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A. B. CHEN ETAL

3,159,475

APPARATUS FOR FORMING FIBERS

Filed May 5, 1955

Fig. 1.

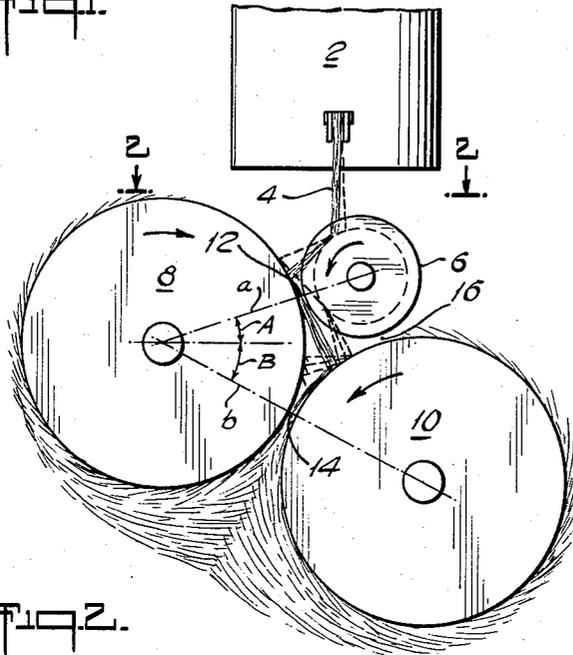


Fig. 2.

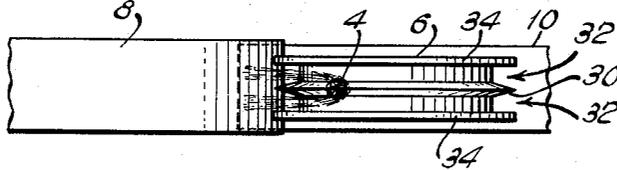


Fig. 3.

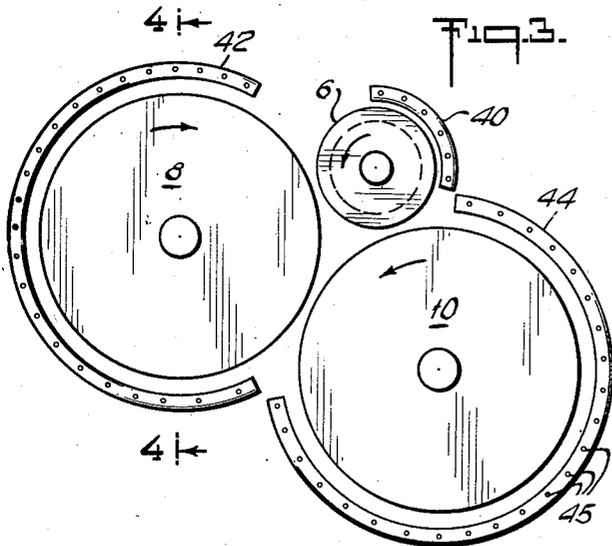
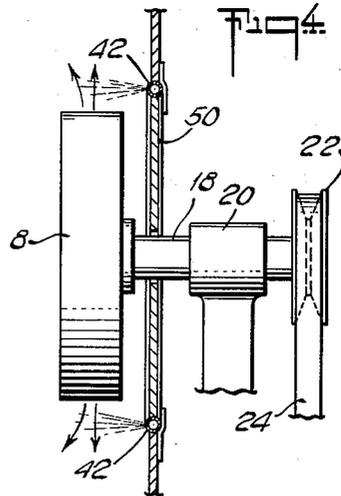


Fig. 4.



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APPARATUS FOR FORMING FIBERS

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The present invention relates to the manufacture of fibers and, more particularly, to the conversion of a molten raw material into mineral wool by an improved spinning apparatus of the general type disclosed in U.S. patents to Powell, Nos. 2,520,168 and 2,520,169. The term "mineral wool" is employed herein in a generic sense to include wool of the type formed from molten rock, slag, glass, mixtures thereof, and like inorganic materials. While the improved apparatus is particularly adapted for formation of mineral wool, it will be apparent that it is also adapted to fiberize many organic plastics as well.

One of the major difficulties encountered in adapting the spinning method to production of mineral wool on a commercial basis was the inability of the equipment employed to convert to fiber a satisfactory percentage of the normal output of the cupola conventionally used in such operations. The 3-rotor apparatus shown in Patent No. 2,520,168, while representing a tremendous advance in the art, was found to be in need of improvement in this regard because the feeding of a stream of conventional size to such an apparatus resulted in an undesirable degree of uncontrolled spattering of the material of the stream and consequent inclusion of much unfiberized material in the felted product. Thus the high quality product which the 3-rotor spinner was designed to produce could be produced only at lower production rates than it was desirable to attain for commercial operations. One solution to the spattering problem was found with the 4-rotor arrangement shown in Patent No. 2,520,169 wherein acceleration and spreading of the stream discharged by the cupola was accomplished more gradually with two distributor rolls, rather than one. The use of two distributor rolls permitted increased production of a product far superior in quality to blown wool, but it was found to be not of the same high quality as that produced by the 3-rotor arrangement at lower production rates. The problem, which it is the primary objective of the present invention to solve, is to secure at least the highest quality obtainable with prior 3-rotor arrangements at production rates the same or higher than are obtainable with known 4-rotor arrangements.

Thus, an object of the instant invention is to provide a 3-rotor spinning arrangement in which the size relation, relative positions and spacing of the distributor roll and fiberizing rotors are such that no substantial uncontrolled spattering of molten material occurs in producing high quality fiber at relatively high rates.

A further object of the present invention is to provide an improved distributor roll which not only results in improved distribution of material when employed in any multiple rotor spinning apparatus, but also is peculiarly adapted for highly efficient operation in the particular 3-rotor arrangement of the present invention.

A further object of the present invention is to provide, in association with spinning rotors, fluid jet means which enhance collection of long, relatively shot-free fiber, and is peculiarly adapted to produce this result when employed in the particular arrangement of the present invention.

The invention will be more fully understood and further objects and advantages thereof will become apparent

when reference is made to the following detailed description and to the accompanying drawing in which:

FIG. 1 is a diagrammatic front elevational view of the spinning arrangement of the present invention;

FIG. 2 is a partial view of the apparatus as seen from plane 2-2 of FIG. 1;

FIG. 3 is a diagrammatic front elevation of the spinning arrangement of the present invention in association with fluid jet means adapted for cooperation therewith; and, FIG. 4 is a section, taken on the line 4-4 of FIG. 3.

Referring to the drawing, and particularly to FIG. 1, there is illustrated a cupola 2 of the type common to the mineral wool industry, adapted to melt and discharge molten stream 4 of a material capable of being formed into fibers. In the present invention the material of the stream is converted into fibers by a multi-rotor spinning apparatus including a distributor roll 6 so positioned and rotated as to intercept the stream on a downturning edge of its periphery. The material of stream 4 is spread and accelerated by roll 6 and discharged therefrom onto the peripheral surface of a fiberizing rotor 8 rotating in a direction opposite to the direction of rotation of roll 6. A portion of the material received from roll 6 by rotor 8 is discharged therefrom onto the peripheral surface of a second fiberizing rotor 10 substantially identical to rotor 8 but rotated in a direction opposite to the direction of rotation of rotor 8 and in the same direction as roll 6.

As can be appreciated from FIG. 2, the periphery of roll 6 is in opposed relation to the peripheral surfaces of both fiberizing rotors 8 and 10 which are thus likewise in opposed relation to each other. The peripheral surfaces of the roll and rotors are annular (ring-like and continuous) and whether cylinder-like or frusto-conical, or of other shape, the roll and rotors preferably are arranged so that the central points of opposed peripheries at bights 12, 14 and 16 are opposite each other or aligned, as shown in FIG. 2. Roll 6 and rotors 8 and 10 are each similarly fixed on the end of a shaft 18, as shown in FIG. 4, each shaft being rotatably mounted in a bearing 20 and provided at the end thereof remote from the roll or rotor with a pulley 22 arranged for engagement with the drive belt 24 of a motor, not shown.

As is now well known, molten material bonded to the peripheries of rotors rotated at high speed is apparently thrown therefrom by centrifugal force, with the result that fibers are formed in the area closely adjacent such peripheries. Because it is desirable that little or no fiber be formed by distributor roll 6 and hence that little or no material of stream 4 adhere to the periphery thereof, it is advisable to make the surface or surfaces constituting such periphery smooth in nature. However, it is believed essential to fiberization that the material bond to the peripheries of fiberizing rotors 8 and 10 and, to promote such bonding, it may be necessary to provide relatively small grooves or other texture on such surfaces. For satisfactory distribution and fiberization of material, roll 6 may be driven at a peripheral speed of from 4000-6000 feet/minute, rotor 8 at about 14,000-21,000 feet/minute, and rotor 10 at about 17,000-26,000 feet/minute, although speeds may be varied to obtain differing fiber characteristics.

With the possible exception of the speeds specified, the detailed description above applies equally well to both the apparatus of the present invention and the apparatus of the said Patent No. 2,520,168. As will be apparent from the description which follows, one aspect of the present invention involves a rearrangement of the relative positions of the roll and rotors of prior 3-rotor arrangements in such a way that mineral wool products may be produced which are recognizably superior to prior products and yet are produced at rates equal to, or greater than, normal production rates in the industry. The crit-

ical features of this aspect of the invention are the relative sizes and spacing of the distributor roll and rotors, and the essence of this phase of the invention is to position the roll and rotors quite close to each other, as compared to prior arrangements, with the distributor roll nestled between the fiberizing rotors.

Referring again to FIG. 1, it will be seen that the direction in which the stream is discharged from the roll 6 to rotor 8 is determined by the location at which the stream strikes the roll. Where roll 6 is quite small, a very slight displacement of the point of stream interception results in a great change in the direction of discharge, whereas with a larger roll, this change is much less for the same displacement. On the other hand, it has been observed that when distributor roll 6 is relatively large, it has a tendency to produce fiber to an undesirable degree and, moreover, will not nestle between the fiberizing rotors to the extent necessary to eliminate relatively free spattering of molten material. In manufacturing mineral wool, therefore, there are practical limits to the size of roll 6 and, while as with all size, spacing and location limits specified herein, it cannot be said that complete success lies to one side of such a limit, and complete failure to the other, it will be realized that dimensions clearly beyond these limits will not produce the same advantageous results as dimensions clearly within such limits.

Where a distributor roll with a contoured periphery (as distinguished from a cylindrical periphery) is employed, its effective diameter is the critical dimension insofar as material distribution and fiberization is concerned, whereas its maximum diameter is its critical dimension insofar as nestling between the rotors is concerned. "Effective diameter" refers to the mean diameter of the effective periphery or the surface or surfaces of the roll from which the major portion of molten material is discharged to rotor 8, and "maximum diameter" refers to the greatest diameter of the roll. With a cylindrical roll, the "effective diameter" is the actual diameter. Roll 6 preferably is from 5 to 9 inches in effective diameter and, if contoured, no more than about 11 inches in maximum diameter. The width of roll 6, which is the width of its periphery measured in the direction of the axis of rotation, should be sufficiently great to readily accommodate a molten stream flowing at about 3500 to 5000 lbs./hour. One distributor roll which has produced satisfactory results in actual operation has an effective diameter of 6", a maximum diameter of 7½" and a width of 3".

Certain practical limits for the dimensions of the fiberizing rotors have also been observed in manufacturing mineral wool. Where the rotors are too large it is difficult to position the apparatus satisfactorily in relation to the cupola and the fiber collection chamber (normally about 60" wide). Large rotors, of course, are necessarily rather heavy and extreme care must be exercised in maintaining balance of such rotors to prevent excessive dynamic loads on the bearings. On the other hand, where the fiberizing rotors are relatively small, there is a loss of ability to fiberize large streams with a satisfactory degree of fiber recovery and a satisfactory fiber length. In order that the distributor roll function most satisfactorily in relation to the fiberizing rotors, the rotors should have diameters about two to three times the maximum diameter of the roll, and thus, where a roll of up to 11" is employed, rotors up to about 33" in diameter would be used if the size relation of the distributor roll were the only factor to be considered. The term "diameter" when applied to rotors 8 and 10 refers to the mean diameter of their peripheries. While at the present time it is considered advisable to employ rotors considerably under 33 inches in diameter, it should be noted that any upper limit on the size of the fiberizing rotors is now only theoretical and, as melting and collection equipment and arrangements are changed, it may be practical

to employ fiberizing rotors of much greater diameters than now appear to be suitable. It has been observed that increasing the diameter of fiberizing rotors beyond the 12 to 14 inches, previously in extensive use, has resulted in a marked increase in fiber length and production capacity. Thus it is believed that a range for rotor diameters which is quite practical at the present time is 15" to 21", and it is definitely known from extended experimental operations that 18" rotors are entirely satisfactory from a mechanical viewpoint and function to produce a very high quality product. While the fiberizing rotors are shown as somewhat wider than the distributor roll, these widths may all be the same.

With roll 6 and rotors 8 and 10 of the preferred sizes indicated above; i.e., 6" effective diameter for the roll and 18" diameters for the rotors, and with the roll and rotors positioned as required in the present invention, the angle between the line joining the axes of roll 6 and rotor 8 (line *a*) and the line joining the axes of rotor 8 and rotor 10 (line *b*) is in the neighborhood of 45°. In the arrangement shown in FIG. 1, angle A, the angle line *a* makes with the horizontal, is about plus 19°, whereas angle B, the angle line *b* makes with the horizontal, is about minus 27°, resulting in a total included angle of about 46°. While these exact angles are not considered critical, certain disadvantages result from making large changes therein toward opposite extremes. Thus, when the apparatus as a whole is rotated clockwise to such a degree that angle A approaches 0° or becomes a negative angle, fiber formed on rotor 8 tends to interfere with stream 4 to an undesirable degree. Also, the top of rotor 8 will be so far above the top of roll 6 that difficulty may be experienced in positioning roll 6 close enough to the cupola notch to prevent excessive cooling of stream 4 in its drop from the notch to the roll (a problem well understood by those skilled in the art). With extreme clockwise rotation of the apparatus, material discharged from the roll 6 onto the rotor 8 tends to be continuously thrown back onto the roll to an excessive degree. Where angle A is increased substantially by enlarging the angle between lines *a* and *b* or by rotating the spinner counter-clockwise so that angle B approaches 0°, it becomes difficult or impossible for the stream to be discharged onto rotor 8 at a suitable angle to the rotor periphery. With all of these extreme changes, positioning of the point of stream interception becomes more critical and any wobbling of the stream can cause undesirable results.

As indicated above, one of the most important features of the improved apparatus is the spacing of the roll and rotors in such a way that the roll is located above the bight of the rotors and nestled between the same. The bight 14 of rotors 8 and 10 may be arranged just wide enough to avoid any wiping or squeezing of material therebetween, but is preferably about ⅜" to ½" in width. While there is no clear maximum limit on the width of bight 14, when this width approaches a value as great as 1" (with 18" rotors) there is a noticeable decrease in fiber recovery and increase in shot content of the collected fiber. The allowable width of bight 14 apparently depends, at least in part, on the diameter of the rotors, and a bight width as great as ½ the diameter of the rotors or greater would not be advisable. The width of bight 12 between roll 6 and rotor 8 is preferably as narrow as possible; i.e., just wide enough to insure that material thrown from rotor 8 to rotor 10 will normally clear roll 6. The bight 16 between roll 6 and rotor 10 should also be quite narrow and, in any event, narrow enough to provide for the nestling of roll 6 between the fiberizing rotors. Where roll 6 is arranged to be adjustable in order to permit use of different size rolls, it will usually be found more convenient to make the arrangement such that the width of bights 12 and 16 are always about equal, which can be accomplished by arranging the roll for adjustment along the bi-sector of line *b*. When the width of bight

12 is increased, the distance of travel of the molten stream from roll 6 to rotor 8 is increased, and it has been observed that the tendency toward undesired spattering is at least partially a function of the distance traveled by the stream in this bight. Where wobbling of stream 4 causes the material discharged from roll 6 to rotor 8 to take an abnormal angle laterally of the peripheral surface of the rotor (axially of the rotor), such angle, even though relatively large, will not result in material missing rotor 8 where the distance traveled is small, but probably could easily result in missing where the distance traveled is large. The importance of having a narrow bight between the roll 6 and rotor 10 is illustrated by the dotted lines in FIG. 1, which show that a lateral deflection or wobble of stream 4 may raise the point of stream interception on the peripheral surface of roll 6 with consequent changes in angles of discharge from roll 6 and rotor 8. With bights 12 and 16 relatively narrow, or with roll 6 clearly nestled between rotors 8 and 10, such a deflection of the stream results in material thrown from rotor 8 toward rotor 10 being partially intercepted by roll 6 and thrown downwardly onto rotor 10 at an angle substantially the same as the normal angle at which the material strikes this rotor. Where the effective widths of bights 12 and 16 are greater than about one-quarter of the maximum diameter of the roll as in prior 3-rotor arrangements of this type, such a deflection of stream 4 can result in material thrown from the rotor 8 to rotor 10 traveling over and completely missing rotor 10, or striking it at such an angle that the material merely spatters off the rotor. The "effective width" of bight 12, for example, is the shortest distance between the periphery of rotor 8 and the nearest surface of roll 6 defining its effective diameter. It will be seen, therefore, that the nestling of the distributor roll between the fiberizing rotors to provide short distances of travel for discharged material over relatively confined paths, is a concept which results in the apparatus of the present invention being capable of controlling abnormal deflections of the stream, without spattering and, hence, its ability to produce quality fiber at high production rates. While the bights 12 and 16 should be as narrow as possible consistent with free normal travel of molten material, as indicated above, the advantageous results of this nestling concept may nevertheless be attained to some degree with wider bights, but it is believed that bights of one-quarter the maximum diameter of the roll, or greater, should not be employed. It will be appreciated that the degree of nestling depends not only on the widths of the bights, but also on the diameter of the roll and, hence, the designation of the width in terms of a fraction of the diameter of the roll.

While the nestling of roll 6 between rotors 8 and 10 is considered essential to satisfactory operation of the 3-rotor unit of the type here disclosed, the reduction in length of stream travel between roll 6 and rotor 8, which is one object of the nestling, at the same time results in some diminution of opportunity for the stream to spread during this travel, and it is therefore desirable to employ a contouring of roll 6 particularly adapted to spread the stream in a short distance and yet guard against undesirable results from increasing the angle of spread.

Referring now to FIG. 2, it will be observed that the periphery of roll 6 is provided with an outwardly projecting annular ridge 30, located centrally of the surface, and annular groove-like areas 32 located at each side of the ridge, the borders of the groove-like areas being defined by the ridge sides and by outwardly projecting portions 34 at the sides of the periphery. The roll 6 may also be described as having a relatively deep annular groove in its periphery (both groove-like areas 32 being considered as one groove) and an annular ridge extending outwardly from the central portion of the bottom of the groove. The bottom of the groove or groove-

like areas 32 constitute the effective diameter thereof. The preferred dimensions and the location of the roll have been specified above, it being only necessary to add that the roll is so located with respect to cupola 2 that stream 4 strikes and is divided by the ridge 30 so that the divided portions of the stream are received in groove-like areas 32. While it is the purpose of the ridge to divide the stream and result in material being discharged to a wider area of the peripheral surface of rotor 8, it is desirable that the material be discharged in a direction as nearly perpendicular to the rotor axes as is practicable so that all material discharged from roll 6 to rotor 8 and from rotor 8 to rotor 10 is intercepted by a surface. While various contours of ridge 30 will promote the result just described, it has been found particularly satisfactory to make the ridge peaked, as shown, with the sides of the ridge intersecting at the peak at an acute angle, preferably an angle in the neighborhood of 40°. Side portions 34 function to prevent material from being discharged from roll 6 at a great angle and hence insure that even with wobbling of the stream, discharged material will strike the peripheral surface of rotor 8.

The molten material discharged from the groove-like areas 32 of roll 6 is intercepted by the peripheral surface of rotor 8 over a relatively wide band without substantial spattering. A portion of the material intercepted by rotor 8 bonds to the surface thereof in the form of an incandescent ring and another portion is discharged onto rotor 10. The portion of the molten material discharged by rotor 8 is intercepted by rotor 10 over a relatively wide band without substantial spattering and apparently the great majority of material so intercepted by rotor 10 bonds to the surface thereof in the form of an incandescent ring, although it is believed that some substantial portion of this material may be thrown back onto rotor 8. The material in the incandescent rings is thrown from the respective rotors in the form of fiber and, because of the peculiar construction of the apparatus of the instant invention, longer fiber is produced in greater quantity than with prior apparatus of this type. Because of the length and quantity of fiber, and its formation in areas adjacent the peripheral surfaces of the rotors, the problem of removing the fiber from these areas to prevent its prolonged bombardment by shot (unfiberized particles of material) is more critical in the apparatus of the present invention than with prior arrangements.

Referring to FIGS. 3 and 4, there is disclosed fluid conduits 40, 42 and 44 arranged concentrically of and extending partially around the shafts of roll 6 and rotors 8 and 10, respectively, the conduits being mounted in wall 50 of the conventional housing (not completely shown). The radius of each conduit is somewhat greater than the maximum radius of the corresponding roll or rotor, so that each conduit is spaced radially outwardly thereof. On the sides of the conduits adjacent the roll and rotors, there is provided a series of orifices 45 arranged to direct fluid blasts across the peripheries of the roll and rotors at locations completely surrounding the roll and rotors, except for that portion of the apparatus adjacent the stream 4. The conduits are connected to a fluid source, preferably steam, and the fluid blasts therefrom cause fiber formed adjacent the rotor surfaces to move away from the rotors in the direction of the curved arrows in FIG. 4. The term "fluid blasts," as used herein, refers to blasts created by release of a fluid under pressure and does not refer to fluid currents caused by suction. By reason of the greater momentum of the shot, however, it travels in the direction of the straight arrows in FIG. 4 and is relatively unaffected by the fluid blasts. The provision of fluid blast means thus enables the fiber to be quickly removed from the area of formation and not only results in less bombardment of the fiber by shot, but also aids in partial separation of shot from the fiber.

Having thus described our invention in rather full de-

tail, it will be understood that these details need not be strictly adhered to and that various changes and modifications may suggest themselves to one skilled in the art, all falling within the scope of the invention as defined by the subjoined claims.

What we claim is:

1. Apparatus for converting a molten raw material into fibers comprising means for delivering a stream of said material, fiberizing means including an annular fiberizing surface, a distributor roll having a periphery positioned to receive said stream and discharge said material onto said fiberizing surface, said periphery having a major portion of the width thereof in the form of a relatively deep annular groove, and an annular stream-dividing ridge extending outwardly from an intermediate portion of the bottom of said groove, said ridge being positioned to intercept and spread said stream.

2. Apparatus for converting a molten raw material into fibers comprising means for delivering a stream of said material, fiberizing means including an annular fiberizing surface, and a distributor roll having a periphery positioned to receive said stream and discharge said material onto said fiberizing surface, said periphery including an outwardly projecting annular ridge located at an intermediate portion thereof to intercept and spread said stream, and an annular groove-like area at each side of said ridge.

3. The apparatus of claim 2, wherein said ridge is peaked and includes side surfaces intersecting at the peak at an acute angle.

4. Apparatus for converting molten raw material into fibers comprising means for delivering a stream of the material, a pair of substantially identical fiberizing rotors having generally annular peripheral surfaces positioned

in opposed adjacent relationship to define a bight therebetween having a width at the narrowest point thereof less than $\frac{1}{2}$ the maximum diameter of said rotors, said rotors each being fixed to one end of a rotatably mounted shaft, means for rotating said shafts at high speed in directions to move said surfaces generally downwardly at said bight, a distributor roll having a maximum diameter substantially less than the maximum diameter of said rotors fixed to one end of a rotatable shaft for rotation above said bight and nestled between said rotors, said roll having a periphery positioned in opposed adjacent relation to the peripheral surfaces of said rotors and including an outwardly projecting annular ridge located at an intermediate portion thereof and an annular groove-like area at each side of said ridge, said roll being positioned so that said ridge intercepts and spreads said stream and said periphery being spaced from said surfaces by distances less than one-quarter the maximum diameter of said roll, means for rotating said roll shaft at high speed, and segmental fluid conduits arranged concentrically of and partially around said shafts each on a radius greater than the maximum radius of the corresponding rotor or roll, said conduits having orifices therein arranged to direct fluid blasts across said surfaces.

References Cited in the file of this patent

UNITED STATES PATENTS

2,153,739	Buss	Apr. 11, 1939
2,274,130	Davis	Feb. 24, 1942
2,520,168	Powell	Aug. 29, 1950
2,646,593	Downey	July 28, 1953

FOREIGN PATENTS

668,490	Great Britain	Mar. 19, 1952
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