 26. Johns-Manville French Patent No. 1,018,547. *not in file.*

Same as Attachment 19

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