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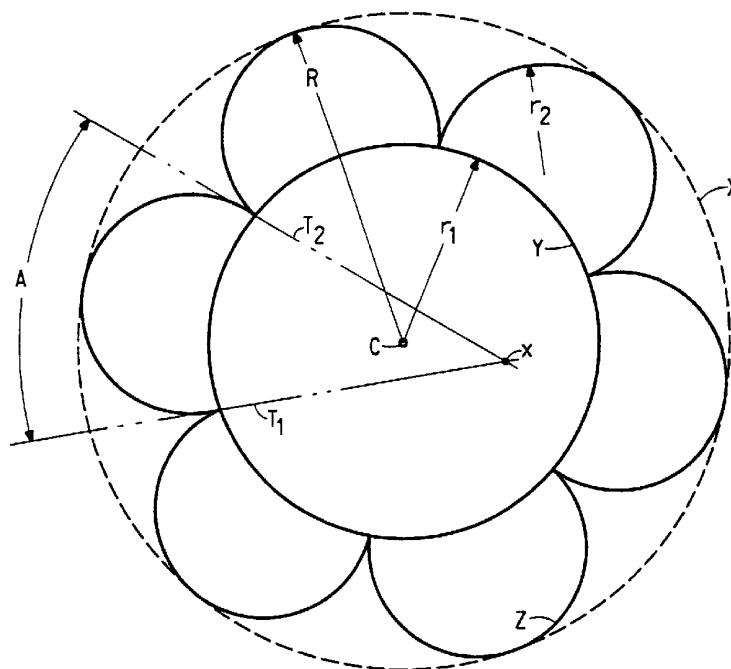
(57) **Abstract:** This invention provides polymer filaments having a multilobal cross-section. The cross-section can have a filament factor of about 2.0 or greater and a tip ratio of greater than about 0.2. The filaments may be used as-spun as a spin-oriented feed yarn or as a partially-oriented yarn. The multifilament yarns made from these filaments are useful to make articles with subdued luster and low glitter.

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TITLE OF THE INVENTION

MULTILOBAL POLYMER FILAMENTS
AND ARTICLES PRODUCED THEREFROM

FIELD OF THE INVENTION

This invention provides synthetic polymer filaments having multilobal cross-sections. The filaments may be used in their as-spun form, for example, in yarns resulting from high speed spin-orientation or coupled spin-drawing processes, or may be used as feed yarns for de-coupled drawing or draw texturing processes. The multifilament yarns made from these filaments are useful to make articles with subdued luster and low glitter.

BACKGROUND OF THE INVENTION

There is a desire to provide textured multifilament yarns capable of being converted into knitted or woven fabrics having no undesired glitter. Draw false twist texturing is a method for producing textured multifilament yarns by simultaneously drawing and false-twist texturing undrawn multifilaments. Draw false twist texturing of filaments eliminates the undesirable slickness of fabrics made from synthetic filaments as well as provides filaments with bulk, which provides better cover. However, false twist texturing and draw false twist texturing of filaments having round cross-sections deform the cross-sections of the filaments to a multi-faceted shape having essentially flat sides. As a result, fabrics made from these textured filaments exhibit a specular reflection from the flattened fiber surfaces creating an undesired glittering or sparkle. In addition, the denier per filament (dpf) may be reduced, for example, to improve the softness of the yarns, fabrics and articles produced therefrom, to less than about 5 dpf, or even

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to deniers below about 1. Such subdenier filaments are
also known as "microfibers". At these subdeniers, the
total amount of this specular reflection is
dramatically increased, due to the increase in total
5   fiber surface area.

Efforts to eliminate the glitter and sparkle
associated with filaments having a round cross-section
has led to the development of various multilobal cross-
sections. For example, U.S. Patent Nos. 5,108,838,
10   5,176,926, and 5,208,106 describe hollow trilobal and
tetralobal cross-sections to increase the cover to
minimize the weight of fiber needed to spread over an
area. These patents relate specifically to carpet
yarns and higher denier filaments, and not to filaments
15   suited for apparel or twist texturing.

Other modified cross-sections have also been
attempted to reduce the glitter from round cross-
sectional filaments. For example, U.S. Patent No.
4,041,689 relates to filaments having a multilobal
20   cross-section. Moreover, U.S. Patent No. 3,691,749
describes yarns made from multilobal filaments prepared
from PACM polyamide. However, the filaments described
in these patents still need to be textured prior to use
and do not provide a means to reduce glitter of fine
25   denier and especially subdenier filaments, yarns,
fabrics and articles produced therefrom.

Other efforts to reduce glitter include the use of
polymer additives. For example, delustrants, such as
titanium dioxide, have been used to decrease the
30   glittering effect from textured yarns. However, such
delustrants alone have been ineffective in reducing the
glitter of fibers having fine deniers.

Various fiber and fabric treatments have been
proposed that effect glitter including caustic
35   treatments. However, such caustic approaches have
inherent disadvantages such as added costs and/or
increased waste by-products.

The use of multicomponent fibers to reduce the glitter effect has also been attempted. For example, U.S. Patent No. 3,994,122 describes a mixed yarn comprising 40-60% by weight of trilobal filaments having a modification ratio within the range of 1.6-1.9, and 40-60% by weight of trilobal filaments having a modification ratio within the range of 2.2-2.5. In addition, U.S. Patent No. 5,948,528 describes obtaining a filament having modified cross-sections for bicomponent fibers, wherein the fibers are composed of at least two polymer components having different relative viscosities. While yarns made from such multicomponent filaments have a bulking effect that does not necessarily require additional texturing, the production of these fibers are encumbered by the necessity to use a mixture of two or more different polymers or fibers.

Accordingly, there is a need to obtain a filament that can be used to make yarns, and articles therefrom, such as fabrics and apparel, having reduced glitter and shine without the necessity for high levels of added delustrants or fabric after-treatments, and that provide the desirable low glitter and shine without the need for additional texturing. Additionally, there is a need, that, if desired, the filaments can be textured, including by false-twist texturing or by draw false-twist texturing, and still provide the desirable low glitter and low shine to the yarns, fabrics and articles produced therefrom. There is additionally a need to obtain a low denier filament, preferably a filament that can be drawn to a subdenier filament, and especially preferred a filament that is subdenier as-produced, that provides low glitter and shine to the fine denier yarns, fabrics and articles produced therefrom. These low denier and subdenier filaments should have sufficient tensile properties to enable the filaments to be subsequently processed, with low levels

of broken filaments, into fabrics and articles
therefrom.

SUMMARY OF THE INVENTION

In accordance with these needs, the present
invention provide a synthetic filament having a
multilobal cross-section, a filament factor of about 2
or greater, wherein the filament factor is determined
according to the following formula:

$$FF = K_1 * (MR)^A * (N)^B * (1/(DPF)^C [K_2 * (N)^D * (MR)^E * 1/(LAF) + K_3 * (AF)],$$

wherein K_1 is 0.0013158; K_2 is 2.1; K_3 is 0.45; A is
1.5; B is 2.7; C is 0.35; D is 1.4; E is 1.3; MR is
R/r_1, wherein R is the radius of a circle centered in
the middle of the cross-section and circumscribed about
the tips of the lobes, and r_1 is the radius of circle
centered in the middle of the cross-section and
inscribed within the cross-section about the connecting
points of the lobes; N is the number of lobes in the
cross-section; DPF is the denier per filament; LAF is
$(TR) * (DPF) * (MR)^2$, wherein TR is r_2/R, wherein r_2 is the
average radius of a circle inscribed about the lobes,
and R is as set forth above, and DPF and MR are as set
forth above; and AF is 15 minus the lobe angle, wherein
the lobe angle is the average angle of two tangent
lines laid at the point of inflection of curvature on
each side of the lobes of the filament cross-section,
and an average tip ratio of $\geq$ about 0.2.

In another embodiment of the invention, a filament
having a multilobal cross-section, wherein the lobe
angle is $\leq$ about 15° and a denier of less than about 5
dpf is disclosed.

The present invention is further directed to
multifilament yarns formed at least in part from the
filaments of the present invention, and fabrics and
articles formed from such yarns.

In another aspect of the invention, a spinneret capillary correlating to a multilobal cross-section with a filament factor of about 2.0 or greater and a tip ratio of greater than about 0.2 is disclosed.

5   In yet another aspect of the invention, there is provided a process for making a filament having a multilobal cross-section, wherein the filament cross-section has a filament factor of $\geq$ about 2.0 and a tip ratio of $\geq$ about 0.2, said process comprising melting a

10   melt-spinnable polymer to form a molten polymer; extruding the molten polymer through a spinneret capillary designed to provide a cross-section having a filament factor of $\geq$ about 2.0 and a tip ratio $\geq$ of 0.2; quenching the filaments leaving the capillary;

15   converging the quenched filaments; and winding the filaments.

The present invention is further directed to a method for reducing glitter in fabric comprising forming said fabric using at least one filament having

20   a multilobal cross-section, a filament factor of about 2 or greater, and a tip ratio of $\geq$ about 0.2.

BRIEF DESCRIPTION OF THE DRAWINGS

25   Fig. 1 represents an illustration of how the modification ratio, lobe angles, and filament factors may be determined based upon measurements of the filament cross-sections.

Fig. 1A is one embodiment of a spinneret capillary

30   that may be used to produce filaments having a 3-lobed cross-section of the present invention.

Fig. 1B is another embodiment of a spinneret capillary that may be used to produce filaments having a 6-lobed cross-section of the present invention.

35   Fig. 1C is another embodiment of a spinneret capillary that may be used to produce filaments having a 6-lobed cross-section of the present invention.

Fig. 2 is a cross-section of trilobal filaments of the present invention. Figure 2A represents the cross-section of the filaments as-spun, having an average DPF of 0.91, MR of 2.32, TR of 0.45, lobe angle of -54.4

5   degrees, and FF of 4.1. Figure 2B represents the cross-section of the filaments after draw false-twist texturing at a 1.44 draw ratio.

Fig. 3 is a cross-section of hexalobal filaments of the present invention. Figure 3A represents the

10   cross-section of the filaments as-spun, having an average DPF of 5.07, MR of 1.48, TR of 0.34, lobe angle of -18.8 degrees, and FF of 4.5. Figure 3B represents the cross-section of the filaments after draw false-twist texturing at a 1.53 draw ratio.

15   Fig. 4 is a cross-section of hexalobal filaments of the present invention. Figure 4A represents the cross-section of the filaments as-spun, having an average DPF of 5.06, MR of 1.70, TR of 0.25, lobe angle of 3.8 degrees, and FF of 4.0. Figure 4B represents

20   the cross-section of the filaments after draw false-twist texturing at a 1.53 draw ratio.

Fig. 5 is a cross-section of hexalobal filaments of the present invention. Figure 5A represents the cross-section of the filaments as-spun, having an

25   average DPF of 5.06, MR of 1.57, TR of 0.26, lobe angle of 6 degrees, and FF of 3.4. Figure 5B represents the cross-section of the filaments after draw false-twist texturing at a 1.53 draw ratio.

Fig. 6 is a cross-section of subdenier trilobal

30   filaments of the present invention, having an average DPF of 0.72, MR of 2.41, TR of 0.45, lobe angle of -51 degrees, and FF of 4.5.

Fig. 7 is a cross-section of hexalobal filaments of the present invention. Figure 7A represents the

35   cross-section of the filaments as-spun, having an average DPF of 1.62, MR of 1.38, TR of 0.32, lobe angle of -5.4 degrees, and FF of 11.0.   Figure 7B

represents the cross-section of the filaments after
draw false-twist texturing at a 1.44 draw ratio.

5   Fig. 8 is a cross-section of hexalobal filaments
of the present invention as spun, having an average DPF
of 0.99, MR of 1.33, TR of 0.35, lobe angle of 4.8
degrees, and FF of 16.7.

        Fig. 9 is a comparative cross-section of a
conventional trilobal filament as described in U.S.
Patent No. 2,939,201.

10   Fig. 10 is a comparative cross-section of
octalobal filaments of a commercially available
product. Figure 10A represents a cross-section of the
filaments as-spun, having an average DPF of 5.1, MR of
1.21, TR of 0.29, lobe angle of 86 degrees, and FF of -

15 2.4. Figure 10B represents the cross-section of the
filaments after draw false-twist texturing at a 1.53
draw ratio.

        Fig. 11 is a comparative cross-section of trilobal
filaments not within the scope of the present

20 invention, having an average DPF of 5.05, MR of 2.26,
TR of 0.45, lobe angle of -39 degrees, and FF of 1.3.

        Fig. 12 is a cross-section of 4-lobed filaments of
the present invention that are asymmetrical. The
shortest lobe had a FF of 5.27 and the longest lobe had

25 a FF of 8.83. The filaments have an average DPF of
1.28 and negative lobe angle.

DETAILED DESCRIPTION OF THE
PREFERRED EMBODIMENTS OF THE INVENTION

30   The filaments of the present invention have a
multilobal cross-section. A preferred multilobal
includes a cross-section having an axial core with at
least three lobes of about the same size. Preferably,
the number of lobes is between 3 to 10 lobes, most

35 preferably between 3 to 8 lobes, for example, having 3,
4, 5, 6, 7, or 8 lobes. The lobes of the cross-section
may be symmetrical or asymmetrical. The lobes may be

essentially symmetrical having substantially equal
lengths and equispaced radially about the center of the
filament cross-section. Alternatively, the lobes may
have different lengths about the center of the filament
5   cross-section, but where the cross-section is still
symmetrical, i.e., having two sides being essentially
mirror images of each other. For example, Figure 12
shows a cross-section of the present invention having
four lobes, wherein the lobes have different lengths,
10   but the lobes are arranged symmetrically around the
core. In yet another embodiment, the lobes may be
asymmetrical having different lengths about the center
of the filament cross-section and the cross-section may
be asymmetrical.
15   The core and/or lobes of the multilobal cross-
section of the present invention may be solid or
include hollows or voids. Preferably, the core and
lobes are both solid. Moreover, the core and/or lobes
may have any shape provided that the tip ratio is $\geq$
20   about 0.2, preferably $\geq$ about 0.3, most preferably $\geq$
about 0.4, and either the filament factor is $\geq$ about 2
or the lobe angle is $\leq$ 15°, as described. Preferably,
the core is circular and the lobes are rounded and
connected to the core, wherein adjacent lobes are
25   connected to one another at the core. Most preferably,
the lobes are rounded, for example, as shown in Figure
1.
The term "essentially symmetric lobes" means that
a line joining the lobe tip to center C will bisect the
30   lobe area located above (outside of) circle Y, as shown
in Figure 1, into two approximately equal areas, which
are essentially mirror images of one another.
By "lobes equispaced radially" is meant that the
angle between a line joining any lobe tip to center C,
35   as shown in Figure 1, and the line joining the tip of
the adjacent lobe is about the same for all adjacent
lobes.

The term "equal length" when applied to lobes
means that in a cross-sectional photomicrograph, a
circle can be constructed, which passes the margins of
each of the tips of the lobes tangentially. Small
5   variations from perfect symmetry generally occur in any
spinning process due to such factors as non-uniform
quenching or imperfect spinning orifices. It is to be
understood that such variations are permissible
provided that they are not of a sufficient extent to
10   cause glitter in fabrics after texturing.

The tip ratio (TR) is calculated according to the
following formula: $TR = r_2/R$, where r_2 is the average
radius of the lobes and R is the radius of circle X
centered at C and circumscribed about the tips of the
15   lobes Z. When all the lobes have essentially the same
radius r_2, the tip ratio is essentially the same for
each lobe. However, the lobes may have different
lengths r_2 relative to each other for both symmetrical
and asymmetrical cross-sections of the present
20   invention. For example, a cross-section of the present
invention may include four lobes, wherein two lobes
have one length and the other two lobes have a
different length, but where the two sides of the cross-
section are symmetrical. Alternatively, the lobes may
25   have different lengths r_2, wherein the two sides of the
cross-section are asymmetrical. Moreover, it is noted
that the radius R may be different for lobes having
different lengths because R is based on a circle X
circumscribing the tips of the lobes. For both
30   symmetrical and asymmetrical lobes, the tip ratio for
each lobe is calculated based on the particular r_2
length of the lobe and the radius R of the circle X
circumscribing each lobe. Then, an average of the tip
ratios for each of the lobes is calculated. As used
35   herein, the "tip ratio" refers to the average tip
ratios for a cross-section unless otherwise specified.
Any suitable tip ratio may be used provided that either

the filament factor is ≥ about 2 or the denier per
filament (dpf) is ≤ about 5. Preferably, the tip ratio
is ≥ about 0.2, more preferably, ≥ about 0.3, and most
preferably ≥ about 0.4. Also, when the lobes are
5   asymmetrical the lobes may differ in other geometric
parameters such as lobe angle or modification ratio, or
in combinations of differing geometric properties such
as modification ratio and lobe angle, as long as the
average filament factor for the filament is at least
10   2.0.
     The lobe angle of the lobes of the filament cross-
section is the angle of two tangent lines laid at the
point of inflection of curvature on each side of the
lobe and may be either negative, positive, or zero.
15   Referring to Figure 1, the lobe angle, A, is considered
to be negative when the two tangent lines T_1 and T_2
converge at a point X inside of the cross-section or
exterior to the cross-section on the side opposite to
the lobe. Conversely, a lobe angle is positive when
20   the two tangent lines converge at a point exterior to
the cross-section on the same side of the lobe (not
shown). As used herein, the "lobe angle" of the cross-
section is the average lobe angle unless otherwise
specified. The cross-section of the filaments of the
25   present invention can have any lobe angle. In one
preferred embodiment, the lobe angle is ≤ 15°, more
preferably, ≤ 0°, and even most preferably, ≤ -30°.
Negative lobe angles are especially preferred in the
filaments of the present invention.
30   The geometric cross-sections of filaments of the
present invention may further be analyzed according to
other objective geometric parameters. For example, the
filament factor (FF) is calculated according to the
following equation:

35

$$FF = K_1*(MR)^A*(N)^B*(1/(DPF)^C [K_2*(N)^D*(MR)^E*(1/(LAF)) + K_3*(AF)],$$

- 10 -

wherein, referring to Figure 1, modification ratio (MR)
= R/r_1; tip ratio (TR) = r_2/R; N is the number of lobes
in the cross-section, DPF is the denier per filament,

5 lobe angle is as described above, angle factor (AF) =
(15 - Lobe Angle), and lobe area factor (LAF) = (TR) *
(DPF) * $(MR)^2$. K_1 is 0.0013158, K_2 =2.1, K_3 = 0.45, A =
1.5, B = 2.7, C = 0.35, D = 1.4, and E = 1.3. R is the
radius of circle X centered at C and circumscribed

10 about the tips of the lobes Z. r_1 is the radius of
circle Y centered at C and inscribed within the cross-
section. r_2 is the average radius of the lobes. As
used herein, the "filament factor" of the cross-section
is the average filament factor for the cross-section.

15 It has been generally found that the greater the
filament factor, the less glitter. Preferably, the
filaments of the present invention have a filament
factor $\geq$ 2.0, more preferably, the filament factors is
$\geq$ 3.0, and most preferably, the filament factor is $\geq$

20 4.0.
     The filaments of the present invention may be made
of homopolymers, copolymers, terpolymers, and blends of
any synthetic, thermoplastic polymers, which are melt-
spinnable. Melt-spinnable polymers include polyesters,

25 such as polyethylene terephthalate("2-GT"),
polytrimethylene terephthalate or polypropylene
terephthalate ("3-GT"), polybutylene terephthalate ("4-
GT"), and polyethylene naphthalate,
poly(cyclohexylenedimethylene), terephthalate,

30 poly(lactide), poly[ethylene(2,7-naphthalate)],
poly(glycolic acid), poly(.alpha.,.alpha.-
dimethylpropiolactone), poly(para-hydroxybenzoate)
(akono), poly(ethylene oxybenzoate), poly(ethylene
isophthalate), poly(hexamethylene terephthalate),

35 poly(decamethylene terephthalate), poly(1,4-cyclohexane
dimethylene terephthalate) (trans), poly(ethylene 1,5-
naphthalate), poly(ethylene 2,6-naphthalate), poly(1,4-

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cyclohexylidene dimethylene terephthalate)(cis), and
poly(1,4-cyclohexylidene dimethylene
terephthalate)(trans); polyamides, such as
polyhexamethylene adipamide (nylon 6,6);
5   polycaprolactam (nylon 6); polyenanthamide (nylon 7);
nylon 10; polydodecanolactam (nylon 12);
polytetramethyleneadipamide (nylon 4,6);
polyhexamethylene sebacamide (nylon 6,10); the
polyamide of n-dodecanedioic acid and
10   hexamethylenediamine (nylon 6,12); the polyamide of
dodecamethylenediamine and n-dodecanedioic acid (nylon
12,12), PACM-12 polyamide derived from bis(4-
aminocyclohexyl)methane and dodecanedioic acid, the
copolyamide of 30% hexamethylene diammonium
15   isophthalate and 70% hexamethylene diammonium adipate,
the copolyamide of up to 30% bis-(P-
amidocyclohexyl)methylene, and terephthalic acid and
caprolactam, poly(4-aminobutyric acid) (nylon 4),
poly(8-aminooctanoic acid) (nylon 8), poly(hapta-
20   methylene pimelamide) (nylon 7,7), poly(octamethylene
suberamide) (nylon 8,8), poly(nonamethylene azelamide)
(nylon 9,9), poly(decamethylene azelamide) (nylon
10,9), poly(decamethylene sebacamide (nylon 10,10),
poly[bis(4-amino-cyclohexyl)methane-1,10-
25   decanedicarboxamide], poly(m-xylene adipamide), poly(p-
xylene sebacamide), poly(2,2,2-trimethylhexamethylene
pimelamide), poly(piperazine sebacamide), poly(meta-
phenylene isophthalamide) poly(p-phenylene
terephthalamide), poly(11-amino-undecanoic acid) (nylon
30   11), poly(12-aminododecanoic acid) (nylon 12),
polyhexamethylene isophthalamide, polyhexamethylene
terephthalamide, poly(9-aminononanoic acid) (nylon 9);
polyolefins, such as polypropylene, polyethylene,
polymethypentene, and polyurethanes; and combinations
35   thereof. Methods of making the homopolymers,
copolymers, terpolymers and melt blends of such
polymers used in the present invention are known in the

art and may include the use of catalysts, co-catalysts, and chain-branchers to form the copolymers and terpolymers, as known in the art. For example, a suitable polyester may contain in the range of about 1
5   to about 3 mole % of ethylene-M-sulfo-isophthalate structural units, wherein M is an alkali metal cation, as described in U.S. Patent No. 5,288,553, or 0.5 to 5 mole% of lithium salt of glycollate of 5-sulfo-isophthalic acid as described in U.S. Patent No.
10 5,607,765. Preferably, the polymer is a polyester and/or polyamide, and most preferably, polyester.

        Filaments of the invention can also be formed from any two polymers as described above into so-called "bicomponent" filaments, including bicomponent
15 polyesters prepared from 2-GT and 3-GT. The filaments can comprise bicomponent filaments of a first component selected from polyesters, polyamides, polyolefins, and copolymers thereof and a second component selected from polyesters, polyamides, polyolefins, natural fibers,
20 and copolymers thereof, the two components being present in a weight ratio of about 95:5 to about 5:95, preferably about 70:30 to about 30:70. In a preferred bicomponent embodiment, the first component is selected from poly(ethylene terephthalate) and copolymers
25 thereof and the second component is selected from poly(trimethylene terephthalate) and copolymers thereof. The cross-section of the bicomponent fibers can be side-by-side or eccentric sheath/core. When a copolymer of poly(ethylene terephthalate) or
30 poly(trimethylene terephthalate) is used, the comonomer can be selected from linear, cyclic, and branched aliphatic dicarboxylic acids having 4-12 carbon atoms (for example, butanedioic acid, pentanedioic acid, hexanedioic acid, dodecanedioic acid, and 1,4-cyclo-
35 hexanedicarboxylic acid); aromatic dicarboxylic acids other than terephthalic acid and having 8-12 carbon atoms (for example, isophthalic acid and 2,6-

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naphthalenedicarboxylic acid); linear, cyclic, and
branched aliphatic diols having 3-8 carbon atoms (for
example, 1,3-propane diol, 1,2-propanediol, 1,4-
butanediol, 3-methyl-1,5-pentanediol, 2,2-dimethyl-1,3-
5   propanediol, 2-methyl-1,3-propanediol, and 1,4-
cyclohexanediol); and aliphatic and araliphatic ether
glycols having 4-10 carbon atoms (for example,
hydroquinone bis(2-hydroxyethyl)ether, or a
poly(ethyleneether)glycol having a molecular weight
10   below about 460, including diethyleneether glycol).
Isophthalic acid, pentanedioic acid, hexanedioic acid,
1,3-propane diol, and 1,4-butanediol are preferred
because they are readily commercially available and
inexpensive. Isophthalic acid is more preferred
15   because copolyesters derived from it discolor less than
copolyesters made with some other comonomers. When a
copolymer of poly(trimethylene terephthalate) is used,
the comonomer is preferably isophthalic acid. 5-
sodium-sulfoisophthalate can be used in minor amounts
20   as a dyesite comonomer in either polyester component.
    Also, a yarn or fabric formed at least in part
from a filament having the cross-section of the present
invention may also include other thermoplastic melt
spinnable polymers or natural fibers, such as cotton,
25   wool, silk, or rayon in any amounts. For example, a
natural fiber and polyester filament of the present
invention in an amount of about 75% to about 25% of the
natural fiber and 25% to about 75% of the polyester
filament of the present invention.
30   It will be understood by one skilled in the art
that filaments of identical configuration but prepared
from different synthetic polymers or from polymers
having different crystalline or void contents can be
expected to exhibit different glitter. Nevertheless,
35   it is believed that improved glitter will be achieved
with any synthetic polymeric filament of the now-

specified configuration regardless of the particular
polymer selected.

The polymers and resultant fibers used in the
present invention can comprise conventional additives,
5   which are added during the polymerization process or to
the formed polymer, and may contribute towards
improving the polymer or fiber properties. Examples of
these additives include antistatics, antioxidants,
antimicrobials, flameproofing agents, dyestuffs,
10   pigments, light stabilizers, such as ultraviolet
stabilizers, polymerization catalysts and auxiliaries,
adhesion promoters, delustrants, such as titanium
dioxide, matting agents, organic phosphates, additives
to promote increased spinning speeds, and combinations
15   thereof. Other additives that may be applied on
fibers, for example, during spinning and/or drawing
processes include antistatics, slickening agents,
adhesion promoters, antioxidants, antimicrobials,
flameproofing agents, lubricants, and combinations
20   thereof. Moreover, such additional additives may be
added during various steps of the process as is known
in the art. In a preferred embodiment, delustrants are
added to the filaments of the present invention in an
amount of 0%, more preferably, less than 0.4%, and most
25   preferably, less than 0.2% by weight. If a delustrant
is added, preferably it is titanium dioxide.

The filaments of the present invention are formed
by any suitable spinning method and may vary based upon
the type of polymer used, as is known in the art.
30   Generally, the melt-spinnable polymer is melted and the
molten polymer is extruded through a spinneret
capillary orifice having a design corresponding to the
desired lobe angle, number of lobes, modification
ratio, and filament factor desired, according to the
35   present invention. The extruded fibers are then
quenched or solidified with a suitable medium, such as
air, to remove the heat from the fibers leaving the

capillary orifice. Any suitable quenching method may
be used, such as cross-flow, radial, and pneumatic
quenching.

Cross-flow quench, as disclosed, e.g., in U.S.
5   Patent Nos. 4,041,689, 4,529,368, and 5,288,553,
involves blowing cooling gas transversely across and
from one side of the freshly extruded filamentary
array. Much of this cross-flow air passes through and
out the other side of the filament array. "Radial
10   quench", as disclosed, e.g., in U.S. Patent Nos.
4,156,071, 5,250,245, and 5,288,553, involves directing
cooling gas inwards through a quench screen system that
surrounds the freshly extruded filamentary array. Such
cooling gas normally leaves the quenching system by
15   passing down with the filaments, out of the quenching
apparatus. The type of quench may be selected or
modified according to the desired application of the
filaments and the type of polymers used. For example,
a delay or anneal zone may be incorporated into the
20   quenching system as in known in the art. Moreover,
higher denier filaments may require a quenching method
different from lower denier filaments. For example,
laminar cross-flow quenching with a tubular delay has   .
particularly been found useful for fine filaments
25   having ≤ 1 dpf. Also, radially quenching has been
found preferred for fine filaments below 1 dpf.

Pneumatic quenching and gas management quenching
techniques have been discussed, for example, in U.S.
Patent Nos. 4,687,610, 4,691,003, 5,141,700, 5,034,182,
30   and 5,824,248. These patents describe processes
whereby gas surrounds freshly extruded filaments to
control their temperature and attenuation profiles.

The spinneret capillaries through which the molten
polymer is extruded are cut to produce the desired
35   cross-section of the present invention, as described
above. For example, the capillaries are designed to
provide a filament having a filament factor of at least

2.0, preferably $\geq$ 3.0, and most preferably $\geq$ 4.0. This may be done, for example, by modifying the capillary to give a filament having a desired modification ratio, number of lobes, and lobe angle. Furthermore, the

5   capillaries may further be designed to provide filaments having any lobe angle provided that the filament factor is $\geq$ 2.0. For example, the capillaries may be designed to provide filaments that have a lobe angle of $\leq$ 15°, preferably $\leq$ 0°, and most preferably $\leq$

10   -30°. The capillaries or spinneret bore holes may be cut by any suitable method, such as by laser cutting, as described in U.S. Patent No. 5,168,143, herein incorporated by reference, drilling, Electric Discharge Machining (EDM), and punching, as is known in the art.

15   Preferably, the capillary orifice is cut using a laser beam. The orifices of the spinneret capillary can have any suitable dimensions and may be cut to be continuous or non-continuous. A non-continuous capillary may be obtained by boring small holes in a pattern that would

20   allow the polymer to coalesce and form the multilobal cross-section of the present invention. Examples of spinneret capillaries suitable for producing filaments of the invention are shown in Figures 1A, 1B, 1C. Figure 1A depicts a spinneret capillary having three

25   slots 110 centrally-joined at a core 120 and projecting radially. The angle (E) between the slot center lines can be any suitable angle and the slot width (G) can have any suitable dimension. Furthermore, the end of the slots (H) may have any desired shape or dimension.

30   For example, Figures 1A and 1C show circular enlargement (H) at the end of the slots, while Figure 1B shows a rectangular opening having a width (J) and length (H) at the end of the slot. The length of the slots (F) can further be any desired length. The

35   spinneret capillaries of Figures 1A, 1B, and 1C may be modified to achieve different multilobal filaments having FF of at least 2.0, for example, by changing the

number of capillary legs for a different desired lobe
count, changing slot dimensions to change the geometric
parameters, for production of a different DPF, or as
desired for use with various synthetic polymers. For
5   example, in Figure 1A, the capillary can have an angle
(E) of 120°, a slot width (G) of 0.043 mm, a diameter
(H) of the circular enlargement at the end of the slot
of 0.127 mm, and a slot length (F) of 0.140. In Figure
1B, the capillary can have an angle (E) of 60°, a slot
10   width (G) of 0.081 mm, a length (H) of the rectangular
opening of 0.076 mm, a width (J) of the rectangular
opening of 0.203 mm, and a slot length (F) of 0.457 mm.
In Figure 1C, the capillary can have an angle (E) of
60°, a slot width (G) of 0.081 mm, a diameter (H) of
15   the circular openings 0.127 mm, and a slot length (F)
of 0.457 mm. A metering capillary may be used upstream
of the shaping orifice, for example, to increase the
total capillary pressure drop. The spinneret capillary
plate can have any desired height, such as, for
20   example, 0.254 mm.

      After quenching, the filaments are converged,
interlaced, and wound as a multifilament bundle.
Filaments of the invention, if sufficiently spin-
oriented, can be used directly in fabric production.
25   Alternatively, filaments of the invention can be drawn
and/or heat set, e.g., to increase their orientation
and/or crystallinity. Drawing and/or heat setting can
be included in the drawing or texturing processes, for
example, by draw warping, draw false-twist texturing or
30   draw air-jet texturing the filaments and yarns of the
invention. Texturing processes known in the art, such
as air-jet texturing, false-twist texturing, and
stuffer-box texturing, can be used. The multifilament
bundles can be converted into fabrics using known
35   methods such as weaving, weft knitting, or warp
knitting. Filaments of the invention can alternatively
be processed into nonwoven fibrous sheet structures.

Fabrics produced using the as-spun, drawn, or textured filaments of the invention can be used to produce articles such as apparel and upholstery.

5   The filaments of the invention, whether in as-spun form or textured form, provide advantages to the multifilament bundles, fabrics and articles produced therefrom, such as a pleasing fabric luster essentially free of objectionable glitter. The highly-shaped filaments of the invention, even in very fine deniers

10   including subdeniers, can be produced with tensile properties sufficient to withstand demanding textile processes such as draw false-twist texturing with low levels of broken filaments. The fine and subdenier filaments of the invention, in either as-spun or

15   textured form, can be used to provide fabrics and articles therefrom having properties such as moisture transport that are especially advantageous to performance apparel applications. Accordingly, in one preferred embodiment, the filaments are spun as a

20   direct-use yarn, which may be immediately used in manufacturing articles. Furthermore, as a result of the ability to use the present process to produce direct-use yarns via high speed spinning, it has been found that the process of the present invention is

25   capable of generating an increased spinning productivity.

Optionally, however, the filaments of the present invention may be textured, also known as "bulked" or "crimped," according to known methods. In one

30   embodiment of the invention, the filaments may be spun as a partially oriented yarn and then textured by techniques, such as by draw false-twist texturing, air-jet texturing, gear-crimping, and the like.

Any false-twist texturing process may be used.

35   For example, a continuous false-twisting process may be conducted, wherein a substantial twist is applied to the yarn by passing it through a rotating spindle or

other twist-imparting device. As the yarn approaches
the twist-imparting device, it accumulates a high
degree of twist. Then, while the yarn is in a high
degree of twist, it is passed through a heating zone

5   and a permanent helical twist configuration is set in
the yarn. As the yarn emerges from the twist-imparting
device, the torsional restraint on the forward end of
the yarn is released and the yarn tends to resume its
twisted configuration, thereby promoting the formation

10   of helical coils or crimps. The degree of crimping is
dependent upon factors such as the torsion applied,
amount of heat applied, frictional qualities of the
twist-imparting device, and turns per inch of twist
applied to the yarn.

15   An alternative draw-texturing process includes the
simultaneous drawing and texturing of a partially
oriented yarn as is known in the art. In one such
process, the partially oriented yarn is passed through
a nip roll or feed roll and then over a hot plate (or

20   through a heater), where it is drawn while in a twisted
configuration. The filaments in the yarn then pass
from the hot plate (heater) through a cooling zone and
to a spindle or twist-imparting device. As they exit
the spindle, the filaments untwist and are passed over

25   a second roller or draw roll. After the yarn exits
from the draw roll, the tension is reduced as the yarn
may be fed to a second heater and/or wound up.
     The filaments of the invention can be processed
into a multifilament fiber, yarn or tow having any

30   desired filament count and any desired dpf. Moreover,
the dpf may differ between a draw-false-twist textured
yarn and a spin-oriented direct use yarn. The drawn or
as-spun yarn of the present invention may be used, for
example, in apparel fabrics, which can have a dpf of

35   less than about 5.0 dpf, preferably less than about 2.2
dpf. Most preferably, the yarn is formed of filaments
of less than about 1.0 dpf. Such subdenier yarns are

also known as "microfibers." Typically, the lowest dpf
attained is about 0.2. In one embodiment of the
invention, the filaments are made up of polyester in
which the denier per filament after draw-false-twist
5   texturing is less than about 1 dpf. In another
embodiment, the filaments are spin-oriented direct-use
polyesters having a denier of about less than about 5.0
dpf, preferably less than about 3.0 dpf, and most
preferably less than about 1.0 dpf. Other yarns may be
10   useful in textiles and fabrics, such as in upholstery,
garments, lingerie, and hosiery, and may have a dpf of
about 0.2 to about 6 dpf, preferably about 0.2 to about
3.0 dpf. Finally, higher denier yarns are also
contemplated for uses, for example, in carpets, having
15   a dpf of about 6 to about 25 dpf.

        The yarns of the present invention may further be
formed from a plurality of different filaments having
different dpf ranges. In such case, the yarns should
be formed from at least have one filament having the
20   multilobal cross-section of the present invention.
Preferably, each filament of a yarn containing a
plurality of different filaments, has the same or
different dpf, and each dpf is from about 0.2 to about
5.

25   The synthetic polymer yarns may be used to form
fabrics by known means including by weaving, warp
knitting, circular knitting, or hosiery knitting, or a
continuous filament or a staple product laid into a
non-woven fabric.

30   The yarns formed from the filaments of the present
invention have been found to provide fabrics having low
glitter and subdued luster or shine. It is believed
that the unique cross-section of the filament
attributes to the reduced glitter. In particular, it
35   has been found that as the filament factor is increased
with cross-sections having low lobe angles, and
preferably $\leq$ about 15°, the glitter effect is

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dramatically reduced, particularly in fine denier and
subdenier filaments. This glitter effect is even more
subdued in subdenier filaments with cross-sections
having negative lobe angles.

5   Moreover, it has further been unexpectedly found
that yarns having the filaments with filament factor of
at least 2, with a low dpf in the fine range and sub-
dpf (microfiber) range have a reduced glitter effect.
The term "glitter" is reflection of light in intense
10   beams from tiny areas of the filament or fabric,
contrasting with the general background reflection.
Glitter can occur from small flat areas on the fiber
surface, which act as mirrors that reflect full
spectrum (white) light. The areas are large enough
15   such that the light reflections termed "glitter" are
distinct and can be pinpointed by the eye. Glitter can
be rated by a number of means such as rating low,
medium, or high levels of glitter, or rating in terms
of relative glitter. Both as-spun yarns and textured
20   yarns of the present invention had low levels of
glitter.

In addition, it has advantageously been found that
the filaments of the present invention are able to
absorb dyes, such as cationic dyes, and color. As the
25   denier per filament is reduced in conventional
filaments, especially to subdeniers, the fabric depth
of color is generally reduced due to the increased
fiber surface area and shorter within-fiber distances
in which light and dye interactions can occur. It was
30   surprisingly found that subdenier filaments of the
invention, even though having greatly increased surface
area due to the highly shaped filament exteriors,
exhibited fabric coloration superior to prior-art
multilobal filaments and approaching that of round
35   cross-sections, in either as-spun or draw-textured
configurations, as well as enhanced fabric performance
such as moisture transport or wicking. The high

coloration and wicking are benefits to the filaments of
the present invention in addition to the added
advantage of low glitter.

Further, the filaments of the present invention
5   have high tensile properties enabling the filaments to
be further processed in texturing and/or fabric
formation processes with low levels of broken
filaments. In particular, the subdenier multifilament
bundles of the invention exhibited tenacity and
10   elongation values, in as-spun and after draw false
texturing, that were similar to those achieved with
round subdenier filaments. This was surprising due to
the much more rapid and non-uniform quenching that was
expected when spinning highly-shaped subdenier
15   filaments of the present invention.

As a result of the high tensile properties of the
filaments of the present invention, the filaments are
especially suited to high stress application including
draw false-twist texturing, high speed spinning, and
20   spinning of modified polymers. These findings were
particularly found for the sub-dpf filaments of the
present invention, which, when draw false-twist
textured, exhibited high tensile strength and an
orientation level similar to that of round sub-dpf
25   filaments, resulting in low levels of broken filaments.
Measurements relating to the orientation level of the
spin-oriented filaments are tenacity at 7% elongation
(T_7), as set forth above, and draw tension (DT). The
ability to essentially match the orientation level of
30   the prior-art round fine and subdenier filaments was an
advantage in enabling similar draw texturing processes
to be used for filaments of the invention. The term
"textured yarn broken filaments" (herein "TYBF")
references "fray count" in number of frays (broken
35   filaments) per unit length. As compared to its round
cross-section counterparts, the sub-dpf filaments
having the cross-sections of the present invention were

capable of being subjected to the same types of
texturing processes as round cross-section yarns,
without the production of undesired glitter and high
levels of broken filaments.

5   Moreover, the high tensile strength with low
glitter of the filaments of the present invention have
been found particularly suitable for fabric
applications such as performance apparel and
bottomweight-end uses such as slacks and suiting

10   materials, and for blending with low-luster spun fibers
such as cotton and wool.

For example, it has been found that the yarns of
the present invention have increased cover,
particularly relative to yarns having round cross-

15   sections. In addition, the increased cover becomes
even more dramatic for lesser denier filaments.

The fabrics of the present invention further have
higher wicking rates than many other known cross-
sections. Wicking refers to the capillary movement of

20   water through or along the fibers. The ability of the
fibers to wick, therefore, increases the ability of the
fabric to absorb water and move it away from the body.
It has been particularly found that the fabrics using
microfibers of the present invention have higher

25   wicking rates than fabric of round microfibers of
comparable dpf.

The fabrics of the present invention do not
require an external additive such as TiO_2 or post-
treatments such as described in the art to obtain low

30   glitter. The amount of delustrant may be added in an
amount of 0%, or less than about 0.1%, less than about
0.2%, or less than about 1% by weight of delustrant.
This has been found particularly compelling for
subdeniers, which typically require such delustrant

35   additives or post-treatments to minimize glitter.
However, these types of treatments may be used, if

desired, for any of the fabrics of the present invention.

TEST METHODS

5   In the following Examples, circular knit fabrics were prepared using the multifilament yarns of the present invention and assessed for parameters such as glitter and shine ratings, fabric cover and color depth. In some examples the fabrics were made from the

10   as-spun yarn. In some examples the fabrics were made after draw false-twist texturing the feed yarn.

       Fabrics were dyed to a deep black shade; all fabrics of a given series were dyed using the same procedure. Fabric glitter and shine were observed in

15   bright sunlight viewing conditions. "Shine" is the low angle surface reflection of full spectrum (white) light with no dye value from the surfaces of fibers. "Glitter", on the other hand, is the reflection of light in intense beams from tiny areas of the filament

20   or fabric, contrasting with the general background reflection. Glitter can occur from small flat areas on the fiber surface, which act as mirrors that reflect full spectrum (white) light. The relative glitter and shine ratings of each item were determined using a

25   paired comparison test, in which each fabric sample was rated against every other sample. A rating for each pairing was assigned: 2 when the sample had less glitter (or shine) than the comparison sample, 1 when the sample had equivalent glitter (or shine), 0 when

30   the sample had more glitter (or shine). Then a total rating for each sample was assigned by totaling the ratings of each paired comparison. By this method, the relative glitter, and relative shine of each sample was determined. For example, the highest numerical rating

35   was obtained by the sample having the lowest glitter.

       The Covering Power and Color Depth ratings were assessed using the same fabric samples for which

glitter was rated, and were rated using diffuse, fluorescent room lighting. A paired comparison test was used. The relative covering power of each item was determined using a paired comparison test, in which

5   each fabric sample was rated against every other sample. A rating for each pairing was assigned: 2 for the sample having the greatest degree of cover over the white grading surface, i.e., the sample allowing the least amount of white grading surface to be visible

10   through the fabric; a rating of 1 for the sample having equivalent covering power, 0 for the sample having lower covering power. Then a total covering power relative rating was determined for each sample.

Likewise, the relative color depth ratings were

15   determined using a paired comparison test in which each fabric sample was rated against every other sample. A rating for each pairing was assigned: 2 for the sample having deepest black coloration, 1 for the sample having equivalent color depth, 0 for the sample having

20   lower depth of color. Then a total rating for each sample was assigned by totaling the ratings of each paired comparison. By this method, the relative color depth of each sample was determined.

Most of the fiber properties of conventional

25   tensile and shrinkage properties were measured conventionally, as described in the art. Relative viscosity is the ratio of the viscosity of a solution of 80 mg of polymer in 10ml of a solvent to the viscosity of the solvent itself, the solvent used

30   herein for measuring RV being hexafluoroisopropanol containing 100 ppm of sulfuric acid, and the measurements being made at 25°C. This method has particularly been described in U.S. Patent Nos. 5,104,725 and 5,824,248.

35   Denier spread (DS) is a measure of the along-end unevenness of a yarn by calculating the variation in mass measured at regular intervals along the yarn.

Denier Spread is measured by running yarn through a
capacitor slot, which responds to the instantaneous
mass in the slot. As described in U.S. Patent No.
6,090,485, the test sample is electronically divided

5   into eight 30 meter subsections with measurements every
0.5 meter. Differences between the maximum and minimum
mass measurements within each of the eight subsections
are averaged. DS is recorded as a percentage of this
average difference divided by the average mass along

10   the whole 240 meters of the yarn. Testing can be
conducted on an ACW 400/DVA (Automatic Cut and
Weigh/Denier Variation Accessory) instrument available
form Lenzing Technik, Lenzing, Austria, A-4860.

Tenacity is measured on an Instron equipped with

15   two grips, which hold the yarns at the gauge lengths of
10 inches. The yarn is then pulled by the strain rate
of 10 inch/minute, the data are recorded by a load
cell, and stress-strain curves are obtained.

The elongation-to-break may be measured by pulling

20   to break on an Instron Tester TTB (Instron Engineering
Corporation) with a Twister Head made by the Alfred
Suter Company and using 1-inch x 1-inch flat-faced jaw
clamps (Instron Engineering Corporation). Samples
typically about 10-inches in length are subjected to

25   two turns of twist per inch at a 60% per minute rate of
extension at 65% Relative Humidity and 70°F.

The boil-off shrinkages of the yarn may be
measured using any known method. For example, it may
be measured by suspending a weight from a length of

30   yarn to produce a 0.1 gram/denier load on the yarn and
measuring its length (L_0). The weight is then removed
and the yarn is immersed in boiling water for 30
minutes. The yarn is then removed, loaded again with
the same weight, and its new length recorded (L_f). The

35   percent shrinkage (S) is calculated by using the
formula:

$$\text{Shrinkage (\%)} = 100 \ (L_0 - L_f) / L_0$$

Draw Tension is used as a measure of orientation, and is a very important requirement especially for texturing feed yarns. Draw tension, in grams, was measured generally as disclosed in U.S. Patent No.

5   6,090,485, and at a draw ratio of 1.707x for as-spun yarns having elongations of at least 90% at 185°C over a heater length of 1 meter at 185 ypm (169.2 mpm). Draw tension may be measured on a DTI 400 Draw Tension Instrument, available from Lenzing Technik.

10   Broken filaments, especially of textured yarns, may be measured by a commercial Toray Fray Counter (Model DT 104, Toray Industries, Japan) at a linear speed of 700 mpm for 5 minutes i.e., number of frays per 3500 meters, and then the numbers of frays are

15   expressed herein as the number of frays per 1000 meters.

The invention will now be illustrated by the following non-limiting examples. Although the geometric parameters (refer to Fig. 1) were intended to

20   be applied to multilobal filaments, for the purposes of the round comparative examples, the following geometric parameters were assumed: number of lobes = 1, modification ratio = 1, tip ratio = 1, and the lobe angle = -180°.

EXAMPLES

Example I

Yarns of 100 fine filaments of nominal 1.15 dpf
5   were spun from poly(ethylene terephthalate) of nominal
21.7 LRV (lab relative viscosity) and containing 0.3
weight percent TiO_2. The spinning process was
essentially as described in USP 5,250,245 and USP
5,288,553 and using a radial quench apparatus having a
10   delay "shroud" length (L_{DQ}) of about 1.7 inches (4.3
cm). Example I-1 yarn was comprised of 3-lobe
filaments of the invention having filament cross-
sections in appearance similar to Figure 2A, and was
made using 100-capillary spinnerets using 9 mil (0.229
15   mm) diameter x 36 mil (0.914 mm) length metering
capillaries and spinneret exit orifices having three
slots centrally-joined and projecting radially; slot
center lines being separated by 120 degrees (E) as set
forth in Figure 1A. Each slot had the following
20   geometry: 1.7 mil (0.043 mm) slot width (G), having a 5
mil (0.127 mm) diameter circular enlargement (H) at the
end of each slot, the center of said circular
enlargement being located 5.5 mils (0.140 mm)(F) from
the capillary center, said spinneret slots being formed
25   by a method as described in U.S. Patent No. 5,168,143.

The capillary dimensions used can be adjusted, for
example, to produce filaments differing in DPF or in
filament geometric parameters, or as desired for a
different synthetic polymer. Comparative Example I-A
30   was a trilobal multifilament yarn as disclosed in USP
5,288,553 having filament cross-sections in appearance
similar to Figure 9, and was made using spinnerets with
9 x 36 mil (0.229 x 0.914 mm) (DxL) metering
capillaries and Y-shaped exit orifices having three
35   equally-spaced slots with 5 mil (0.127 mm) slot width
and 12 mil (0.305 mm) slot length. Example I-1 and
Comparative Example I-A were spun using a spinning
speed of 2795 ypm (2556 meters/minute) to obtain

partially oriented feed yarns. Comparative Example I-B
was a 100-filament yarn having 100 round filaments of
nominal 1.15 dpf and produced using 100-capillary
spinnerets having round cross-section orifices having 9
5   mil (0.229 mm) capillary diameter and 36 mil (0.914 mm)
capillary depth. Physical properties and cross section
parameters of the as-spun examples are given in Table
I-1. Draw tension was measured using 1.707 draw ratio,
185°C heater temperature and 185 ypm (169
10   meters/minute) feed rate. Example I-1 filaments had
average lobe angle of -37.4 degrees and "filament
factor" of 2.57, whereas Example I-A filaments had
average lobe angle of +19.8 degrees and "filament
factor" of 0.84.
15   Yarns I-1, I-A, and I-B were draw false-twist
textured using the same texturing conditions on a
Barmag L-900 texturing machine equipped with
polyurethane discs and using 1.54 draw ratio, 1.74 D/Y
ratio, 180 °C first heater temperature. The draw-
20   textured yarns had a denier per filament (dpf) of
approximately 0.76; i.e., the draw-textured filaments
were "subdeniers" or "microfibers" by virtue of having
denier per filament below 1. Properties of the draw-
textured yarns are given in Table I-2. The three-lobe
25   yarn of Example I-1 had lower feed yarn draw tension,
and higher tenacity-at-break (T_B) and higher elongation
in both as-spun and draw-textured forms compared to the
trilobal yarn of Example I-A, which was surprising
given the more highly-modified cross-sectional shape
30   evidenced by the higher modification ratio and greater
lobe wrap angle of the Example I-1 yarn. It had been
expected that more highly modified cross sections would
result in more highly oriented yarns having higher draw
tension and lower elongation in as-spun and draw-
35   textured forms.
          Black-dyed, circular-knit fabrics were made from
each draw-textured yarn I-1, I-A, and I-B using the

same fabric construction and dyeing conditions. Fabrics were rated for relative glitter and shine under bright sunlight viewing, and rated for relative covering power under diffuse room lighting. Fabric ratings are shown in Table I-3. The fabric made from Example I-1 yarn comprised of false-twist textured subdenier filaments of three lobes and "filament factor" ≥ 2 had the lowest glitter and shine (highest numerical ratings) and highest covering power. The draw-textured filaments of Example I-1 had filament cross-sections in appearance similar to Figure 2B, which exhibited some lobe distortion from the texturing process but retained in general distinctly 3-lobed filaments that provided low fabric glitter.

TABLE I-2

TEXTURED YARN PROPERTIES

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
I-1	76	0.76	4.41	39.3	6.14	13.30	1.1
I-A	78	0.78	4.50	35.2	6.09	15.20	0.0
I-B	76	0.76	4.63	40.4	6.50	18.02	2.2

TABLE I-3
FABRIC RATINGS

	Fabric Ratings		
Ex.	Shine Rating	Covering Power	Glitter Rating
I-1	9	7	9
I-A	4	6	5
I-B	2.5	1	1

Example II

Yarns comprised of fine filaments of nominal 1.24 dpf and 3-lobe cross-sections were spun at 2675 ypm

(2446 meters/minute), essentially as described in Example I-1; 100-filament yarn bundles were combined prior to takeup to produce 200-filament yarn bundles. Example II-1 yarn was comprised of fine multilobal

5   filaments of the invention, having average filament factor of 2.37; average lobe angle was -35.4 degrees, having filament cross-sections similar in appearance to Figure 2A. Comparative Example II-A yarn was comprised of fine trilobal filaments not of the invention, having

10   average filament factor of 0.77; average lobe angle was +18.6 degrees, having filament cross-sections similar in appearance to Figure 9. Comparative Example II-B was a unitary 200-filament yarn as described in U.S. Patent Nos. 5,741,587 and USP 5,827,464 and having

15   round cross-section filaments. Physical properties and cross section parameters of the as-spun yarns are listed in Table II-1.

       Yarns II-1, II-A, and II-B were draw false-twist textured using a Barmag L-900 texturing machine

20   equipped with polyurethane discs and using 1.506 draw ratio, 1.711 D/Y ratio, 180 °C first heater temperature. The trilobal yarn of Example II-A was not textured at these conditions because of the high draw tension of this example. The draw-textured yarns had

25   denier per filament (dpf) of approximately 0.8, i.e., the draw-textured filaments were "subdeniers" or "microfibers" by virtue of having denier per filament below 1. Properties of the draw-textured yarns are given in Table II-2.

30   Consistent with the observation of Example I, the feed yarn of Example II-1 had lower draw tension, higher tenacity-at-break (T_B) and higher elongation compared to the trilobal yarn of Comparative Example II-A. The 3-lobe yarn of the invention had draw

35   tension level similar to that of the round control yarn, and could be textured using the same draw-texturing conditions. The textured 3-lobe yarn of the

invention had a low level of textured yarn broken
filaments that was equivalent to that of the round
control.

5   Black-dyed, circular-knit fabrics were made from
draw-textured yarns II-1, II-A, and II-B using
equivalent fabric construction and dyeing conditions.
Fabrics were rated for relative glitter and shine under
bright sunlight viewing, and rated for relative
10   covering power under diffuse room lighting. The fabric
made from Example II-1 yarns having subdenier filaments
of three lobes and "filament factor" ≥ 2 had
significantly lower glitter and shine (higher numerical
ratings), and greater covering power when compared to
the round cross-section filament yarn of Comparative
15   Example II-B. Fabric ratings are shown in Table II-3.

TABLE II-2

TEXTURED YARN PROPERTES

Ex.	Text. Denier	Text. Dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
II-1	166	0.83	4.27	51.2	6.46	7.09	6.7
II-A	not textured						
II-B	152	0.76	4.35	50.6	6.55	6.78	6.7

20

TABLE II-3

FABRIC RATINGS

Ex.	Shine Rating	Covering Power	Glitter Rating
II-1	8	6	6
II-A			
II-B	1.5	1	1

25

Example III

Yarns comprised of fine filaments of nominal 1.4
dpf and 3-lobes were produced essentially as described

in Example II, except that 88-filament yarn bundles were combined prior to takeup to produce 176-filament yarn bundles. Examples III-1 and III-2 yarns were comprised of fine 3-lobe filaments having average

5   filament factor of ≥ 2 and having cross-sections in appearance similar to Figure 2A. The polymer of Example III-1 contained 1.0% TiO_2 and was of nominal 20.2 LRV, whereas the polymer of Example III-2 contained 0.30% TiO_2 and was of nominal 21.7 LRV.

10 Comparative Example III-A polymer contained 1.5% TiO_2 and was of nominal 20.6 LRV, and the Comparative Example III-A yarn was comprised of round filaments. The spinning speed of each Example III-1, III-2, and III-A was adjusted to achieve a draw tension of about

15 0.45 grams/denier. Physical properties and cross section parameters of the as-spun yarns are listed in Table III-1.

Yarns III-1, III-2, and III-A were draw false-twist textured using a Barmag L-900 texturing machine

20 equipped with polyurethane discs and using 1.506 draw ratio, 1.711 D/Y ratio, 180 °C first heater temperature. The draw-textured yarns had denier per filament (dpf) of approximately 0.95; i.e., the draw-textured filaments were "subdeniers" or "microfibers"

25 by virtue of having denier per filament below 1. Properties of the draw-textured yarns are given in Table III-2.

Black-dyed, circular-knit fabrics were made from draw-textured yarns III-1, III-2, and III-A using

30 equivalent fabric construction and dyeing conditions. Fabrics were rated for relative glitter and shine under bright sunlight viewing, and rated for relative color depth and covering power under diffuse room lighting. The fabrics made from Example III yarns comprised of

35 draw-textured, subdenier, 3-lobe filaments of the invention had equal luster ratings. This was surprising given that Example III-1 contained 1.0%

added delusterant (TiO$_2$), whereas Example III-2
contained 0.30% added delusterant (TiO$_2$). Both fabrics
from Examples III-1 and III-2 had lower glitter (higher
numerical ratings) than fabrics made from Comparative
5   Example III-A yarn comprised of round filaments, even
though the polymer used in Comparative Example III-A
had significantly higher added delusterant (1.5% TiO$_2$)
than either Example III-1 or III-2. The use of the
multilobal cross section with a filament factor ≥ 2 had
10   a much greater delustering effect, i.e., reduction of
glitter, in fabrics made from the fine subdenier
textured filaments than did increasing the level of
delusterant added to the polymer, which was very
surprising. The use of increased delusterant level did
15   however have a significant negative effect on the
quality of the textured yarn, as evidenced by the
increasing level of textured yarn broken filaments
(fray count) as the level of added TiO$_2$ was increased.
        A very significant delustering effect was obtained
20   in draw false-twist textured subdenier yarns and
fabrics by using multilobal filaments having a filament
factor ≥ 2, when compared to prior art filaments having
round or trilobal cross sections. Delustering of these
fine filament yarns was best achieved by the cross
25   section change and not by increasing the delusterant
(TiO$_2$) level, even when using "dull" polymers having
1.0% to 1.5% TiO$_2$. This benefit of the high filament
factor, multilobal filaments was surprising, in view of
prior art, which stated that by reducing the dpf
30   sufficiently, "glitter-free yarns could be produced
after texturing regardless of the starting cross-
section". (McKay, U.S. Patent No. 3,691,749) A second
surprising benefit of the high filament factor
multilobal fine and subdenier filaments was that the
35   spinning orientation level, as indicated by draw
tension and % elongation to break, and the filament
tenacity-at-break (T$_B$ = Tenacity * (1 + %

Elongation/100%) were similar to those of round
filaments. It is hypothesized that the rounded,
relatively large-area lobes having high tip (radius)
ratios contributed to a more uniform and slower
5   quenching compared to the more pointed tips of the
standard trilobal filaments having positive lobe angle
and low tip ratio. It was further surprising that the
negative lobe angle trilobal filaments, even though
they had larger lobe areas due to the high tip (radius)
10   ratio, gave lower glitter after draw false-twist
texturing than the smaller-lobed standard trilobal
filaments. McKay, U.S. Patent No. 3,691,749 and Duncan
U.S. Patent No. 4,040,689 both stated that "lobe angles
which are positive are especially preferred in the feed
15   yarns of the invention for lobes of this type are less
likely to flatten in texturing".

Table III-2

TEXTURED YARN PROPERTIES

Ex.	Text. Denier	Text. Dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
III-1	167	0.95	3.82	43.4	5.48	5.83	6.5
III-A	167	0.95	4.00	52.6	6.10	7.83	12.5
III-2	165	0.94	3.92	43.4	5.62	6.20	1.1

Example IV

Yarns comprised of 88 fine filaments of nominal
0.84 dpf and of 100 fine filaments of nominal 0.75 dpf
25   were spun from poly(ethylene terephthalate) of nominal
21.7 LRV and containing 0.035 weight percent TiO_2.
Spinning process was similar to that described in
Example I, except spinning speed was increased to 4645
ypm (4247 meters/minute) to spin nominal 75 denier, 88
30   and 100 filament low-shrinkage yarns suitable as
direct-use textile yarns for knits and wovens and as
feed yarns for air-jet and stuffer-box texturing

wherein no draw is required. Example IV-1 was a yarn
comprised of 88 filaments of nominal 0.84 dpf and
filament cross-section having 3 lobes and average
filament factor of 5.01. Comparative Example IV-A was

5   a yarn comprised of 100 round filaments of nominal 0.75
dpf. Example IV-2 was a yarn comprised of 100
filaments of nominal 0.75 dpf and filament cross-
section having 3 lobes and average filament factor of
3.69. Examples IV-1 and IV-2 had filament cross-

10   sections in appearance similar to Figure 6. Comparison
Example IV-B was a yarn comprised of 100 trilobal
filaments of nominal 0.75 dpf and filament cross-
section having average filament factor of 1.76 and
having filament cross-sections in appearance similar to

15   Figure 9. Yarns IV-1, IV-2, IV-A, and IV-B were
"subdeniers" or "microfibers" by virtue of having
denier per filament below 1. Comparison Example IV-C
was a yarn comprised of 34 trilobal filaments of   .
nominal 2.2 dpf and having average filament factor of

20   0.21. Physical properties and cross-section parameters
are listed in Table IV-1. Draw tension results in this
table were measured at 1.40 draw ratio and 150 ypm (137
meters/minute) feed rate.

       Black-dyed, circular-knit fabrics were made from

25   as-spun, direct-use yarns IV-1, IV-2, IV-A, IV-B, and
IV-C using equivalent fabric construction and dyeing
conditions. Fabrics were rated for relative glitter
and shine under bright sunlight viewing, and rated for
relative covering power and color depth under diffuse

30   room lighting. The fabrics made from Examples IV-1 and
IV-2 yarns having subdenier filaments of three lobes
and "filament factor" ≥ 2 had significantly less
(higher numeric ratings) glitter and shine compared to
the trilobal filament yarns IV-B and IV-C, and greater

35   covering power when compared to the round cross-section
filament yarn of Example IV-A. Furthermore, the
fabrics made from Examples IV-1 and IV-2 had

significantly greater depth of color when compared to
fabric made using the prior-art trilobal subdenier
Comparative Example IV-C. It was surprising that the
subdenier 0.85 dpf Example IV-1 yarn gave equivalent
5   fabric depth of color to the 2.2 dpf Comparative
Example IV-C yarn, which was unexpected in view of the
significantly greater filament denier of the
Comparative Example IV-C yarn. Fabric visual ratings
are shown in Table IV-2. The fabrics made from
10 Examples IV-1 and IV-2 multilobal subdenier yarns of
the invention also had a combination of rapid moisture
wicking and high thermal conductivity, making this type
yarn especially suitable for performance fabric
applications such as athletic wear.
15

Table IV-2
FABRIC RATINGS

Ex.	Shine Rating	Covering Power	Glitter Rating	Color Depth
IV-1	7	5	7	5
IV-A	5	1	6	8
IV-2	5	7	6	3
IV-B	0	6	0	0
IV-C	2	2	2	5

20   **Example V**
    Yarns comprised of fine spin-oriented filaments
were prepared from basic-dyeable ethylene terephthalate
copolyester containing 1.35 mole percent of lithium
salt of a glycollate of 5-sulfo-isophthalic acid and of
25 nominal 18.1 LRV, said polymer being essentially as
described in USP 5,559,205 and USP 5,607,765. Polymer
contained 0.30 weight percent of TiO_2. Yarns were spun
at 2450 ypm (2240 meters/minute) using spinning process
essentially as described in Example I. Example V-1
30 yarn was comprised of 88 filaments of nominal 1.31 dpf
and filament cross section having 3 lobes and average

filament factor of 2.97, and having filament cross-
sections in appearance similar to Figure 2A.
Comparative Example V-A yarn was comprised of 100 round
filaments of nominal 1.15 dpf. Comparative Example V-B
5   yarn was comprised of 100 filaments of nominal 1.15 dpf
and having a trilobal cross-section with average
filament factor of 0.72, and having filament cross-
sections in appearance similar to Figure 9. Example V-
2 yarn was comprised of 100 filaments of nominal 1.15
10   dpf and filament cross section having 3 lobes and
average filament factor of 2.77, and having filament
cross-sections in appearance similar to Figure 2A. A
summary of yarn physical properties and filament cross-
section parameters is in Table V-1.
15   Yarns V-1, V-2, V-A, and V-B were draw false-twist
textured using the same texturing conditions on a
Barmag L-900 texturing machine equipped with
polyurethane discs and using 1.506 draw ratio, 1.635
D/Y ratio, 160 °C first heater temperature. The
20   Example V-1 draw-textured yarn had a denier per
filament (dpf) of approximately 0.89 and the draw-
textured yarns of Examples V-A, V-B, and V-2 had dpf of
approximately 0.78, i.e., the draw-textured filaments
were "subdeniers" or "microfibers" by virtue of having
25   denier per filament below 1. Properties of the draw-
textured yarns are given in Table V-2. The three-lobe
yarns of Examples V-1 and V-2 had lower feed yarn draw
tension, and higher tenacity-at-break (T_B) and higher
elongation in both as-spun and draw-textured forms
30   compared to the trilobal yarn of Comparative Example V-
B. The 3-lobe filament yarns of the invention had spun
yarn draw tension and elongation values very similar to
those of the round cross-section comparison yarn, even
when spun at identical spinning speeds, which was very
35   surprising. It was expected that, when spun at equal
speeds and quenching conditions, non-round cross-
section filaments would have higher orientation (e.g.,

higher draw tension) and lower elongation when compared
to round filaments, because the non-round filaments
were expected to quench more rapidly due to the
increased fiber surface area. Textured yarn broken

5   filaments (fray count) were at a low level for the 3-
lobe, basic-dyeable, subdenier yarns of the invention,
whereas fray count was very high for the textured
trilobal cross-section multifilament yarn of
Comparative Example V-B.

10   Black-dyed, circular-knit fabrics were made from
draw-textured yarns V-A, V-B, and V-2 using equivalent
fabric construction and dyeing conditions. Fabrics
were rated for relative glitter and shine under bright
sunlight viewing, and rated for relative covering power

15   and color depth under diffuse room lighting. The
fabric made from Example V-2 yarns having subdenier
basic-dyeable filaments of three lobes and "filament
factor" $\geq$ 2 had significantly less glitter and shine
(higher numerical ratings) when compared to the

20   textured round and trilobal Comparative Examples V-A
and V-B, and greater covering power when compared to
the round cross-section filament yarn of Example V-A.
The fabric made from Example V-2 trilobal subdenier
false-twist textured yarns of the invention also had

25   greater depth of color when compared to fabric made
from prior-art trilobal subdenier false-twist textured
yarn of Example V-C. Fabric ratings are shown in Table
V-3.

30   **TABLE V-2**
                    Textured Yarn Properties

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
V-1	78	0.89	2.95	36.3	4.02	8.36	2.2
V-A	79	0.79	3.08	43.9	4.43	9.43	20.1
V-B	78	0.78	3.05	31.5	4.01	8.85	232.0
V-2	78	0.78	3.00	35.4	4.06	7.61	11.2

TABLE V-3

FABRIC RATINGS

Ex.	Shine Rating	Covering Power	Glitter Rating	Color Depth
V-A	1	1	1	9
V-B	5	7	5	1
V-2	9	7	9	5

Example VI

Basic-dyeable feed yarns comprised of 34 filaments of nominal 2.4 dpf were prepared using polymer essentially as described in Example V. Comparative Example VI-A yarn was comprised of 34 filaments having round cross-section. Comparative Example VI-B yarn was comprised of 34 filaments having trilobal cross-section with average filament factor of 0.39 and average lobe angle of +19.7 degrees. Example VI-1 yarn was comprised of 34 filaments having 6-lobe cross- section with average lobe angle of -9.1 degrees and average filament factor of 6.98, and having filament cross-sections in appearance similar to Figure 7A. Example VI-2 yarn was comprised of 34 filaments having 3-lobe cross-section with average lobe angle of -52.6 degrees and average filament factor of 4.07. Yarn physical properties and cross-section parameters are listed in Table VI-1.

Yarns VI-A, VI-B, VI-1, and VI-2 were draw false-twist textured using the same texturing conditions on a Barmag L-900 texturing machine equipped with polyurethane discs and using 1.44 draw ratio, 1.635 D/Y ratio, 160 °C first heater temperature. The draw false-twist textured yarns of Examples VI had dpf of approximately 1.7; i.e., these yarns were comprised of filaments having dpf above the subdenier level. Properties of the draw-textured yarns are given in Table VI-2.

Black-dyed, circular-knit fabrics were made from
draw-textured yarns VI-A, VI-B, VI-1, and VI-2 using
equivalent fabric construction and dyeing conditions.
Fabrics were rated for relative glitter and shine under

5   bright sunlight viewing, and rated for relative
covering power under diffuse room lighting. The
fabrics made from Examples VI-1 and VI-2 yarns having
basic-dyeable multilobal filaments and "filament
factor" ≥ 2 had significantly lower glitter and shine

10   (higher numerical ratings) when compared to the
textured round and trilobal Comparative Examples VI-A
and VI-B, and greater covering power when compared to
the round cross-section filament yarn of Example VI-A.
Fabric ratings are shown in Table VI-3. The draw-

15   textured 6-lobe filaments of Example VI-1 had filament
cross-sections in appearance similar to Figure 7B,
which exhibited some lobe distortion from the false-
twist texturing process but retained in general
filaments with six distinct lobes and along-fiber

20   grooves, said filaments providing low fabric glitter
even after draw false-twist texturing.

TABLE VI-2

TEXTURED YARN PROPERTIES

25

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
VI-A	58	1.69	2.72	69.7	4.62	16.14	0.0
VI-B	57	1.68	2.62	47.1	3.85	13.01	0.0
VI-1	57	1.68	2.75	46.4	4.03	10.84	0.0
VI-2	57	1.68	2.72	44.4	3.93	10.29	0.0

TABLE VI-3

FABRIC RATINGS

Ex.	Shine Rating	Covering Power	Glitter Rating
VI-A	5	1	1
VI-B	3	8	5
VI-1	13	8	13
VI-2	10	11	10

Example VII

Basic-dyeable feed yarns comprised of 34 filaments of nominal 1.9 dpf, or of 50 filaments of nominal 1.3 dpf, were prepared using polymer essentially as described in Example V. Comparative Example VII-A yarn was comprised of 34 filaments having round cross-section and nominal 1.9 dpf. Comparative Example VII-B yarn was comprised of 34 filaments of nominal 1.9 dpf and having trilobal cross-section with average filament factor of 0.50 and average lobe angle of +19.2 degrees. Example VII-1 yarn was comprised of 34 filaments having 6-lobe cross-section with average lobe angle of -7.7 degrees and average filament factor of 8.86. Example VII-2 yarn was comprised of 34 filaments having 3-lobe cross-section with average lobe angle of -51.3 degrees and average filament factor of 4.21. Comparative Example VII-C yarn was comprised of 50 filaments of nominal 1.3 dpf and having trilobal cross-section with average filament factor of 0.68 and average lobe angle of +24.8 degrees. Example VII-3 yarn was comprised of 50 filaments of nominal 1.3 dpf and having 6-lobe cross-section with average lobe angle of +22.8 degrees and average filament factor of 10.2. Yarn physical properties and cross-section parameters are listed in Table VII-1.

Yarns VII-1 through VII-3 and VII-A through VII-C were draw false-twist textured using the same texturing

conditions on a Barmag L-900 texturing machine equipped
with polyurethane discs and using 1.44 draw ratio,
1.635 D/Y ratio, 160 °C first heater temperature. The
draw false-twist textured yarns of Examples VII-1, VII-
5   2, VIII-A, and VII-B had dpf of approximately 1.4;
i.e., these yarns were comprised of filaments having
dpf above the subdenier level. The draw false-twist
textured yarns of Examples VII-C and VII-3 had dpf of
approximately 1. Properties of the draw-textured yarns
10   are given in Table VII-2.

     Black-dyed, circular-knit fabrics were made from
the draw-textured yarns of Example VII using equivalent
fabric construction and dyeing conditions. · Fabrics
were rated for relative glitter and shine under bright
15   sunlight viewing, and rated for relative covering power
under diffuse room lighting. Fabric glitter and shine
were reduced (higher numerical ratings) by reducing the
yarn dpf when a similar cross-section was maintained.
Fabrics could be made using the higher 1.4 dpf
20   filaments and having equal or lower fabric glitter and
shine to fabrics constructed of finer 1.0 dpf
filaments, when the higher dpf yarns used multilobal
filaments with high filament factors of the invention.
Fabric ratings are shown in Table VII-3.
25

TABLE VII-2

TEXTURED YARN PROPERTIES

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
VII-A	49	1.44	2.62	78.8	4.68	10.97	0.0
VII-B	49	1.44	2.51	53.0	3.84	10.22	0.0
VII-1	49	1.44	2.60	49.4	3.88	8.09	2.2
VII-2	49	1.44	2.61	51.4	3.95	7.39	0.0
VII-C	50	1.00	2.52	44.3	3.64	8.75	0.0
VII-3	50	0.99	2.59	40.2	3.63	8.17	0.0

TABLE VII-3

FABRIC RATINGS

Ex.	Shine Rating	Covering Power	Glitter Rating
VII-A	7	1	1
VII-B	5	8	5
VII-1	19	10	17
VII-2	9	11	11
VII-C	7	14	11
VII-3	19	18	21

Example VIII

Direct-use spin-oriented yarns comprised of 50
through 100 filaments and 0.7 through 1.4 dpf were
produced from basic-dyeable polymer as described in
Example V. Spinning process was similar to that
described in Example I, except spinning speed was
increased to 4200 ypm (3840 meters/minute) to obtain
yarns suitable as direct-use textile yarns for knits
and wovens and as feed yarns for air-jet and stuffer-
box texturing wherein no draw is required. Examples
VIII-1, VIII-3 and VIII-5 yarns were comprised of 3-
lobe filaments having filament factors ≥ 2, and having
filament cross-sections in appearance similar to Figure
6. Examples VIII-2 and VIII-4 yarns were comprised of
6-lobe filaments having filament factors ≥ 2, and
having filament cross-sections in appearance similar to
Figure 8. Comparative Example VIII-A was comprised of
round cross-section filaments. Comparative Examples
VIII-B and VIII-C were comprised of trilobal filaments
having filament factors below 2, and having filament
cross-sections in appearance similar to Figure 9.
Summary of yarn physical properties and filament
geometric parameters is given in Table VIII-1. Draw
tension results in this table were measured at 1.40
draw ratio and 150 ypm (137 meters/minute) feed rate.

Black-dyed, circular-knit fabrics were made from
the as-spun, direct-use yarns VIII-1 through VIII-3 and
VIII-A through VIII-C using equivalent fabric
construction and dyeing conditions. Fabrics were rated

5   for relative glitter and shine under bright sunlight
viewing, and rated for relative color depth and
covering power under diffuse room lighting. The
fabrics made from the multilobal yarns having filament
factors ≥ 2 exhibited improved cover when compared to

10   fabrics constructed of the comparison examples of
equivalent dpf. The fabrics made from the multilobal
yarns having filament factors ≥ 2 exhibited lower
combined glitter and shine (higher combined glitter and
shine numerical ratings) and greater depth of color

15   when compared to fabrics constructed of comparison
examples of equivalent dpf and having trilobal cross-
sections with low filament factors below 2.

TABLE VIII-2
20   ## FABRIC RATINGS

Ex.	Shine Rating	Color Depth	Covering Power	Glitter Rating
VIII-A	0	1.5	0	1
VIII-1	2	1	2	1
VIII-B	0	2.5	1.5	0
VIII-2	4	5	2.5	4
VIII-C	3	0.5	4	4
VIII-3	5	5	5	4

Example IX

Yarns comprised of 50 filaments of nominal 5.1 dpf

25   were spun from poly(ethylene terephthalate). The
polyester polymer used in Examples IX-A, IX-B, and IX-1
through IX-5 was of nominal 20.6 LRV and contained 1.5
weight percent TiO_2 added delusterant. The polyester
polymer used in Examples IX-C, IX-D, and IX-6 through

30   IX-10 was of nominal 21.3 LRV and contained 0.30 weight

percent TiO$_2$ as added delusterant. A modified cross
flow quench system using a tubular delay assembly
essentially as described in U.S. Patent 4,529,368 was
used in the spinning process. Comparative Examples IX-
5   A and IX-C yarns were comprised of octalobal filaments
essentially as described in U.S. Patent No. 4,041,689
and having average filament factors of -3.36 and -2.39,
respectively, and having filament cross-sections in
appearance similar to Figure 10A. Comparative Examples
10   IX-B and IX-D yarns were comprised of filaments having
3 rounded lobes and average filament factors of 1.28
and 1.32, respectively, and having filament cross-
sections in appearance similar to Figure 11. Examples
IX-2 and IX-7 yarns were comprised of filaments having
15   6 rounded lobes and average filament factors of 4.0 and
4.9, respectively, and having lobe angles of -19.6
degrees and -18.8 degrees, respectively, and having
filament cross-sections in appearance similar to Figure
3A. Examples IX-3, IX-4, IX-5, IX-8, IX-9 and IX-10
20   yarns were comprised of filaments having filament
factors between 2.39 and 4.01 and having low average
lobe angles generally about 15 degrees or less.
Examples IX-4 and IX-9 had filament cross-sections in
appearance similar to Figure 4A, and were produced
25   using spinneret capillaries illustrated in Figure 1C.
Examples IX-3 and IX-8 had filament cross-sections in
appearance similar to Figure 5A, and were produced
using spinneret capillaries illustrated in Figure 1B,
which had a capillary leg length of about 0.457 mm.
30   Examples IX-5 and IX-10 had filament cross-sections in
appearance similar to Figure 5A, and were produced
using spinneret capillaries illustrated in Figure 1B,
but with capillary leg length increased from 0.457 mm
to 0.508 mm. The spinneret capillaries of Figures 1B
35   or 1C may be modified to achieve different multilobal
filaments having FF of at least 2, for example, by
changing the number of capillary legs for a different

desired lobe count, changing slot dimensions to change
the geometric parameters, for production of a different
DPF or as desired for use with various synthetic
polymers. Examples IX-1 and IX-6 yarns were comprised
5   of filaments having 8 lobes and average filament
factors of 2.7 and 6.0, respectively. Yarn physical
properties and cross-section parameters are listed in
Table IX-1.

Yarns of Example IX were draw false-twist textured
10 using a Barmag AFK texturing machine equipped with
polyurethane discs and using 1.53 draw ratio, 1.51 D/Y
ratio and 210 °C first heater temperature. The draw-
textured yarns had a denier per filament (dpf) of
approximately 3.4. The draw textured yarns of Example
15 IX had tensile properties and had low levels of
textured yarn broken filaments suitable for high speed
commercial fabric forming processes such as weaving and
knitting. Properties of the draw-textured yarns are
given in Table IX-2. After draw false-twist texturing,
20 the filaments of Examples IX-2 and IX-7 had filament
cross-sections in appearance similar to Figure 3B.
After draw false-twist texturing, the filaments of
Examples IX-4 and IX-9 had filament cross-sections in
appearance similar to Figure 4B, and the filaments of
25 Examples IX-3, IX-5, IX-8 and IX-10 had cross-sections
in appearance similar to Figure 5B. The draw-false-
twist textured multilobal filaments having FF of at
least 2 exhibited some lobe distortion from the
texturing process, but retained in general filaments
30 having distinct lobes and multiple along-filament
grooves, said filaments providing low fabric glitter
even after draw false-twist texturing.

Black-dyed, circular-knit fabrics were made from
draw-textured yarns of Example IX using equivalent
35 fabric construction and dyeing conditions. Fabrics
were rated for relative glitter under bright sunlight
viewing, and rated for relative color depth under

diffuse room lighting. A reduction in glitter of
fabrics made from these higher dpf yarns was achieved
by increasing the level of added delusterant from 0.30%
to 1.5%; however, the increase in TiO_2 reduced the
5 relative color depth of the fabric, which was a
disadvantage. A more significant reduction in fabric
glitter was achieved, without the penalty of loss of
fabric coloration, by modifying the fiber cross section
and using lower delusterant level. Examples IX-6 and
10 IX-8 through IX-10 had significantly reduced glitter
and higher coloration when compared to yarns having the
prior art octalobal cross-section, even when the prior
art cross section was combined with high delusterant
level. The fabrics made from Example IX multilobal
15 yarns comprised of filaments with filament factor ≥ 2,
even when fewer than 8 lobes were used, had glitter
ratings generally superior to fabrics made from yarns
comprised of filaments of the prior-art octalobal
cross-section. The yarns comprised of 3-lobe filaments
20 having negative lobe angles but with filament factors
below 2 did not provide low fabric glitter. Fabric
ratings are shown in Table IX-3.

TABLE IX-2

TEXTURED YARN PROPERTIES

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
IX-A	170	3.40	4.36	35.6	5.91	49.70	0.0
IX-1	171	3.42	4.26	32.6	5.65	45.00	0.0
IX-2	171	3.42	4.29	33.2	5.72	39.90	0.0
IX-3	169	3.38	3.97	28.5	5.10	34.60	0.0
IX-4	170	3.40	4.02	28.6	5.17	32.60	0.0
IX-5	170	3.40	4.05	29.4	5.24	35.00	0.0
IX-B	168	3.36	4.21	34.4	5.66	37.40	0.0
IX-C	170	3.40	4.39	32.7	5.83	47.10	0.0
IX-6	169	3.38	4.25	29.6	5.51	43.20	2.2
IX-7	169	3.38	4.19	29.5	5.42	37.20	0.0
IX-8	168	3.36	3.94	25.7	4.95	34.90	0.0
IX-9	169	3.38	4.10	27.9	5.25	34.50	0.0
IX-10	169	3.38	3.98	25.6	5.00	35.70	0.0
IX-D	168	3.36	4.14	32.4	5.48	37.30	0.2

5

TABLE IX-3

FABRIC RATINGS

Ex.	Color Depth	Glitter Rating
IX-A	11.3	11.7
IX-1	9	27
IX-2	9	12
IX-3	3	32
IX-4	.3	32
IX-5	3	31
IX-B	4	2
IX-C	28	10
IX-6	27	24
IX-7	26	10
IX-8	19	23
IX-9	22	25
IX-10	23	27
IX-D	27	0

10   **Example X**

Basic-dyeable feed yarns comprised of 88 filaments of nominal 1.28 dpf were prepared using polymer

essentially as described in Example V. Comparative
Example X-A filaments had 4 symmetric lobes having
negative lobe angles and having an average filament
factor of 6.86. Example X-1 filaments had 4 lobes
5   having negative lobe angles and having differing lobe
heights by use of capillary slots having differing slot
lengths. Opposing lobes were of essentially equal lobe
height, while adjacent lobes were of differing heights.
The ratio of modification ratios M_1/M_2 was used to
10   quantify the relative difference in lobe heights,
wherein M_1 was the modification ratio obtained using
the outermost circle (reference "R" of Figure 1), which
circumscribes the longest opposing pair of lobes, and
M_2 is the modification ratio obtained using the circle,
15   which circumscribes the shortest opposing pair of
lobes. The filament factor of Example X-1 was 5.27 if
the lobe geometric parameters of the shortest lobes
were used in the filament factor determination, and the
filament factor was 8.83 if the lobe geometric
20   parameters of the longest lobes were used in the
filament factor determination. In either
determination, the filament factor of the asymmetric
cross-section Example X-1 was at least 2.0, and the
average filament factor was at least 2.0. The
25   filaments of Example X-1 had cross-sections in
appearance similar to Figure 12. Table X-1 contains a
summary of yarns physical properties and filament
geometric parameters.

        Yarns of Example X were draw false-twist textured
30   using a Barmag AFK texturing machine equipped with
polyurethane discs and using 1.40 draw ratio, 1.80 D/Y
ratio and a non-contact first heater at 220 °C. The
draw-textured yarns had a denier per filament (dpf) of
approximately 0.89; i.e., the draw-textured filaments
35   were "subdeniers" or "microfibers" by virtue of having
denier per filament below 1. Both the symmetric and
asymmetric cross section multifilament feed yarns had

similar tensile properties, and the textured yarns had
low levels of broken filaments and tensile properties
suitable for fabric formation processes such as weaving
and knitting. Table X-2 contains a summary of textured
5 yarn physical properties.

     Black-dyed, circular-knit fabrics were made from
each draw-textured yarn X-A and X-1 using the same
fabric construction and dyeing conditions. Fabrics
were rated for relative glitter and shine under bright
10 sunlight viewing, and rated for relative covering power
under diffuse room lighting. The fabric using the
Example X-1 yarn having the asymmetric cross-section
filaments had similar low glitter to the fabric made
using the symmetric cross-section filaments of Example
15 X-A. The relative lobe heights of the multilobal
filaments of the invention can be adjusted, for example
as a means to influence filament-to-filament packing
and moisture transport properties, without negating the
improved luster properties of the filaments.
20

TABLE X-2

TEXTURED YARN PROPERTIES

Ex.	Text. Denier	Text. dpf	Text. Tenacity (gpd)	Text. Elo. (%)	Text. Tb (gpd)	Leesona Shrinkage (%)	Fray Count (bf/1000 meters)
X-A	78.5	0.89	2.73	28.4	3.50	12.50	3.3
X-1	78.5	0.89	2.69	26.4	3.40	12.60	1.1

25   **Example XI**

     Bicomponent filaments having three lobes and
filament factor > 2.0 were produced by bicomponent
spinning of polyethylene terephthalate and
polytrimethylene terephthalate polymers. The polymers
30 were located within the filaments in intimate adherence
and in side-by-side configuration, and each polymer
component extended longitudinally through the length of

the filaments. Multiple filaments were simultaneously
extruded from a spinneret, and the filaments were
formed into multifilament bundles and wound.
Bicomponent filaments having cross-section

5   configurations according to the present invention may
be bulked as result of their latent crimpability
without the need to mechanically texture the filaments,
as is described in the art (e.g., U.S. Patent No.
3,454,460).

10   Those skilled in the art, having the benefit of
the teachings of the present invention as hereinabove
set forth, can effect numerous modifications thereto.
These modifications are to be construed as being
encompassed within the scope of the present invention

15   as set forth in the appended claims.

TABLE I-1

As-Spun Physical Properties

Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T_7 (gpd)	Shrinkage @ Boil (%)
I-1	115.0	100	1.15	1.05	65.6	0.57	2.82	145.0	6.91	0.66	49.9
I-A	118.0	100	1.18	1.01	87.1	0.74	2.78	131.0	6.42		
I-B	115.6	100	1.16		69.0	0.60	2.80	131.0	6.47		

Cross Section Description

Ex.	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
I-1	3	2.09	-37.4	217	52.4	0.445	2.235	2.572
I-A	3	1.89	19.8	160	-4.8	0.342	1.443	0.838
I-B	1	1.00	-180.0	360	195.0	1	1.156	0.112

Table II-1

As-Spun Physical Properties

Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T_7 (gpd)	Shrinkage @ Boil (%)
II-1	248.1	200	1.24	1.31	113.6	0.46	2.70	160.8	7.04	0.61	55.8
II-A	253.3	200	1.27	1.15	151.2	0.60	2.65	141.5	6.40		
II-B	226.0	200	1.13		107.0	0.47	2.45	142.0	5.93		

Cross Section Description

Ex.	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
II-1	3	2.08	-35.4	215	50.4	0.441	2.367	2.373
II-A	3	1.91	18.6	161	-3.6	0.349	1.615	0.773
II-B	1	1.00	-180.0	360	195.0	1	1.130	0.113

Table III-1

| | As-Spun Physical Properties | | | | | | | | | | | Cross Section Description | | | | | | | |
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T$_B$ (gpd)	T7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
III-1	246.8	176	1.40	1.21	111.6	0.45	2.23	135.0	5.24	0.61	54.4	3	2.21	-39.0	219	54.0	0.448	3.057	2.473
III-A	246.6	176	1.40	1.42	115.1	0.47	2.43	150.5	6.09			1	1.0	-180.0	360	195.0	1	1.399	0.104
III-2	245.9	176	1.40	1.15	113.1	0.46	2.38	139.2	5.69			3	2.39	-59.9	240	74.9	0.456	3.644	3.534

Table IV-1

| | As-Spun Physical Properties | | | | | | | | | | | Cross Section Description | | | | | | | |
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T$_B$ (gpd)	T7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
IV-1	73.9	88	0.84	1.53	105.9	1.43	2.47	68.04	4.15	1.29	3.2	3	2.65	-49.8	230	64.8	0.43	2.527	5.011
IV-A	74.5	100	0.75	1.22	108.4	1.46	2.63	73.3	4.55	1.33	3.6	1	1.0	-180.0	360	195.0	1	0.745	0.132
IV-2	74.7	100	0.75	1.33	109.2	1.46	2.36	57.6	3.72	1.39	3.5	3	2.15	-39.0	219	54.0	0.451	1.560	3.692
IV-B	75.5	100	0.75	1.45	110.5	1.46	2.23	49.8	3.34	1.44	3.1	3	1.96	21.9	158	-6.9	0.312	0.902	1.762
IV-C	74.2	34	2.18	1.46	80.1	1.08	2.69	90.6	5.13	0.97	3.3	3	1.95	25.4	155	-10.4	0.327	2.720	0.207

TABLE V-1

| | As-Spun Physical Properties | | | | | | | | | | | Cross Section Description | | | | | | | |
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T_7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
V-1	115.0	88	1.31	0.79	66.4	0.58	1.95	134.1	4.57	0.63	48.9	3	2.36	-44.2	224	59.2	0.473	3.432	2.973
V-A	114.9	100	1.15	0.65	66.4	0.58	2.02	137.2	4.79	0.64	50.1	1	1.0	-180.0	360	195.0	1	1.149	0.112
V-B	115.1	100	1.15	0.98	79.9	0.69	1.95	120.8	4.31	0.68	44.1	3	1.92	26.8	153	-11.8	0.328	1.394	0.720
V-2	114.9	100	1.15	0.81	69.3	0.60	2.02	137.0	4.79	0.64	48.5	3	2.16	-42.2	222	57.2	0.49	2.625	2.770

TABLE VI-1

| | As-Spun Physical Properties | | | | | | | | | | | Cross Section Description | | | | | | | |
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T_7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
VI-A	80.3	34	2.36	0.86	28.4	0.35	1.90	160.4	4.95	0.57	49.9	1	1.0	-180.0	360	195.0	1	2.362	0.086
VI-B	80.6	34	2.37	0.87	38.0	0.47	1.44	129.2	3.30	0.60	47.1	3	2.16	19.7	160	-4.7	0.28	3.083	0.389
VI-1	80.9	34	2.38	0.84	47.6	0.59	1.83	131.3	4.23	0.63	41.4	6	1.36	-9.1	189	24.1	0.348	1.527	6.978
VI-2	80.9	34	2.38	0.75	43.5	0.54	1.67	115.4	3.60	0.61	42.4	3	3.37	-52.6	233	67.6	0.398	10.767	4.072

TABLE VII-1

	As-Spun Physical Properties											Cross Section Description							
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
VII-A	64.8	34	1.91	1.19	26.9	0.42	1.92	153.8	4.87	0.59	53.1	1	1.0	-180.0	360	195.0	1	1	0.093
VII-B	65.1	34	1.91	1.32	35.5	0.55	1.69	119.7	3.71	0.63	48.1	3	2.00	19.2	161	-4.2	0.298	1.906	0.500
VII-1	65.0	34	1.91	1.11	43.6	0.67	1.87	123.2	4.17	0.65	41.3	6	1.35	-7.7	188	22.7	0.339	2.279	8.858
VII-2	64.8	34	1.91	1.28	40.3	0.62	1.77	113.3	3.77	0.64	38.9	3	3.25	-51.3	231	66.3	0.411	1.187	4.210
VII-C	65.6	50	1.31	1.31	43.0	0.66	1.81	115.3	3.90	0.67	37.7	3	1.87	24.8	155	-9.8	0.303	8.242	0.681
VII-3	65.4	50	1.31	1.03	53.6	0.82	1.96	115.9	4.23	0.75	28.2	6	1.25	22.8	157	-7.8	0.325	1.383	10.215

TABLE VIII-1

	As-Spun Physical Properties											Cross Section Description							
Ex.	Denier	# Fils.	Spun dpf	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	T_B (gpd)	T7 (gpd)	Shrinkage @ Boil (%)	# Lobes	MR	Lobe Angle (deg.)	Wrap Angle per lobe (deg.)	Angle Factor	Tip Ratio	Lobe Area Factor	Filament Factor
VIII-A	71.5	100	0.72	1.60	77.1	1.08	2.19	74.2	3.82	1.29	8.4	1	1.00	-180	360	195.0	1	1.906	0.093
VIII-1	71.5	100	0.72	1.53	75.5	1.06	2.08	66.2	3.46	1.28	8.6	3	2.41	-51.0	231	66.0	0.45	1.863	4.948
VIII-B	71.7	50	1.43	1.40	63.4	0.88	1.80	63.9	2.95	1.08	6.4	3	2.02	23.2	157	-8.2	0.283	1.656	0.715
VIII-2	71.7	50	1.43	1.65	68.9	0.96	1.88	62.9	3.06	1.20	6.0	6	1.44	-1.3	181	16.3	0.331	0.983	12.479
VIII-C	71.9	68	1.06	1.60	70.4	0.98	1.82	56.8	2.85	1.21	7.6	3	2.24	19.7	160	-4.7	0.281	1.489	1.391
VIII-3	72.0	68	1.06	1.44	73.4	1.02	1.89	59.0	3.01	1.28	7.0	3	2.81	-40.8	221	55.8	0.424	3.541	4.209
VIII-4	49.7	50	0.99	1.59	54.3	1.09	1.98	62.5	3.22	1.40	5.1	6	1.33	4.8	175	10.2	0.347	0.605	16.762
VIII-5	47.5	68	0.70	2.02	58.8	1.24	1.93	48.7	2.87	1.51	5.6	3	2.54	-46.1	226	61.1	0.422	1.898	5.246

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TABLE IX-1

Ex.	As-Spun Physical Properties				Draw Tension	Draw Tension	Tenacity	Elongation	T_B	T7	Cross Section Description			Wrap				Lobe	Filament
	Denier	# Fils.	Spun dpf	Denier Spread (%)	(g)	(gpd)	(gpd)	(%)	(gpd)	(gpd)	# Lobes	MR	Lobe Angle (deg.)	Angle per lobe (deg.)	Angle Factor	Tip Ratio	Area Factor	Factor
IX-A	256.7	50	5.13	1.08	146.5	0.57	2.52	129.7	5.79	0.58	8	1.17	90.5	90	-75.5	0.321	2.262	-3.360
IX-1	256.2	50	5.12	1.00	155.2	0.61	2.44	127.4	5.55	0.59	8	1.25	49.0	131	-34.0	0.26	2.083	2.700
IX-2	256.6	50	5.13	1.15	150.5	0.59	2.41	124.8	5.42	0.59	6	1.35	-19.6	200	34.6	0.348	3.244	4.000
IX-3	255.5	50	5.11	1.01	148.9	0.58	2.34	119.5	5.14	0.58	6	1.41	4.5	176	10.5	0.317	3.238	2.716
IX-4	255.7	50	5.11	1.02	150.2	0.59	2.34	119.3	5.13	0.59	6	1.56	2.5	178	12.5	0.273	3.408	3.507
IX-5	254.6	50	5.09	0.94	151.5	0.59	2.25	122.3	5.00	0.60	6	1.55	13.2	167	1.8	0.265	3.223	2.697
IX-B	253.5	50	5.07	1.09	118.8	0.47	2.31	126.7	5.24	0.57	3	2.20	-40.1	220	55.1	0.473	11.621	1.283
IX-C	255.1	50	5.10	0.86	142.3	0.56	2.40	119.9	5.28	0.54	8	1.21	86.0	94	-71.0	0.287	2.131	-2.390
IX-6	254.1	50	5.08	0.90	152.8	0.60	2.34	116.8	5.07	0.55	8	1.32	29.7	150	-14.7	0.24	2.125	6.025
IX-7	253.3	50	5.07	0.87	149.0	0.59	2.31	102.5	4.68	0.55	6	1.48	-18.8	199	33.8	0.342	3.783	4.486
IX-8	253.0	50	5.06	0.98	149.0	0.59	2.04	108.2	4.25	0.54	6	1.57	17.8	162	-2.8	0.262	3.264	2.394
IX-9	253.2	50	5.06	1.00	147.8	0.58	2.10	104.9	4.30	0.54	6	1.70	3.8	176	11.2	0.248	3.627	4.006
IX-10	252.8	50	5.06	0.98	149.7	0.59	2.09	105.3	4.29	0.55	6	1.57	6.0	174	9.0	0.26	3.230	3.396
IX-D	252.7	50	5.05	0.96	111.9	0.44	2.22	119.5	4.87	0.51	3	2.26	-38.9	219	53.9	0.453	11.728	1.316

TABLE X-1

As-Spun Physical Properties

Ex.	Denier	# Fils.	Spun DpF	Denier Spread (%)	Draw Tension (g)	Draw Tension (gpd)	Tenacity (gpd)	Elongation (%)	TB (gpd)	T7 (gpd)
X-A	112.6	88	1.28	1.31	77.8	0.69	1.92	124	4.3	0.63
X-1	112.7	88	1.28	1.63	77.6	0.69	1.98	132.6	4.61	0.63

Cross Section Description

# Lobes	MR1	MR2	MR1/MR2	Lobe Angle 1 (deg.)	Lobe Angle 2 (deg.)	Angle Factor 1	Angle Factor 2	Tip Ratio1	Tip Ratio2	Lobe Area Factor 1	Lobe Area Factor 2	Filament Factor1	Filament Factor2
4	2.291	n.a.		-33.9	n.a.	48.9	n.a.	0.4	n.a.	2.559	n.a.	6.857	n.a.
4	2.566	2.05	1.25	-38.8	-23.6	53.8	38.6	0.3	0.385	2.774	2.064	8.829	5.27

WHAT IS CLAIMED IS:

5   1.   A synthetic filament having a multilobal cross-
section, a filament factor of about 2 or greater,
wherein the filament factor is determined according to
the following formula:

10   $FF = K_1 * (MR)^A * (N)^B * (1/(DPF))^C [K_2 * (N)^D * (MR)^E * 1/(LAF) + K_3 * (AF)]$,

wherein K_1 is 0.0013158; K_2 is 2.1; K_3 is 0.45; A is
1.5; B is 2.7; C is 0.35; D is 1.4; E is 1.3; MR is
R/r_1, wherein R is the radius of a circle centered in
15   the middle of the cross-section and circumscribed about
the tips of the lobes, and r_1 is the radius of a circle
centered in the middle of the cross-section and
inscribed within the cross-section about the connecting
points of the lobes; N is the number of lobes in the
20   cross-section; DPF is the denier per filament; LAF is
$(TR) * (DPF) * (MR)^2$, wherein TR is r_2/R, wherein r_2 is the
average radius of a circle inscribed about the lobes,
and R is as set forth above, and DPF and MR are as set
forth above; and AF is 15 minus the lobe angle, wherein
25   the lobe angle is the average angle of two tangent
lines laid at the point of inflection of curvature on
each side of the lobes of the filament cross-section,
and an average tip ratio of $\geq$ about 0.2.

30   2.   The filament of claim 1, wherein the tip ratio is
$\geq$ about 0.3.

3.   The filament of claim 2, wherein the tip ratio is
$\geq$ about 0.4.
35

4   The filament of claim 1, wherein the lobe angle is
$\leq$ about 15°.

5.   The filament of claim 1, wherein said lobe angle
40   is $\leq$ about 0°.

- 60 -

6.   The filament of claim 4, wherein said lobe angle
is ≤ about -30°.

5

7.   The filament of claim 1, wherein said filament is
comprised of at least one melt-spinnable polymer
selected from the group consisting of polyesters,
polyamides, polyolefins, and combinations thereof.

10

8.   The filament of claim 4, wherein said polymer is a
polyester selected from the group consisting of
polyethylene terephthalate, polytrimethylene
terephthalate, polybutylene terephthalate,
15   polypropylene terephthalate, polyethylene naphthalate,
and combinations thereof.

9.   The filament of claim 7, wherein said filament is
a bicomponent filament.

20

10.   The filament of claim 9, wherein the bicomponent
filament comprises a first component selected from the
group consisting of poly(ethylene terephthalate) and
copolymers thereof and a second component selected from
25   the group consisting of poly(trimethylene
terephthalate) and copolymers thereof, the two
components being present in a weight ratio of about
95:5 to about 5:95.

30   11.   The filament of claim 1, wherein said filament has
a filament factor of greater than or equal to about
3.0.

12.   The filament of claim 11, wherein said filament
35   has a filament factor of greater than or equal to 4.0.
13.   The filament of claim 1, wherein said filament has
3 to 8 lobes.

14. The filament of claim 1, wherein the filament has a denier in the range of between about 0.2 to about 5.0 denier per filament.

5

15. A multifilament yarn formed at least in part from a filament of claim 1.

16. A multifilament yarn formed at least in part from
10 a filament of claim 4.

17. The yarn of claim 15, wherein the filaments of the yarn have a denier in the range of between about 0.2 to about 5.0 denier per filament.

15

18. The yarn of claim 16, wherein the filaments of the yarn have a denier in the range of between about 0.2 to about 1.0 denier per filament.

20 19. The yarn of claim 17, wherein the yarn is false-twist textured.

20. The yarn of claim 18, wherein the yarn is false-twist textured.

25

21. An article formed at least in part from a filament of claim 1.

22. A garment formed at least in part from a filament
30 of claim 1.

23. A fabric formed at least in part from a filament of claim 1.

35 24. A spinneret capillary capable of producing a filament as claimed in claim 1.

25. A process for making a filament having a
multilobal cross-section, wherein the filament cross-
section has a filament factor of $\geq$ about 2.0 and a tip
ratio of $\geq$ about 0.2, said process comprising melting a
melt-spinnable polymer to form a molten polymer;
extruding the molten polymer through a spinneret
capillary designed to provide a cross-section having a
filament factor of $\geq$ about 2.0 and a tip ratio $\geq$ of
0.2; quenching the filaments leaving the capillary;
converging the quenched filaments; and winding the
filaments.

26. The process of claim 25, wherein after the
converging step, the filaments are further drawn and
textured.

27. The process of claim 26, further comprising
forming a yarn containing at least a portion of the
filaments.

28. A filament having a multilobal cross-section,
wherein the lobe angle is $\leq$ about 15° and which has a
denier of less than about 5 dpf.

29. The filament of claim 28, having a denier of less
than about 2.2.

30. The filament of claim 29, having a denier of less
than about 1.0.

31. The filament of claim 28, which is a bicomponent
filament comprising a first component selected from the
group consisting of poly(ethylene terephthalate) and
copolymers thereof and a second component selected from
the group consisting of poly(trimethylene
terephthalate) and copolymers thereof, the two

components being present in a weight ratio of about
95:5 to about 5:95.

5   32.   The filament of claim 31, wherein the first
     component is a copolymer of poly(ethylene
     terephthalate), wherein a comonomer used to prepare the
     copolymer is selected from the group consisting of
     isophthalic acid, pentanedioic acid, hexanedioic acid,
10   1,3-propane diol, and 1,4-butanediol.

     32.   A garment or fabric formed at least in part from a
     filament of claim 28.

15   33.   A method for reducing glitter in fabric comprising
     forming said fabric with multifilament yarns, wherein
     at least a portion of the filaments of the yarn have a
     multilobal cross-section, a filament factor of about 2
     or greater, wherein the filament factor is determined
20   according to the following formula:

$$FF = K_1 * (MR)^A * (N)^B * (1/(DPF)^C [K_2 * (N)^D * (MR)^E * 1/(LAF) + K_3 * (AF)],$$

     wherein K_1 is 0.0013158; K_2 is 2.1; K_3 is 0.45; A is
25   1.5; B is 2.7; C is 0.35; D is 1.4; E is 1.3; MR is
     R/r_1, wherein R is the radius of a circle centered in
     the middle of the cross-section and circumscribed about
     the tips of the lobes, and r_1 is the radius of circle
     centered in the middle of the cross-section and
30   inscribed within the cross-section about the connecting
     points of the lobes; N is the number of lobes in the
     cross-section; DPF is the denier per filament; LAF is
     $(TR) * (DPF) * (MR)^2$, wherein TR is r_2/R, wherein r_2 is the
     average radius of a circle inscribed about the lobes,
35   and R is as set forth above, and DPF and MR are as set
     forth above; and AF is 15 minus the lobe angle, wherein
     the lobe angle is the average angle of two tangent
     lines laid at the point of inflection of curvature on

each side of the lobes of the filament cross-section,
and a tip ratio of ≥ about 0.2.

5   34.   A method for reducing glitter in fabric comprising
forming said fabric with multifilament yarns, wherein
at least a portion of the filaments of the yarn have a
multilobal cross-section, a dpf less than about 5, and
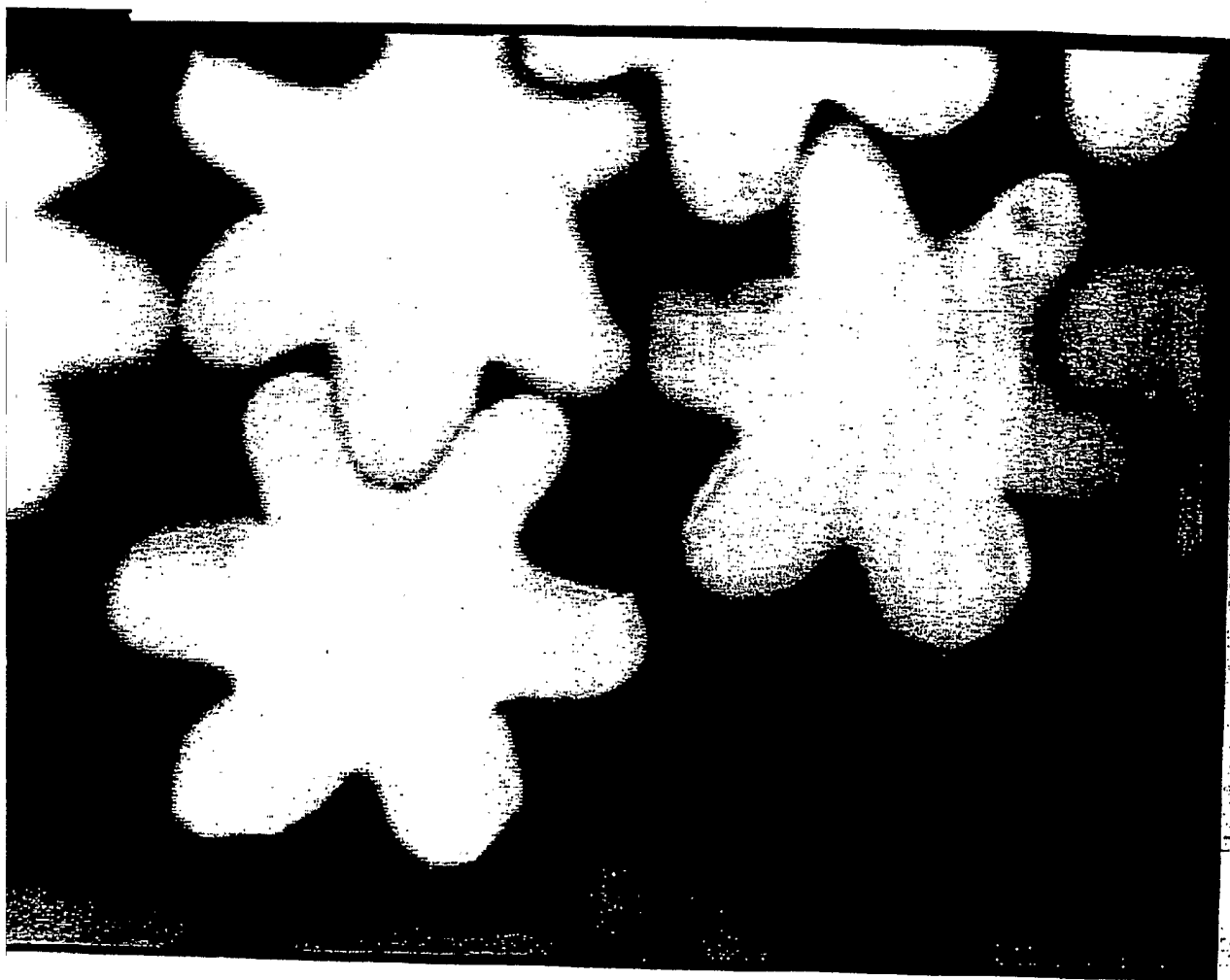a lobe angle less than 15°.
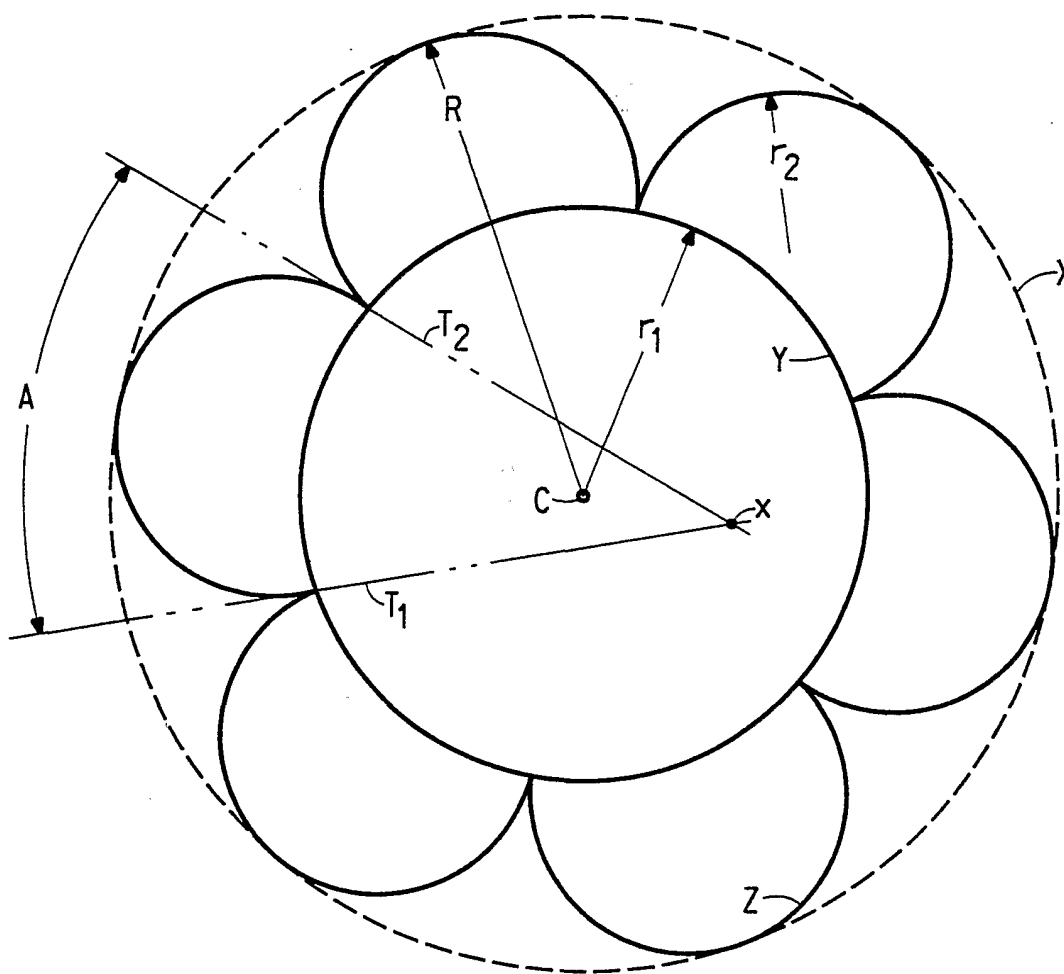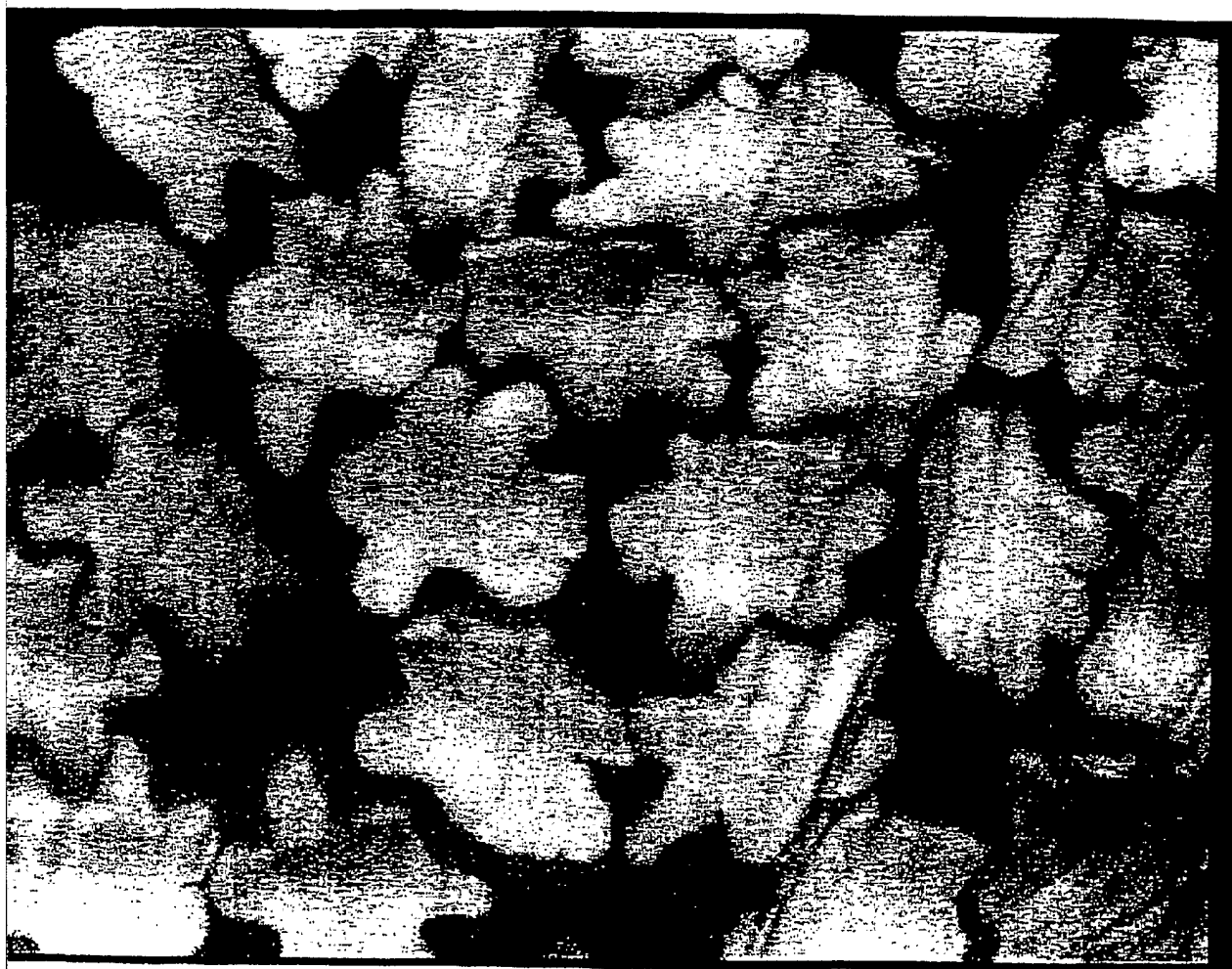
FIG. 1
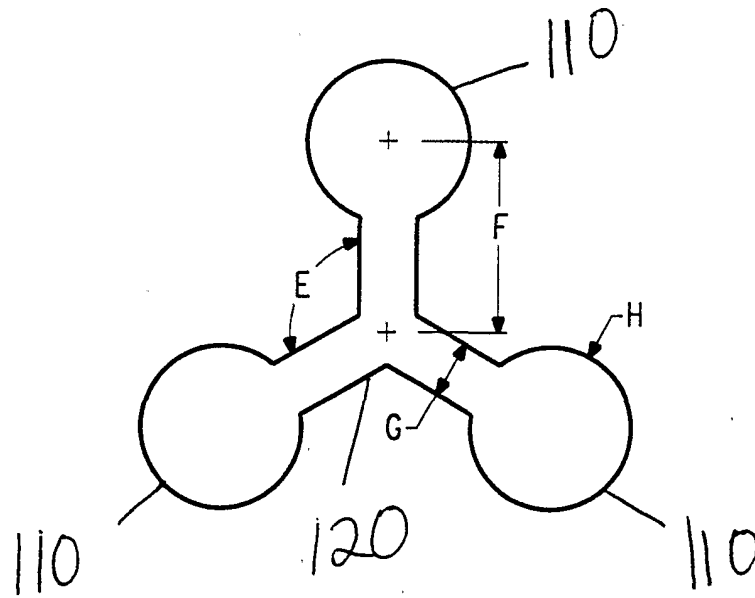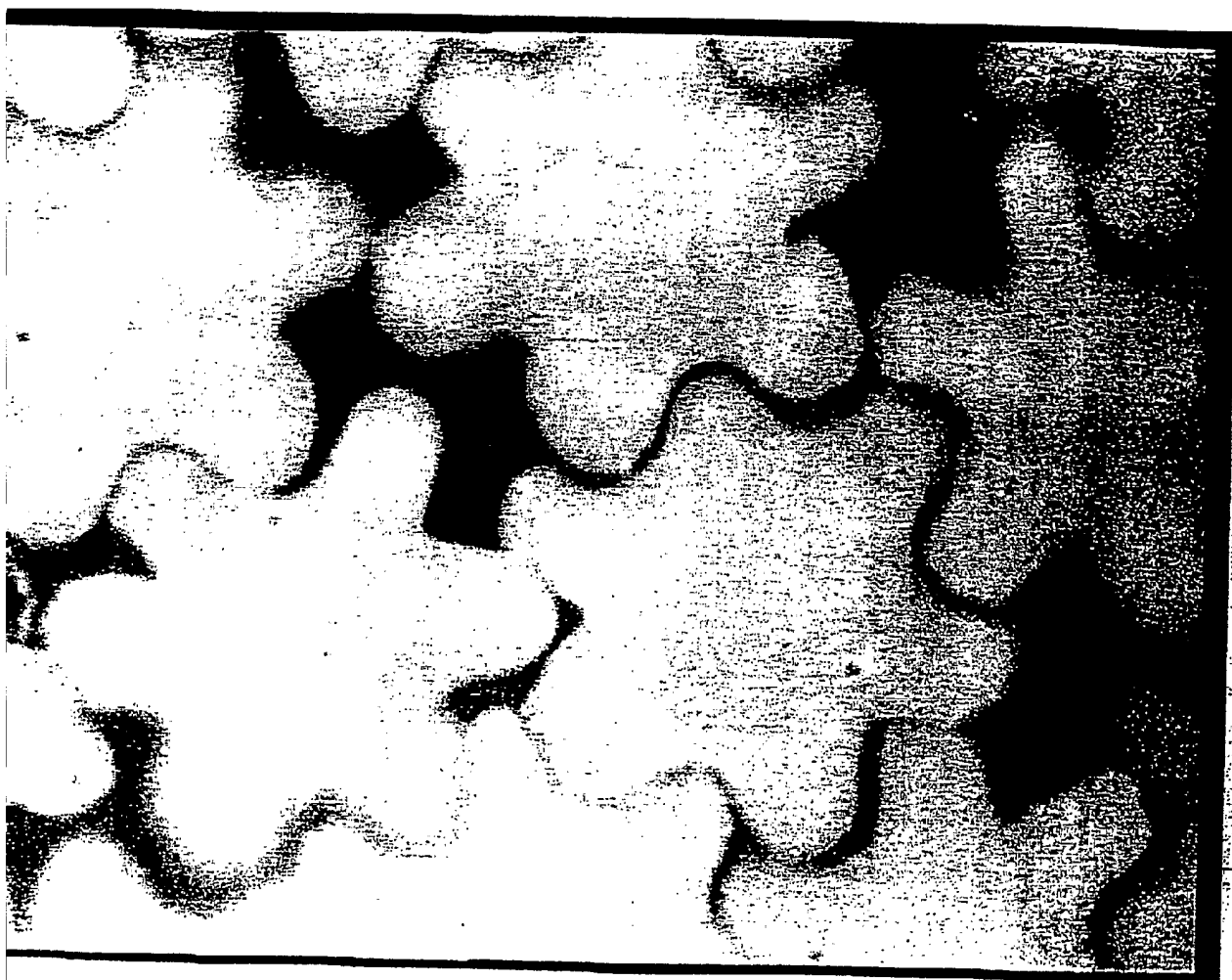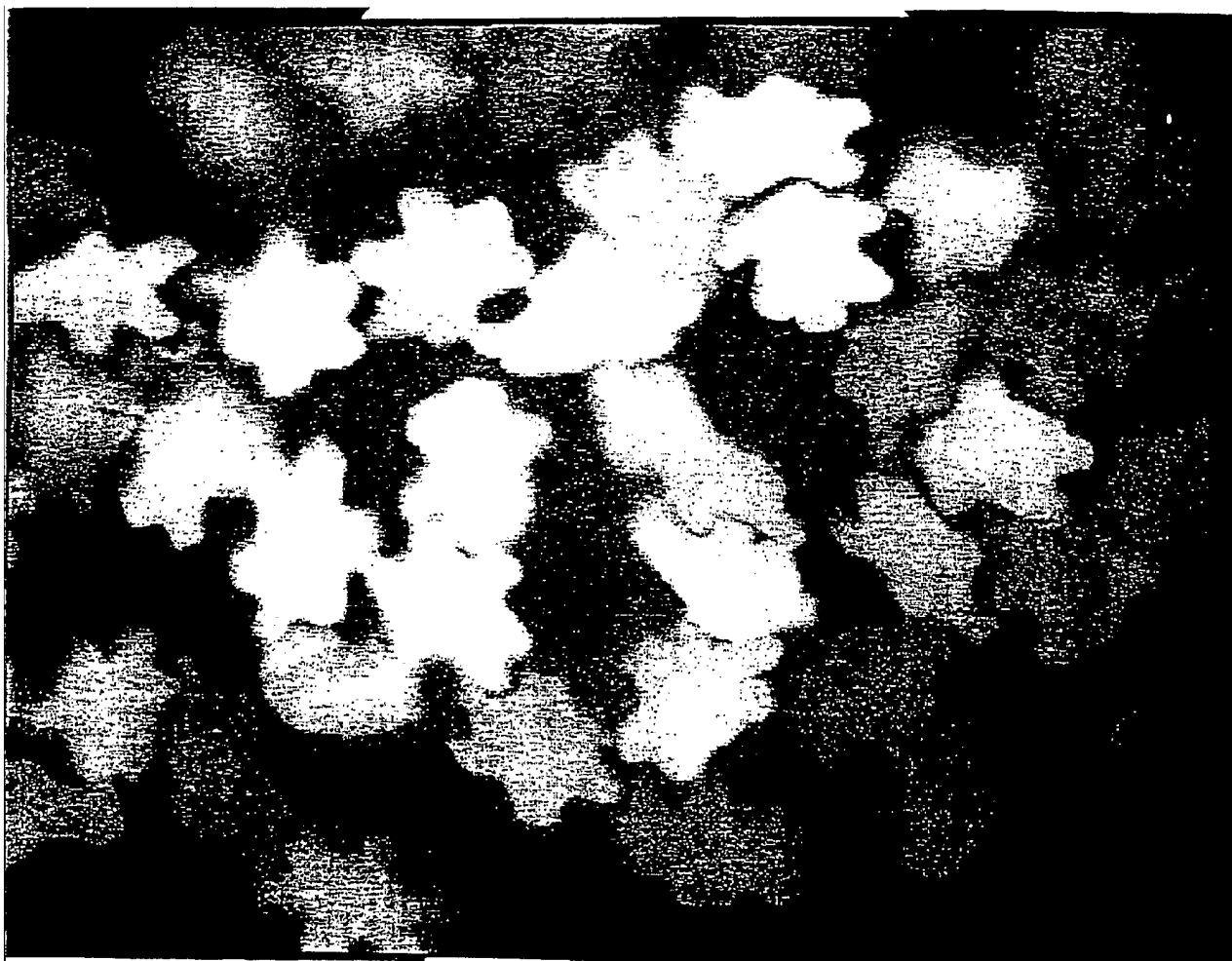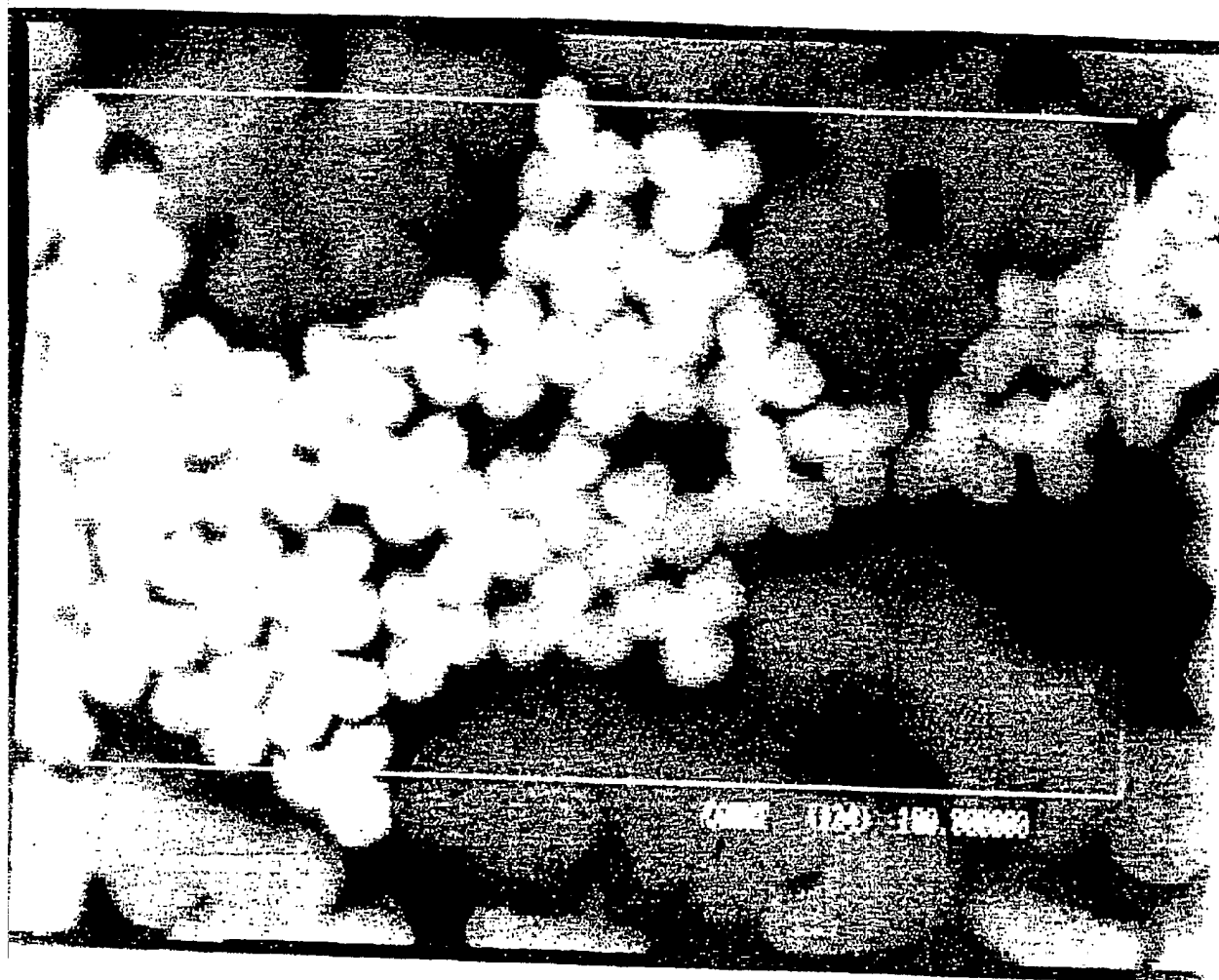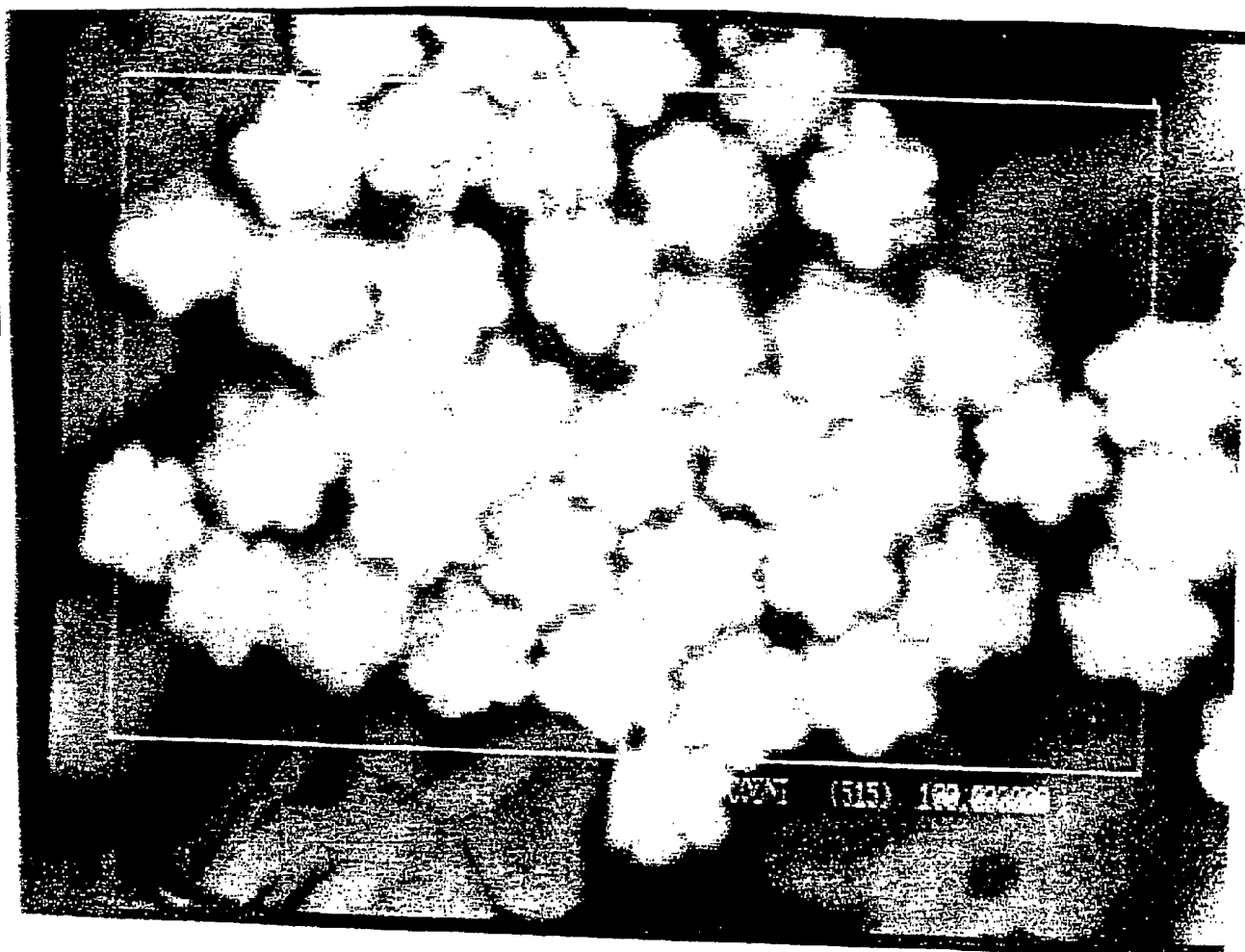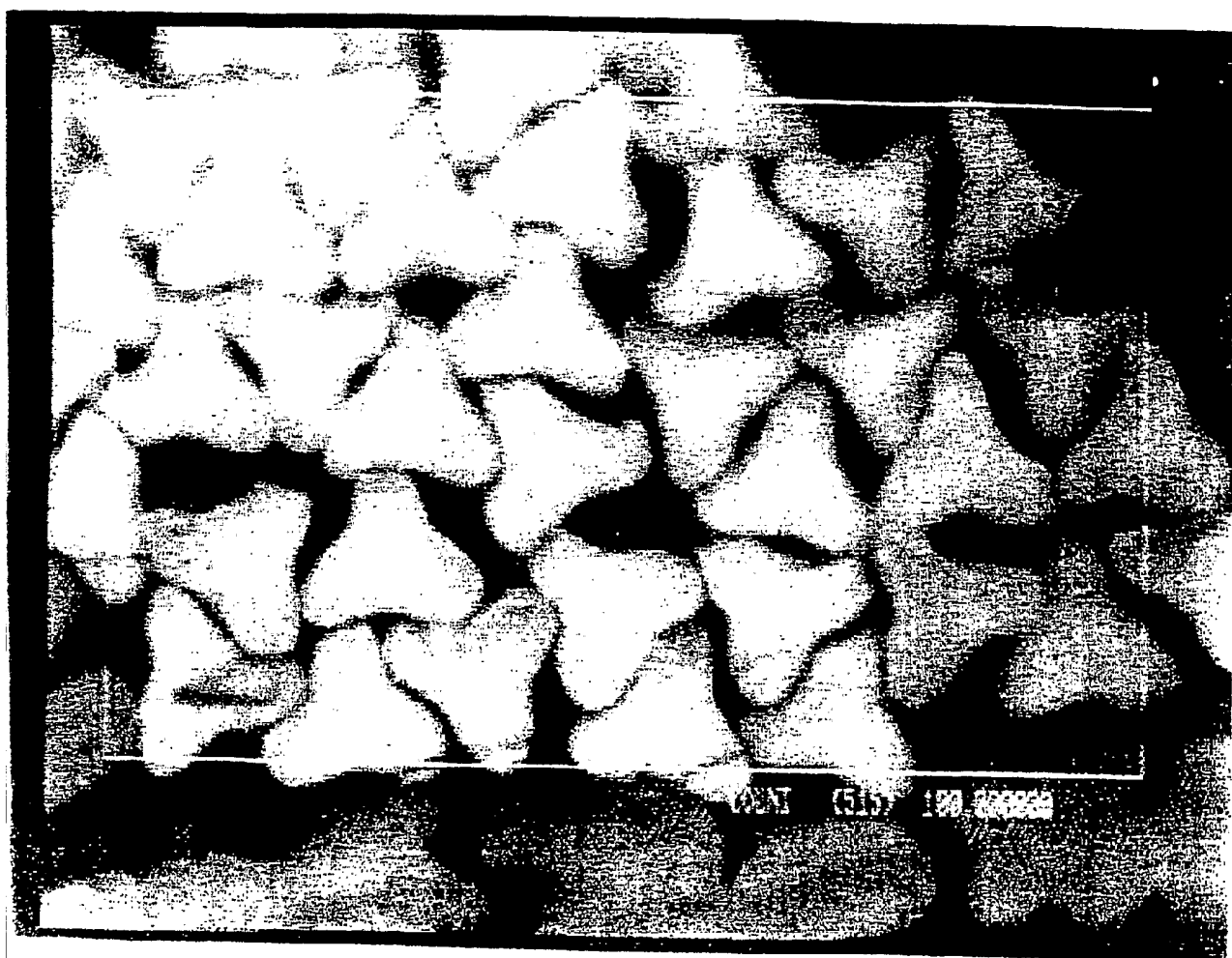
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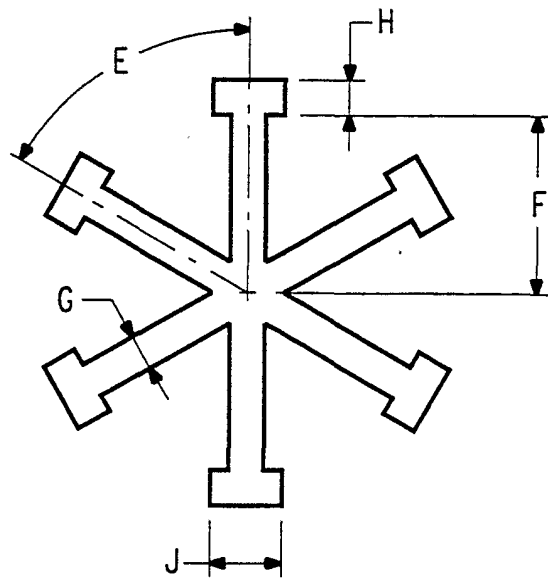
FIG. 1B

FIG. 1C
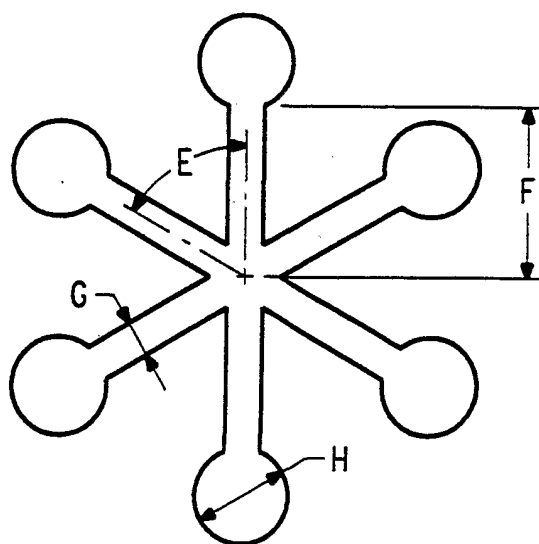
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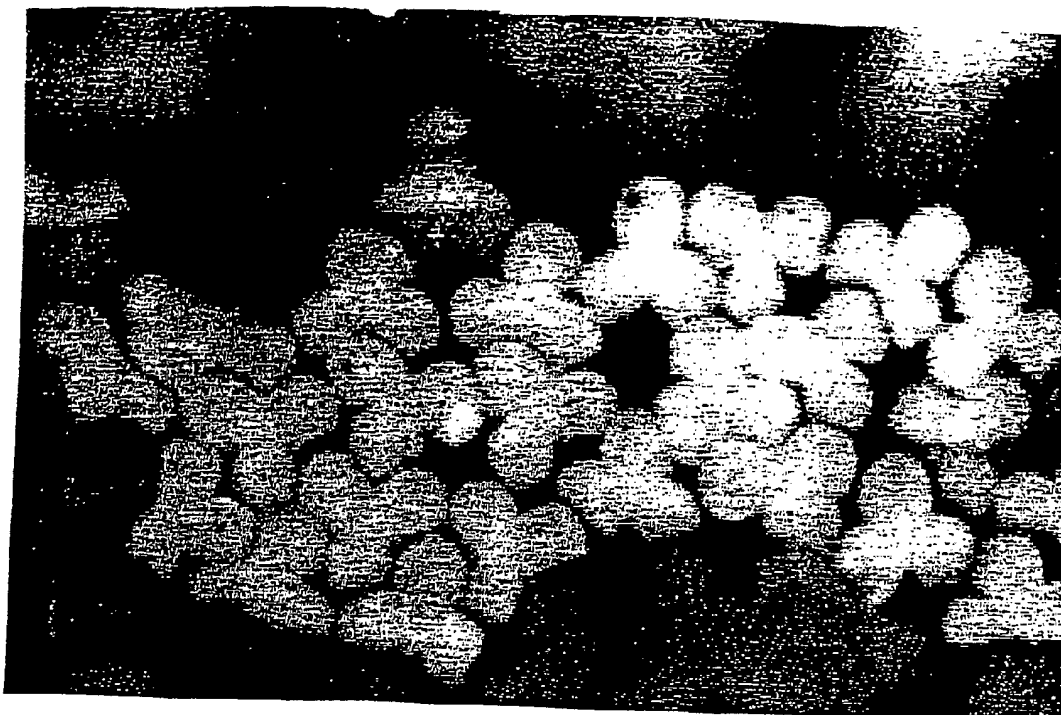
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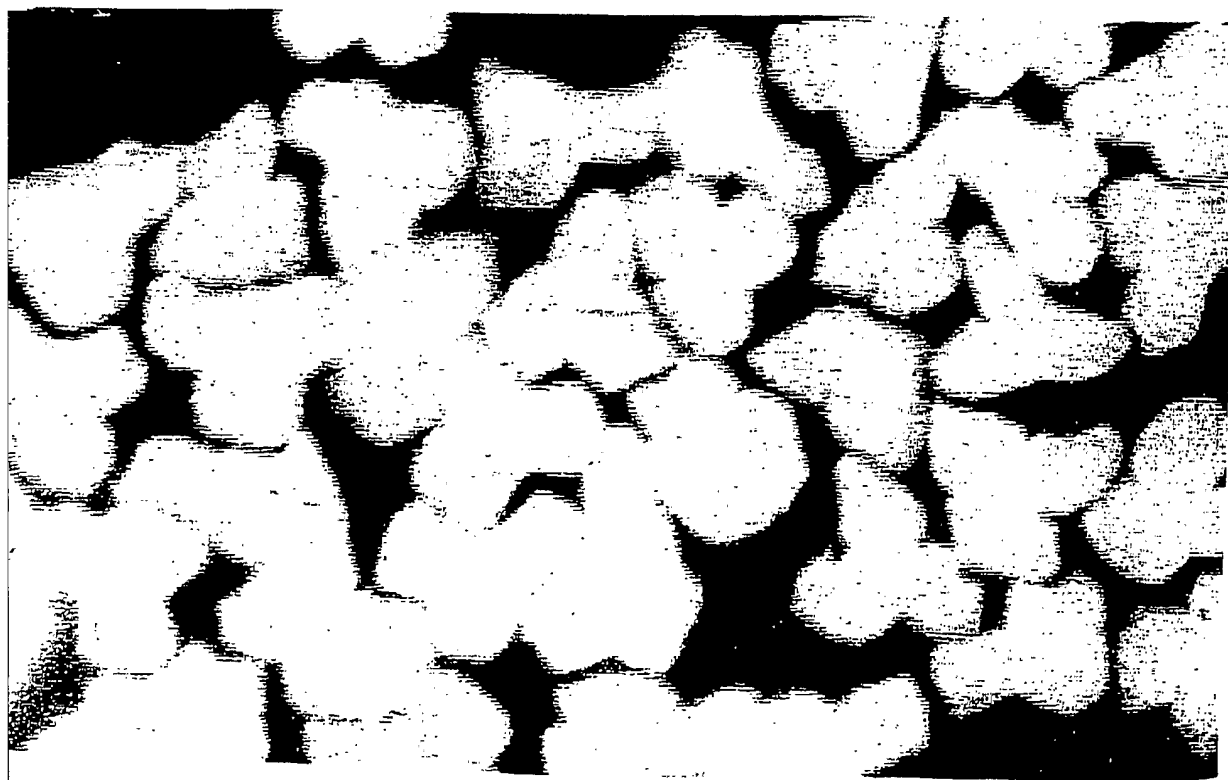
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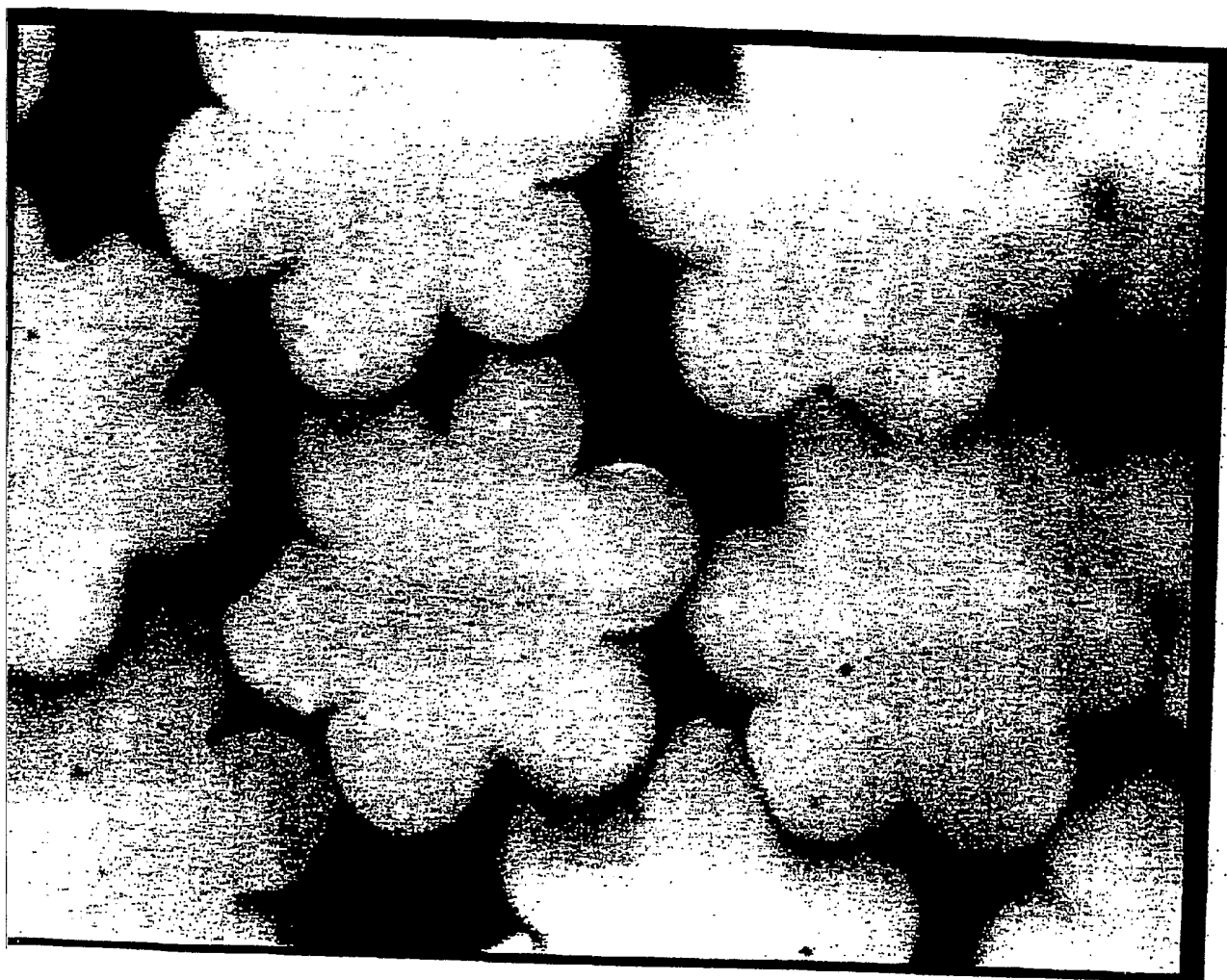
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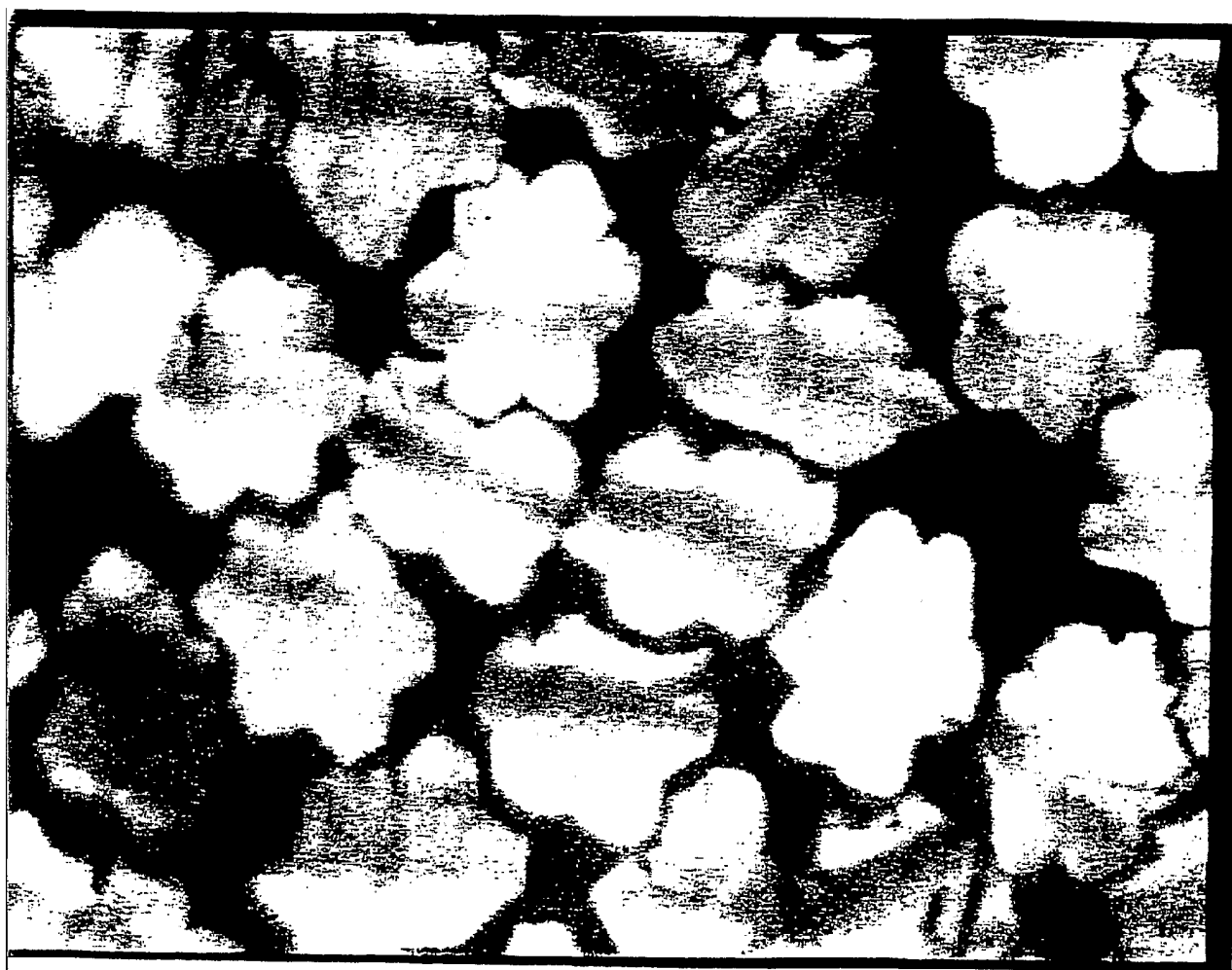
FIG. 4A

FIG. 4B

FIG. 5A

FIG. 5B

FIG. 6

FIG. 7A
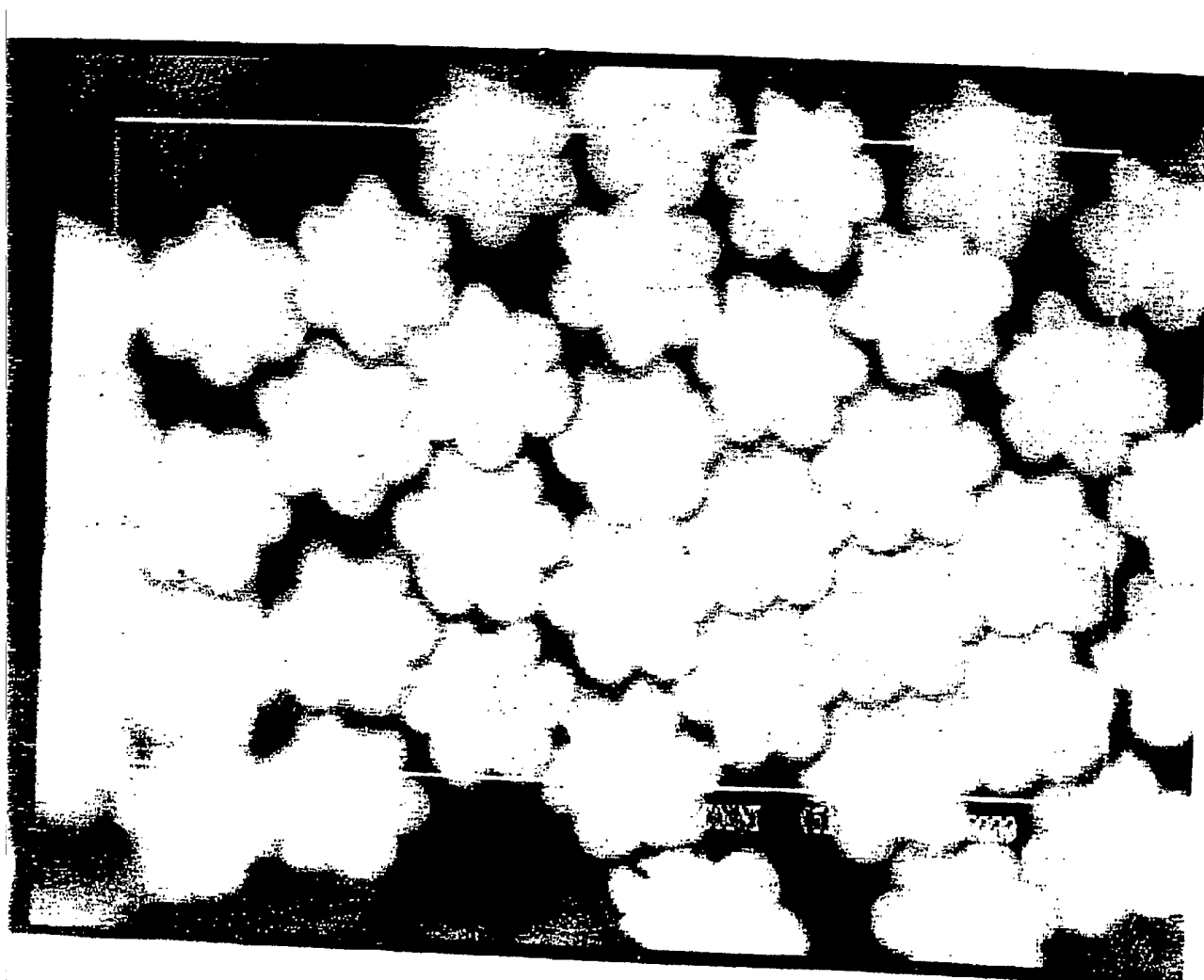
FIG. 7B
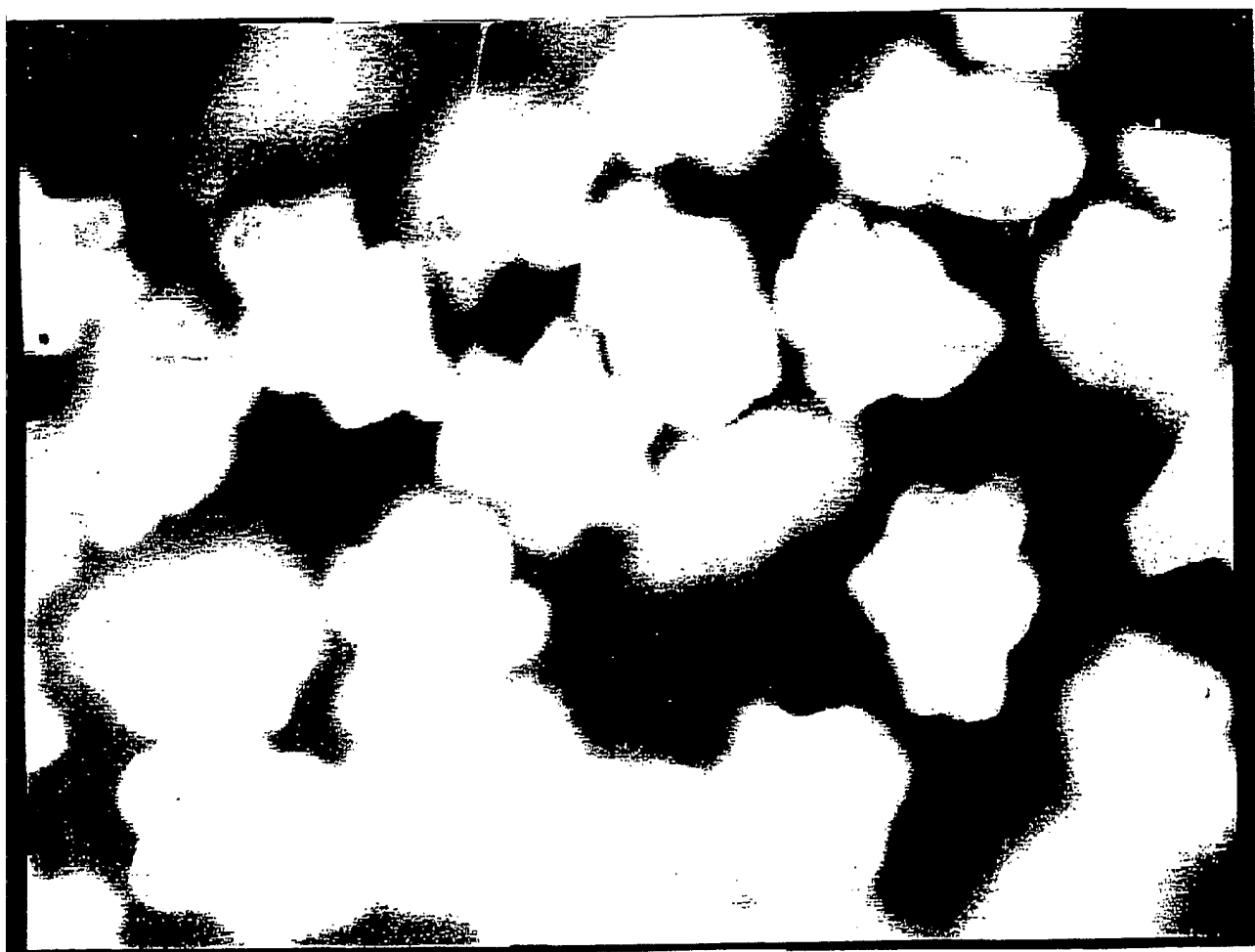
FIG. 8

FIG. 9

FIG. 10A
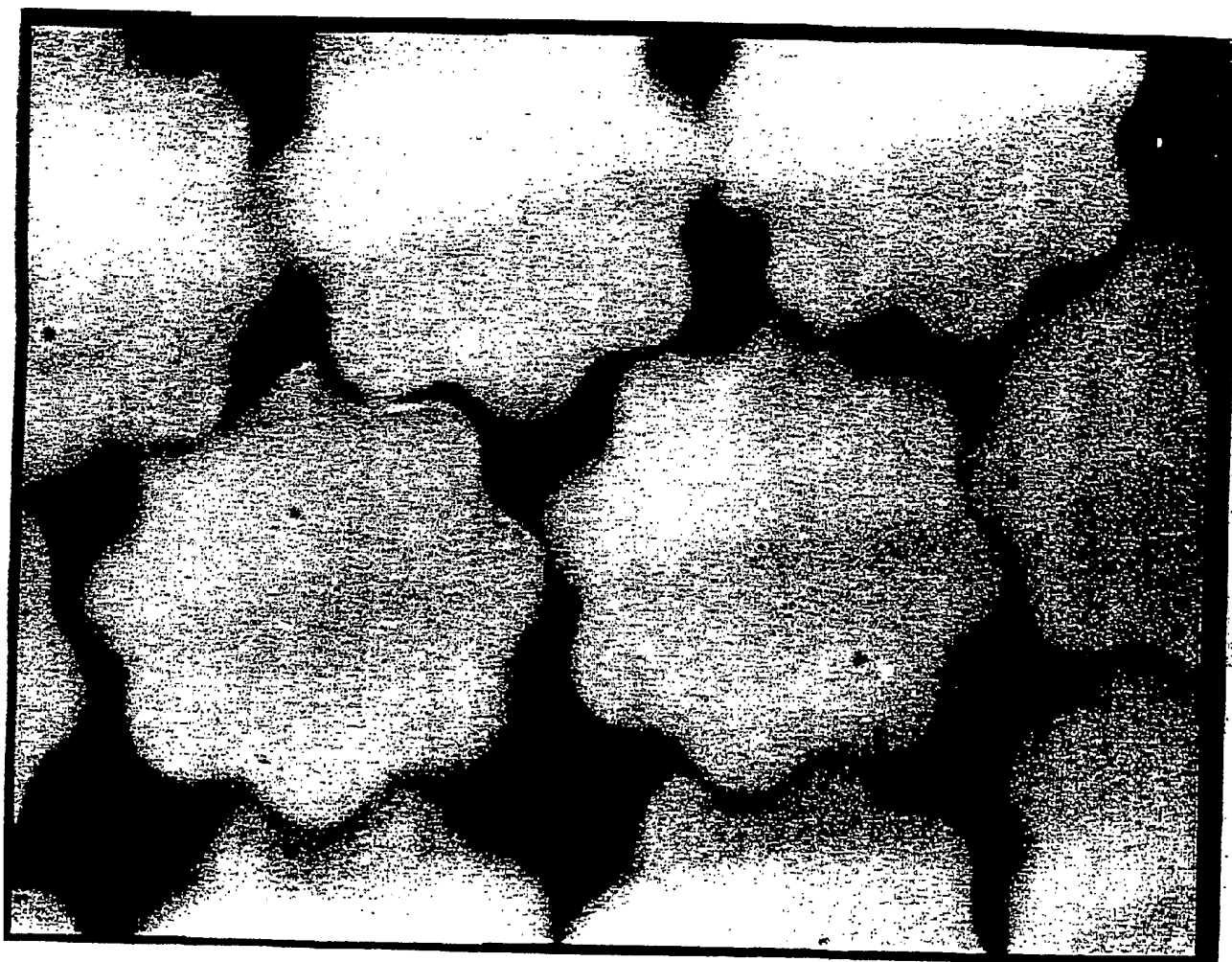
FIG. 10B
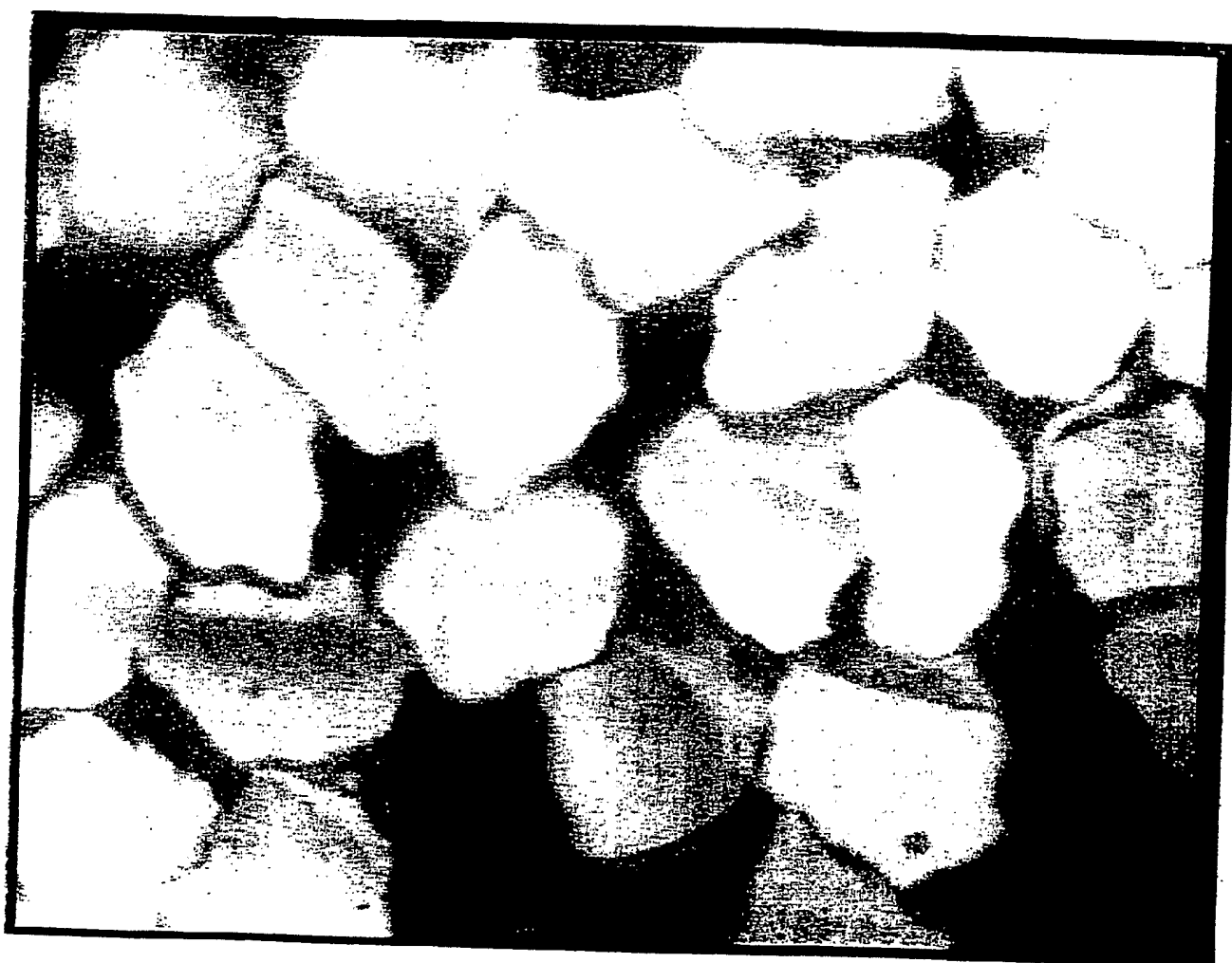
FIG. 11
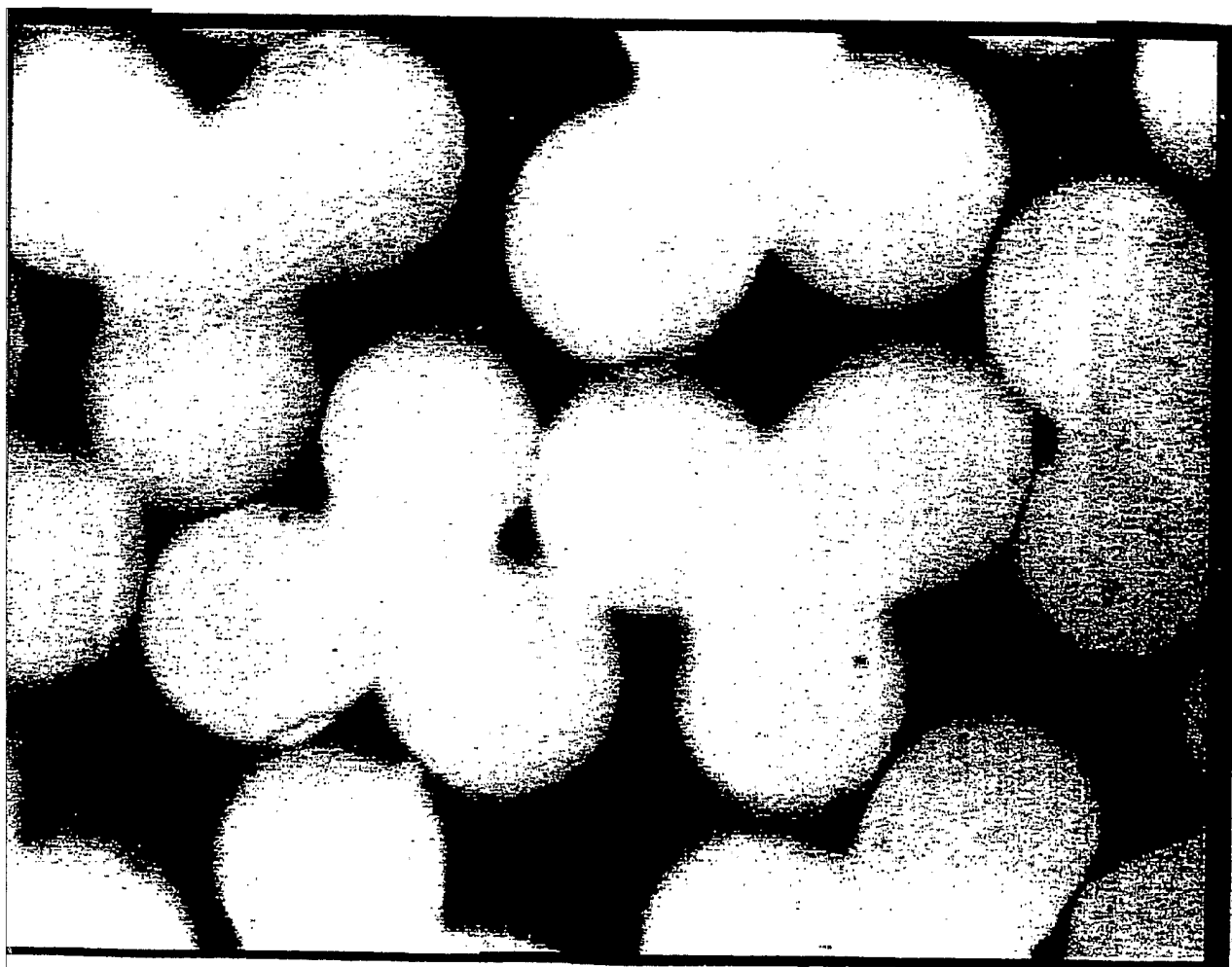
FIG. 12
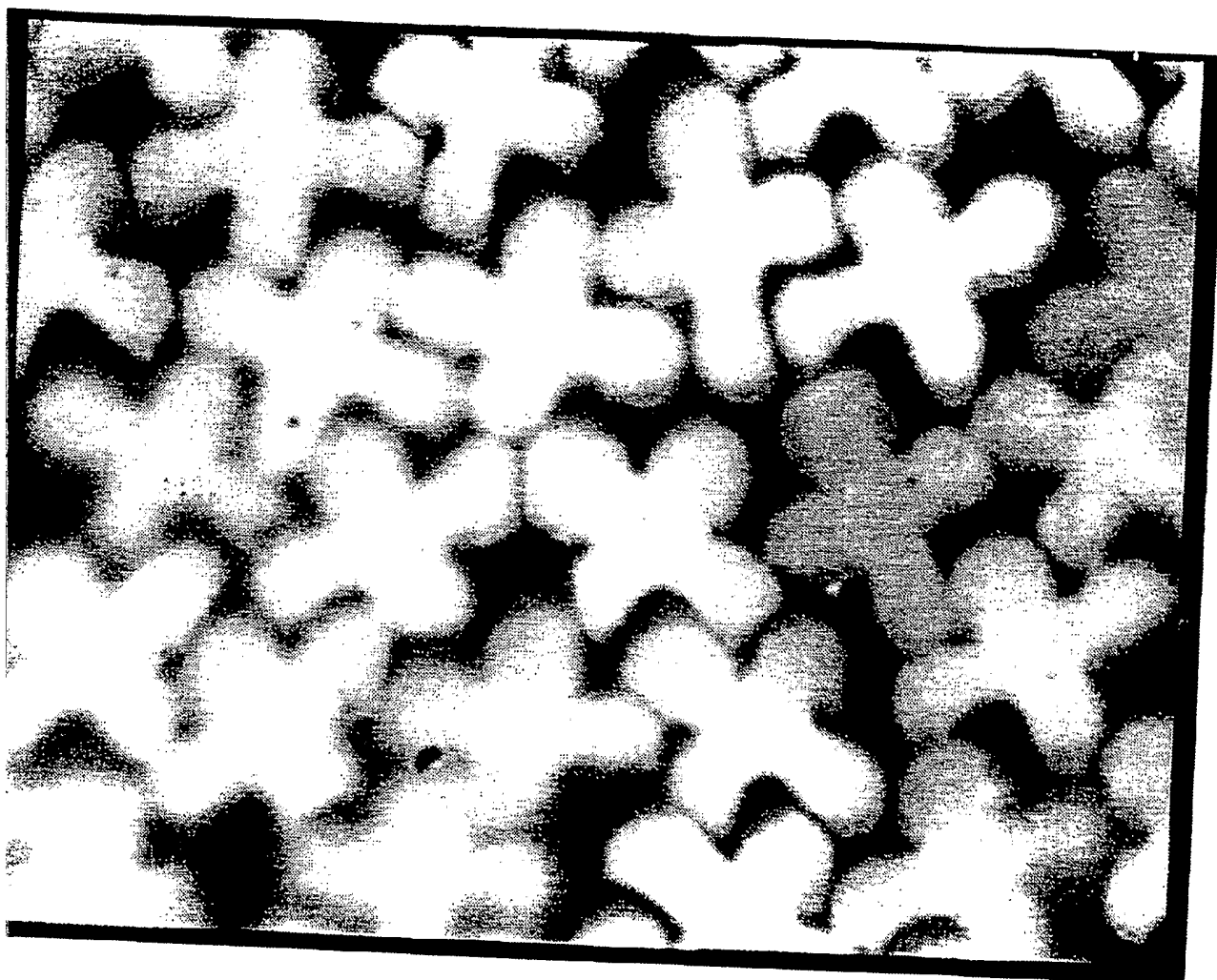
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   D01D5/253   D01F6/62   D01F8/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   D01D   D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 097 416 A (MCKINNEY ALFRED H) 16 July 1963 (1963-07-16) the whole document	28-30, 32,34
X	US 3 508 390 A (BAGNALL HARRY R ET AL) 28 April 1970 (1970-04-28) the whole document	28-30, 32,34
X	US 4 041 689 A (DUNCAN PATRICK JOSEPH ET AL) 16 August 1977 (1977-08-16) cited in the application the whole document	28-30, 32,34

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[X]	Further documents are listed in the continuation of box C.	[X]	Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
30 October 2001	13/11/2001

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 283 (C-0955), 24 June 1992 (1992-06-24) & JP 04 073209 A (MITSUBISHI RAYON CO LTD), 9 March 1992 (1992-03-09) abstract	28-30, 32,34
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