Multicomponent Fibers

1971

C. Placek

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Thirty-Five Dollars

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FOREWORD

The detailed, descriptive information in this book is based on U.S. Patents since 1960 relating to the production of multicomponent fibers.

This book serves a double purpose in that it supplies detailed technical information and can be used as a guide to the U.S. patent literature in this field. By indicating only information that is significant, this book then becomes an advanced review of multicomponent fiber technology.

The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical, commercial, timely process information assembled here than is available from any other source. The technical information obtained from a patent is extremely reliable and comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure".

The patent literature covers a substantial amount of information not available in the journal literature. The patent literature is a prime source of basic commercially utilizable information. This information is overlooked by those who rely primarily on the periodical journal literature. It is realized that there is a lag between a patent application on a new process development and the granting of a patent, but it is felt that this may roughly parallel or even anticipate the lag in putting that development into commercial practice.

Many of these patents are being utilized commercially. Whether used or not, they offer opportunities for technological transfer. Also, a major purpose of this book is to describe the number of technical possibilities available, which may open up profitable areas of research and development.

These publications are bound in paper in order to close the time gap between "manuscript" and "completed book". Industrial technology is progressing so rapidly that hard cover books do not always reflect the latest developments in a particular field, due to the longer time required to produce a hard cover book.

The Table of Contents is organized in such a way as to serve as a subject index. Other indexes by company, inventor, and patent number help in providing easily obtainable information.

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INTRODUCTION

Few segments of the chemical process industries can boast of production statistics as imposing as those which characterize the man-made fiber industry during the 1960's. And, perhaps even fewer can claim as large a number of variations in their products. With man-made fibers, one major reason for these many variations lies among multicomponent (also called multisubstituent) fibers — that is, those filaments which consist of two or more polymeric compounds spun together. Processes for fiber blends, which bring together single filaments after spinning, are not included in this publication.

The fraction of man-made fiber production accounted for by multicomponent materials is not a figure generally reported. These data are usually lumped together with statistics pertaining to the fiber that is the major component. For instance, data concerning a fiber which consists of 75% nylon and 25% of one or more other polymers would appear among the totals for nylon. For purposes of this report, however, such a composition is a multicomponent one, as is a fiber consisting of two or more different types of nylon.

That research and development had a busy decade insofar as multicomponent fibers are concerned is evidenced by this report, which covers 106 patents issued between 1960 and the first ten months of 1970. These processes range over a wide spectrum of fiber technology — composition, properties, physical forms, and spinning technology. The common denominator among these processes is that they all deal with multicomponent fibers, but each one includes one or more of the other parameters as well. A study of each of these processes, however, does show a particular thrust, or emphasis, that enables setting it apart from others which, at least on the surface, bear a close resemblance. This report is organized in the following manner.

Chapters 1 and 2 deal with the chemical nature of the polymers. The distinction here is a chemical one — the kind of polymers used — although of necessity these chapters also include spinning technology and some other considerations which overlap with succeeding chapters.

Chapters 3 and 4 deal with crimping processes. Crimping can be accomplished mechanically or by choice of fiber components and/or processing conditions. The latter approach is the one dealt with here.

Chapters 5, 6, and 7 deal with properties of multicomponent filaments — adhesion, dyeability, and cross sections, to mention but three.

Chapter 8 covers spinning technology. Although all the processes in this book involve spinning, the emphasis in this chapter is on spinning regardless of the polymers involved, together with auxiliary matters such as spinneret plates, handling of polymer solutions, and the like. Subsequent treatment of the fibers produced by these methods is not included.

Finally, for a more complete overview of multicomponent fiber processes, the reader is urged to view each chapter (and the processes in it) in context with the others. The compartmentalization used here is primarily one of organization and, hopefully, convenience. Cross references appear throughout the report, further evidence of the kinship among developments in this field.

VARIATIONS OF THE SAME POLYMER

GLASS WITH GLASS

A process developed by R.L. Tiede; U.S. Patent 3,073,005; January 15, 1963 and U.S. Patent 3,259,479; July 5, 1966; both assigned to Owens-Corning Fiberglas Corporation gives curled glass fibers formed of a composite of more than one glass. Synthetic fibers, such as glass fibers or synthetic resin fibers, are usually smooth surfaced and straight with limited tendencies toward interadherence or establishment of interclinging relationships of themselves, but instead being more slidably related en masse than interlocking.

Glass fibers in particular are of this character, but in addition, such fibers have limited extensibility which in some instances is of itself a limitation preventing their adaptability for specific application. The properties of curliness in synthetic fibers overcomes these limitations and makes the fibers adaptable for many applications where they would otherwise be barred from use.

Methods for forming continuous or discontinuous curly glass fibers have been developed in the past, but in each such method, some type of aftertreatment is required following formation of the fibers to impart the properties of curliness desired. Glass fibers are known to have weakness to abrasion accordingly, and the method of imparting the curliness is desirably such that it be accomplished without physical handling such as in an aftertreatment.

Aftertreatment usually entails physical action on the fiber such as a mechanical crimping or curl setting of the fibers while hot when the surfaces are especially subject to damage due to abrasion. Such action requires special handling and almost invariably reduces the maximum attainable strength of the fibers.

The process consists of combining, into individual fibers, glasses having different coefficients of expansion brought into intimate side-by-side contacting relationship in the fiber forming region in such a way that there is very little diffusion and they are capable of being attenuated into a single fine fiber with each glass lending its individuality in properties to such fiber.

As the fiber so-produced cools to room temperature the differences in coefficients of expansion of the composite establishes forces due to contraction, which in the absence of restraint cause the fibers to curl. The radius of curl is dependent upon the relative magnitude of the coefficients of expansion of the different glasses and upon the diameter of the resulting fiber.

Variations of the Same Polymer

Thin biglass fibers usually curl more tightly than thick composite fibers of the same glasses. The following are examples of glass compositions which may be paired to produce curly biglass fibers or filaments. Composition "A" is a commercially used standard composition for textile fibers, while streams of any of compositions "B," "C," and "D" can be combined with composition "A" to successfully form curly fibers.

Compositions

	A	B	C	D
SiO_2	54.2	65.0	64.0	72.7
Al_2O_3	14.6	3.6	4.0	2.0
CaO	17.3	14.4	-	5.6
MgO	4.6	2.7	-	3.3
B_2O_3	8.4	5.5	6.0	-
Na_2O	0.6	8.2	16.0	15.6
K_2O	-	-	-	0.2
TiO_2	-	-	4.0	-
ZrO_2	-	-	2.0	-
Fe_2O_3	0.2-0.3	0.2-0.3	0.14	0.2-0.3
Zn	-	-	3.0	-
Coefficient of thermal expansion x 10^{-7} per °C.	50	72	80	87

Referring to the drawings, Figure 1.1a illustrates a strand forming operation in which glass fibers 12 are attenuated from orificed tips 11 of a feeder 10 containing and supplying two separate glasses as hereinafter described in greater detail. After attenuation, the fibers 12 are drawn over a roll-type size applicator 13 for receipt of a coat of sizing material prior to the fibers being drawn together over a gathering wheel 14 at which the fibers are formed into a strand 15.

The strand 15 is wound by a winder 17 into a package on a rotating collet 19 and is traversed into the package by a suitable traverse such as a spiral wire-type traversing device 18. The fibers are wound into the package under tension, and thus, even though being inherently of a curly character, the curl of the fibers does not evidence itself until the strand is released from its taut or tensioned condition in the package.

Figure 1.1b illustrates the helical form of a single fiber produced by combining a pair of glasses in side-by-side relationship to produce a curled biglass fiber or filament. The shape illustrated corresponds to that acquired by a free biglass fiber when released from a taut condition such as on a package. A free strand of such curly fibers acquires a corresponding curled condition.

Figure 1.1c illustrates a feeder 30 in which two glasses are partitioned from each other by a divider 31 extending generally through the longitudinal center of the feeder. Electrical terminals are provided at opposite ends of the length of the feeder in conventional manner and electrical current is passed therethrough to heat the molten masses contained in the feeder, but the lower portion of the feeder is baffled, or in a sense bridged widthwise so that each glass extending through the lengthwise half has access to the full width of the feeder in alternate zones along the length of the feeder.

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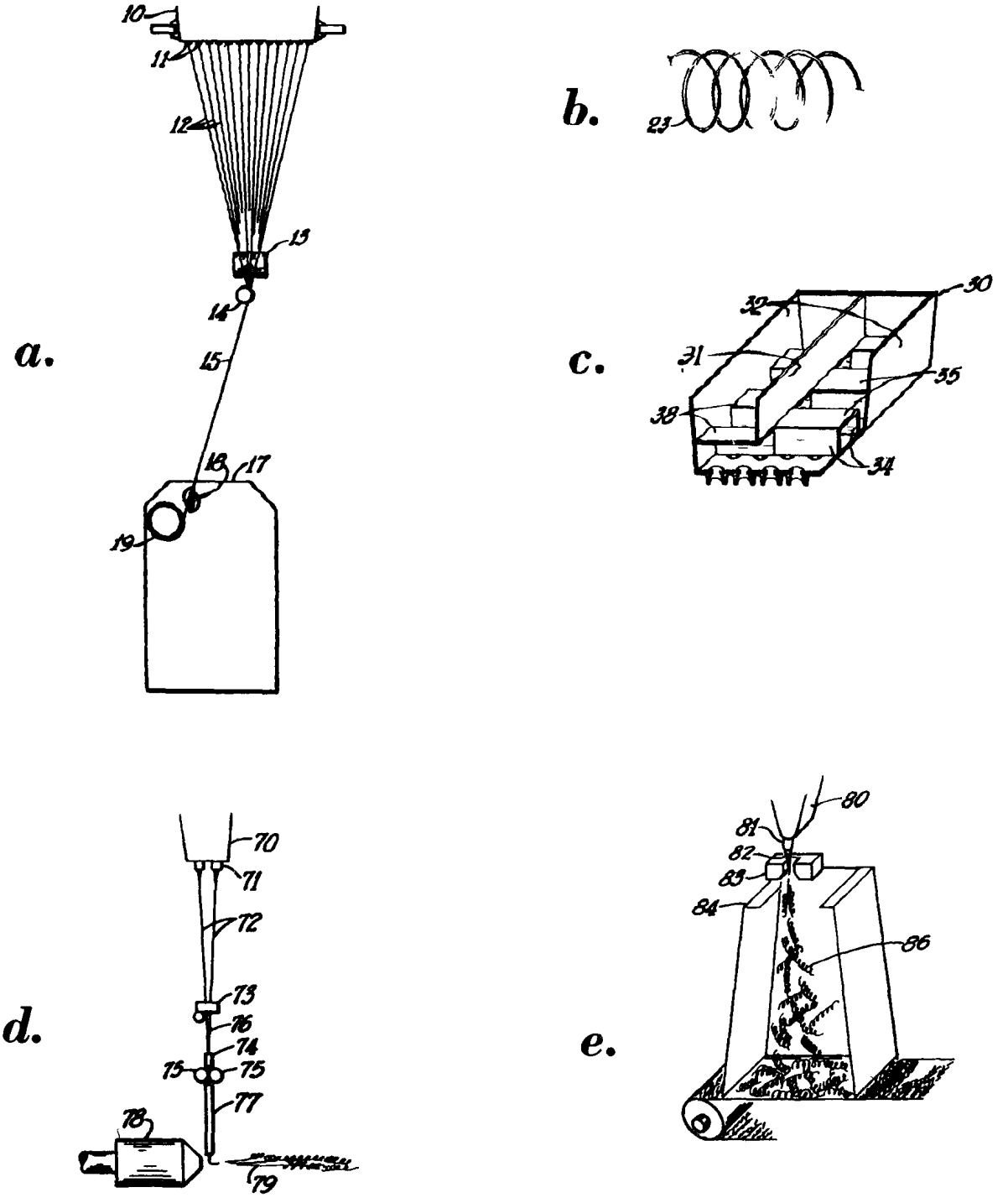
FIGURE 1.1: METHODS OF MAKING COMPOSITE GLASS FIBERS CONTAINING TWO GLASSES



Source: R.L. Tiede; U.S. Patent 3,073,005; January 15, 1963

The baffling is provided by a series of cross-wise partitions 34 spaced from each other the distance equal to the space along the length of the feeder between cross-wise rows of orifices. The partitions 34 extend across the full width of the feeder interior between the longitudinal exterior walls 32 and each is arranged to bisect a row of tip channels or orifices in the tip section of the feeder.

The partition 31 extends from the upper portion of the feeder down to the top of the cross-wise partitions 34. Overhanging flow blocking portions or bridges 35 extend from the front side wall 32 in Figure 1.1c between alternate adjacent pairs of the baffles 34, while overhanging bridge portions 38 are provided next to the back side wall 32 in Figure 1.1c between the alternate adjacent pairs of baffles 34 not bridged by the bridging portions 35.

Such construction maintains the two glasses separated on opposite sides of the partition 31, but with access to each row of tips, since the alternate zones in the tip section each provide a path of emergence for its respective glass through two adjacent rows of half orifices in the bisected tips. The tips thus each provide abutting paths of flow for the two glasses in the feeder and as many longitudinal rows of orifices distributed across the width of the feeder may be formed as are desired.

The feeder is replenished with the two separate fiber forming materials by introduction of marbles or other solid forms of the two materials in their respective separate compartments within the feeder, where they may be maintained at desired levels by suitable level controls. Alternately, molten forms of each of the materials can be introduced into the feeders from separate melting sources, and the materials in each compartment can be maintained and regulated by suitable associated electrical controls.

Figures 1.1d and 1.1e illustrate other fiber forming processes where discontinuous biglass curly fibers are producible. In the process and arrangement of Figure 1.1d, biglass streams, are first attenuated to produce primary fibers or fibers of diameter greater than the finally desired diameter. The primaries are then reattenuated by the high energy blast of a combustion blowing burner to produce secondary, finer fibers of biglass curly character.

As illustrated, a feeder 70 having a pair of rows of partitioned tips 71 supply biglass streams which are attenuated into biglass primary fibers 72. Attenuation of the streams is effected by forces supplied by coacting feed rolls 75 which draw the primaries through a roller guide assembly 73 which hold the fibers in separated and supported relationship as a fan 76 prior to passage through a top guide 74 to the feed rolls 75.

The feed rolls are driven by motor drive means not illustrated. The primary fibers 72 are then fed in aligned relationship through a bottom guide 77 which supports them and aids in penetration of the ends of the fibers into the combustion blast of the burner 78 to produce long, fine secondary fibers 79 of biglass curly character.

Figure 1.1e illustrates another process by which discontinuous fine biglass curly fibers can be produced where gaseous blasts such as from steam air blowers act on the biglass streams to attenuate them into biglass fibers. As illustrated, the feeder 80, having a single row of partitioned tips 81 supplies biglass streams 82 which are attenuated by gaseous blasts from a steam or air blower 83 disposed in the region of the fiber forming cones. The energy of

the blast acts to disrupt the biglass streams and form discontinuous lengths of biglass fibers 86 which are then passed through a hood 84 for accumulation or deposition on a conveyor disposed below.

In either of the arrangements of Figures 1.1d and 1.1e, the discontinuous biglass curly fibers can be accumulated or deposited on a conveyor to form a mat or other mass product. The curliness of the fibers in this arrangement impart a bulkiness to the mass, thereby reducing the density requirements for desired dimensions in the mass. Additionally, the curliness in providing a springy action provides a better recovery characteristic in the mass and is obtainable with straight fibers in a similar product.

Furthermore, the irritability frequently caused by contact with numerous ends of straight fibers is practically eliminated by reason of the individual fibers being more springy and being capable of bending back on themselves in the mass accumulation within which they are incorporated. Discontinuous fibers of this character are especially adaptable to forming staple-type yarns by false or actual twisting and drafting in view of their tendency to cling or interadhere.

TWO CELLULOSICS

Three processes dealing with cellulose-cellulose fibers were developed during the mid-60's. Two of these, both by Beaunit Corporation, are concerned with regenerated cellulose, while the third (by Celanese Corporation) deals with cellulose esters.

Crimpable Fibers of Regenerated Cellulose

The production of crimpable filaments by extruding two or more viscoses, having different shrinkage potentials, through the same spinneret hole is known. While these multicomponent filaments are superior in certain respects to single component filaments, i.e., in each of crimping and crimp retention, they are deficient in other characteristics such as abrasion resistance and resistance to soiling.

The processes developed by R. Woodell; U.S. Patent 3,097,414; July 16, 1963; and U.S. Patent 3,248,466; April 26, 1966; both assigned to Beaunit Corporation give a viscose rayon fiber consisting of two components, a first component having a transverse cross-section characterized by a smooth substantially uncrenulated contour and a thick, preferably at least 80%, skin, and a second component having a transverse cross section characterized by a smooth contour and a core surrounded by a skin, the percentage of skin in the second component being substantially less than the percentage of skin in the first component and the two components being fused together along their entire length to form a single coherent fiber.

The second component has at least about 20% less skin than the first component. Also, each component is substantially oval in shape and the two components are joined in such manner that their long axes, if extended to intercept one another, form a T.

The process for forming the yarn described above comprises preparing two viscoses, A and B, adding to viscose A a small amount of cyclohexylamine as a coagulation modifier, extruding

the two viscoses simultaneously in side-by-side relationship through the same spinneret hole into a coagulating and regenerating bath containing from 6.5 to 10% sulfuric acid, from 12 to 23% sodium sulfate, at least about 5% zinc sulfate and a small amount of cyclohexylamine, viscose A having a salt index of at least 5, viscose B having a salt index of at least 2, and stretching the yarn. Preferably the salt index of viscose A is at least 3 units higher than that of viscose B.

Figure 1.2a is an exploded view of a device useful in the extrusion of the yarn of the process. Figure 1.2b is a rear view of the equalizer and separator section of the device illustrated in Figure 1.2a. Figures 1.2c and 1.2d are illustrations of the yarn cross sections produced as described in Examples 1 and 3, respectively.

The apparatus used in each example is that shown in Figure 1.2a. The yarn produced is extruded through the orifices 1 of spinneret plate 2, the plate being positioned against the equalizer and separator section 3 by means of internally threaded spinneret adapter 4, flange 5 of the spinneret plate being held against the front face of the equalizer and separator section by the face 6 of the spinneret adapter.

Concentric cylindrical separator rings 7 extend through the equalizer and separator section, the rings being supported by the pressure equalizer plate 8 (shown in Figure 1.2b) which holds them in fixed relation to the circumference of the equalizer and separator section. The concentric cylindrical separator rings are beveled to a sharp edge which extends beyond the engaging threads of the equalizer and separator section to such an extent that when the spinneret plate 2 is positioned as previously described the sharp edges of the separator rings are immediately adjacent to the back face of spinneret plate 2 and so arranged that each edge bisects each orifice in a particular ring of the orifices.

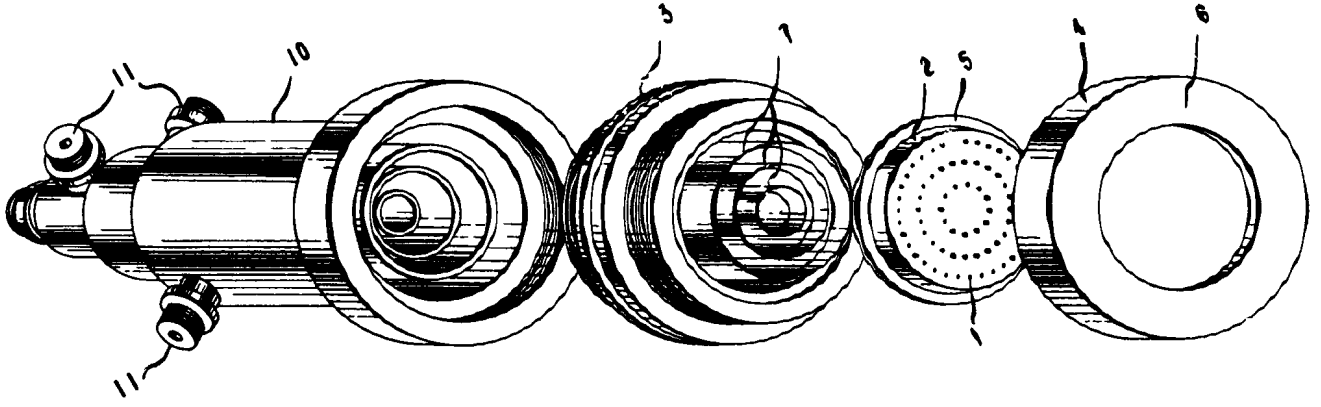
Pressure equalizer plate 8 (Figure 1.2b) contains concentrically arranged holes 9 fitting into spaces between the concentric separator rings previously described and act to control the pressure of, and prevent pressure surges in, viscose delivered to the spinneret plate. Pressure equalizer plate 8 fits by threaded means onto a concentric conduit 10 which contains openings 11 through which various viscoses may be pressure fed to the system.

Example 1: Two viscoses, A and B are prepared in the conventional manner. Viscose A containing 8% recoverable cellulose, and 7% alkali, calculated as sodium hydroxide, is prepared from cotton linters pulp using 30% carbon disulfide based on the air dry weight of the pulp. Sufficient cyclohexylamine is added to the viscose during the mixing operation to give a concentration of 0.15% by weight. Viscose B is prepared in an identical fashion except that the cyclohexylamine is omitted. Viscose A is ripened to a salt index of 8.3, and a viscosity of 40 poises while viscose B is ripened to a salt index of 2.7 and a viscosity of 45 poises.

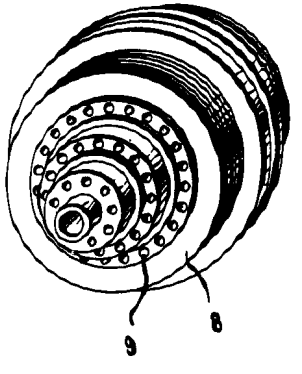
Viscoses A and B are then supplied by means of separate gear pumps, each having a delivery of 158 gpm to alternate openings of a concentric conduit as illustrated in Figure 1.2a. In this manner the two viscoses are extruded through each of the spinneret holes in side-by-side relationship by means of the separator rings and pressure equalizer assembly. A spinneret of 1 13/16 inches diameter having 250 holes of 0.008 inch diameter arranged in three concentric circles, the diameter of the circles being 1/2, 1 and 1 1/2 inches respectively is employed.

FIGURE 1.2: REGENERATED CELLULOSE FIBERS

a.

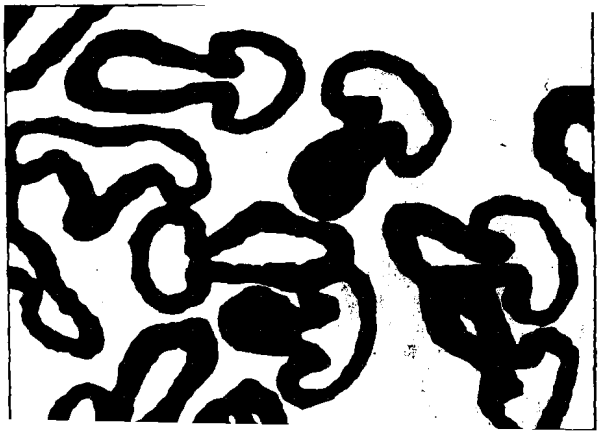


b.



(continued)

FIGURE 1.2: (continued)



Source: R. Woodell; U.S. Patent 3,097,414; July 16, 1963

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