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(54) **Process for producing self-crimping yarns, multifilament yarns containing latent crimp filaments, and multifilament yarns containing developed crimp filaments.**

(57) A yarn for producing fabrics with a wool-like hand, is produced by combining textured filaments with longer filaments preferably of larger average denier. The longer filaments thus protrude in loops from the yarn bundle, and have helical cross-sections. The textured filaments are made by spinning and converging molten polymer streams travelling at different velocities, the resulting filaments having periodic denier variations, a latent crimp and a greater shrinkage than the helical cross-section filaments. When heated the latent crimp filaments shrink and acquire a developed crimp, and pull the less-shrinkable helical cross-section filaments into loops.

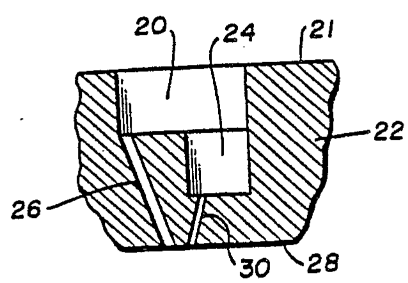

FIG. I.

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Croydon Printing Company Ltd.

PROCESS FOR PRODUCING SELF-CRIMPING YARNS, MULTIFILAMENT YARNS CONTAINING LATENT CRIMP FILAMENTS, AND MULTIFILAMENT YARNS CONTAINING DEVELOPED CRIMP FILAMENTS

The invention relates to the art of melt-spun synthetic yarns and processes for their production, and more particularly to such yarns which combine high bulk with a wool-like hand and improved moisture transport.

It is known to produce somewhat bulky yarns by combining filaments with different shrinkages into a yarn, then shrinking so that the resulting longer filaments protrude in loops from the yarn. This may be done by spinning the filaments from different polymers, as in Reese U.S. patent 3,444,681, or by spinning from different filament cross-sections from a common polymer, as typified by several patents. Such known yarns ordinarily do not have high bulk, nor do fabrics made therefrom ordinarily provide a hand similar to that of wool, combining an initial crispness on light touch with softness on more firm compression. Nor do such known yarns provide good moisture transport.

These and other difficulties of the prior art are avoided by the present invention, which provides novel and useful processes and improved yarn products.

According to a first major aspect of the invention, there is provided a process for producing a self-crimping yarn comprising first and second types of filaments, the process comprising spinning the first type of filaments by generating first and second individual streams of molten polymer of fiber-forming molecular weight, the individual streams travelling at different velocities; converging the individual streams side-by-side to form a combined stream; and quenching the combined stream to form a combined filament, spinning the second type of filaments by extruding a third stream of molten polymer of fiber-forming molecular weight from a helical orifice selected to give a filament with a helical cross section and lower shrinkage than the combined filament at a given common spinning speed; and quenching the third stream into a filament; withdrawing the filaments from the streams at the given common spinning speed; and combining the filaments into a yarn.

According to another aspect, each of the streams is of polyester polymer.

According to another aspect, the spinning speed is selected such that the yarn has a shrinkage below 20%.

According to another aspect, the spinning speed is selected such that the yarn has a shrinkage below 8%.

According to another aspect, the spinning speed is between 5000 and 6000 yards per minute, and each of the first type of filaments is polyester.

According to another aspect, the helical cross-section is open at its inner end.

According to another major aspect of the invention, there is provided a multifilament yarn comprising first and second classes of filaments; each of the first class of filaments having a periodic variation in denier greater than ± 25% about a mean value and possessing latent crimp; each of the second class of filaments having a helical cross-section and having lower shrinkage than the shrinkage of the filaments in the first class.

According to another aspect, each of the second class of filaments has a denier larger than the average denier of the first class of filaments.

According to another aspect, the first class of filaments are formed from polyester.

According to another aspect, the helical cross-section is open at its inner end.

According to another major aspect of the invention, there is provided a multifilament yarn comprising first and second classes of filaments; each of the filaments of the first class having a periodic variation in denier of greater than ± 25% about a mean value and possessing a developed crimp; each of the filaments of the second class having a helical cross-section and being longer than the filaments of the first class whereby the filaments of the second class protrude from the yarn in loops.

According to another aspect, each of the second class of filaments has a denier larger than the average denier of the first class of filaments.

According to another aspect, the first class of filaments are formed from polyester.

According to another aspect, the helical cross-section is open at its inner end.

These and other aspects of the invention will in part appear hereinafter and will in part be obvious in the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a vertical sectional view of a spinneret orifice;

FIGURE 2 is a bottom plan view of the FIGURE 1 orifice, looking up;

FIGURE 3 is a graph of shrinkage versus spinning speed used in explaining the principles upon which certain aspects of the invention are based;

FIGURE 4 is a cross-sectional view of a filament according to certain aspects of the invention;

FIGURE 5 is a side elevation view of the molten streams issuing from the FIGURE 1 spinneret according to certain aspects of the invention;

FIGURE 6 is a graph illustrating the variation in denier along a representative filament according to certain aspects of the invention;

FIGURE 7 is a graph illustrating the distribution of the fluctuations illustrated in FIGURE 5 for a representative multiple orifice spinneret according to certain aspects of the invention; and

FIGURE 8 is a bottom plan view of another spinneret orifice.

The invention will be specifically exemplified using polyester polymer, it being understood that certain aspects of the invention are applicable to the class of melt-spinnable polymers generally. "Polyester" as used herein means fiber-forming polymers at least 85% by weight of which is formable by reacting a dihydric alcohol with terephthalic acid. Polyester typically is formed either by direct esterification of ethylene glycol with terephthalic acid or by ester interchange between ethylene glycol and dimethylterephthalate.

FIGURES 1 and 2 illustrate the preferred embodiment of a spinneret design which can be employed for obtaining the first type of filaments according to the invention. The spinneret includes a large counterbore 20 formed in the upper surface 21 of spinneret plate 22. Small counterbore 24 is formed in the bottom of and at one side of large counterbore 20. A large capillary 26 extends from the bottom of large counterbore 20 at the side opposite small counterbore 24, and connects the bottom of large counterbore 20 with the lower surface 28 of plate 22. Small capillary 30 connects the bottom of couterbore 24 with surface 28. Capillaries 26 and 30 are each inclined four degrees from the vertical, and thus have an included angle of eight degrees. Counterbore 20 has a diameter of 0.113 inch (2.87 mm.), while counterbore 24 has a diameter of 0.052 inch (1.32 mm.). Capillary 26 has a diameter of 0.016 inch (0.406 mm.) and a length of 0.146 inch (3.71 mm.), while capillary 30 has a diameter of 0.009 inch (0.229 mm.) and a length of 0.032 inch (0.813 mm.). Land 32 separates capillaries 26 and 30 as they emerge at surface 28, and has a width of 0.0043 inch (0.109 mm.). Plate 22 has a thickness of 0.554 inch (14.07 mm.). Capillaries 26 and 30 together with counterbores 20 and 24 constitute a combined orifice for spinning various novel and useful filaments according to the invention, as will be more particularly described hereinafter.

FIGURE 3 is a graph showing how polyester filament shrinkage varies with spinning speed for two illustrative cases of jet stretch. The curve in dotted lines shows that the shrinkage falls from about 65% at 3400 ypm (about 3100 mpm) to about 5% at 5000 ypm (about 4500 mpm) when using spinneret capillaries having diameters of 0.063 inch (1.6 mm.) and when simultaneously spinning 34 such filaments to be false-twist draw-textured to yield a textured yarn having 150 denier. The solid curve shows that the shrinkage drops off at higher speeds when using spinneret capillaries having diameters of 0.015 inch (0.38 mm.) when similarly simultaneously spinning 34 such filaments to be false-twist draw-textured to yield a textured yarn having 150 denier. Using different capillary diameters produces a family of curves between, to the left, and to the right of those illustrated. The curves also can be shifted (for a given capillary diameter) by varying the polymer throughput. In other words, the curves can be shifted by varying the jet stretch, which is the ratio of yarn speed just after solidification to average speed of molten polymer in the capillary. It is thus possible to provide a combined orifice for spinning a composite filament of a single polymer wherein one side of the filament has a much higher shrinkage than the other side. This is done by selecting the individual capillaries to give different jet stretches, and also selecting the spinning speed within the range wherein an individual filament quenched from one of the individual streams would have a shrinkage at least ten percentage points higher than that of an individual filament quenched from the other of the individual streams. Under the spinning conditions illustrated in FIGURE 3, at a spinning speed of 5000 yards per minute the individual streams would have shrinkages differing by about 25 percentage points. Combining these molten streams into a side-by-side configuration results in a highly latently crimped filament in its as-spun form, without the necessity of drawing the yarn to develop the crimp. Such combining may be done using a spinneret design similar to that disclosed in FIGURE 1, or the spinneret may merge the two streams at or just prior to emergence of the streams from surface 28. In any event, the two streams merge substantially coincident with the face of the spinneret according to this aspect of the invention.

Advantageously, the spinneret is so designed that one of the individual streams has a velocity in its capillary between 2.0 and 7 times (preferably between 3.5 and 5.5 times) the velocity of the other of the streams in its capillary.

Further advantages are obtained when the faster of the two streams has a smaller cross-sectional area than the slower of the streams, particularly in degree of crimp and spinning stability. Productivity is increased when the spinning speed is selected such that the combined filament has a shrinkage less than 20%, and is maximized when the shrinkage is less than 8%.

Further aspects of the invention, applicable to melt-spinnable polymers as a class, are achievable by use of spinnerets wherein the streams intersect outside the spinneret. As a specific example, molten polyester polymer of normal textile molecular weight is metered at a temperature of 290°C. through a spinneret having 34 combined orifices as above specifically disclosed. The polymer throughput is adjusted to produce filaments of 4 average denier per filament at a spinning speed of 5200 yards per minute, the molten streams being conventionally quenched into filaments by transversely directed quenching air.

Under these spinning conditions a remarkable phenomenon occurs, as illustrated in FIGURE 5. Due to the geometry of the spinneret construction, the polymer flowing through the smaller capillaries 30 has a higher velocity than that flowing through the larger capillaries. The speeds and momenta of the paired streams issuing from each combined orifice and the angle at which the streams converge outside the spinneret are such that the slower streams 34 travel in substantially straight lines after the points at which the paired streams first touch and attach, while each of the smaller and faster of the streams 36 forms sinuous loops back and forth between successive points of attachment 38 with its associated larger streams. This action can be readily observed using a stroboscopic light directed onto the stream immediately below the spinneret face 28. As the molten streams accelerate away from the spinneret, the slower stream attenuates between the points of attachment 38 and the loops of the faster stream become straightened until the faster stream is brought into continuous contact with the slower stream. The slower stream attenuates more between than at the points of first attachment, so that the resulting combined stream has a cross-section which is larger at the points of first attachment than in the regions between these points. The resulting combined stream is then further attenuated somewhat until it is solidified into a filament 40 by the transverse quench air.

Each solidified filament 40 has non-round cross-sectional areas which vary repetitively along its length, and, after being heated while under low tension, has variable pitch S-twisted and Z-twisted helically coiled sections, the sections being less tightly coiled in regions of large cross-sectional area than in regions of small cross-sectional area. As illustrated qualitatively in FIGURE 6, when using the above spinning conditions, the filament cross-sectional area repetitively varies at a repetition rate of about one per meter, although this can be varied by modifying the spinning conditions and the geometry of the spinneret passages.

Due to minor differences between combined orifices, temperature gradations across the spinneret, and other like deviations from exactly the same treatment for each pair of streams, a multiple orifice spinneret will typically provide somewhat different repetition rates among the several resulting streams and filaments. An example of this is qualitatively shown in FIGURE 7, wherein is shown that various orifices produce somewhat different repetition rates as determined by stroboscopic examination of the combined streams just below the spinneret face. The repetition rate is proportional to the stroboscope frequency bringing about apparent cessation (or freezing) of movement of the thick and thin regions of the filament. A number of such frequencies are plotted along the horizontal axis of

FIGURE 7, and on the vertical axis are plotted the number of orifices giving filaments wherein such freezing was observed, at each given stroboscope frequency. In the resulting multifilament yarn, the filaments have non-round cross-sections which vary by more than ± 10% along the length of the filaments, and alternating S-twisted and Z-twisted helically crimped sections, the variations in cross-sectional areas being out of phase from filament to filament and the helically crimped sections being out of phase from filament to filament.

For certain effects, it is advantageous that the filaments vary repetitively along their lengths by more than ± 25% (preferably more than ± 30%) about a mean value in cross-sectional area. The effects are particularly pronounced when the yarn has a Uster unevenness of at least 2.5% U. The Uster measurement is made by using the Uster Evenness Tester, Model C, together with integrator ITG-101 for this instrument.

The yarn speed is 182.8 meters per minute (200 ypm), the service selector is set on normal, and the sensitivity selector is set to 12.5%. The % U is read from the integrator after a sample run time of 5 minutes.

FIGURE 8 shows the preferred embodiment of spinneret design which can be employed for obtaining the second type of filament according to the invention. The orifice is in the form of a spiral slot through the spinneret plate and extending over more than 360 degrees. An exemplary slot may have a width of 0.1 mm. and a length of 4 mm. along the length of the spiral. If the clearance between the inner end and the nearest intermediate portion of the slot is sufficiently small, the molten stream issuing therefrom will bridge the gap between the inner end of the spiral cross-sectioned stream and the nearest intermediate portion of the stream cross-section, forming a filament with a spiral cross-section closed at its inner end. On the other hand, if the noted clearance is slightly larger, the bridging will not occur, and the resulting filament will have a spiral cross-section open at its inner end. Selection of the proper clearance to provide either a closed inner end or an open inner end while using particular spinning and quenching conditions can readily be made by one skilled in the art.

Generally speaking, the filament having a cross-section comprising a spiral closed at its inner end will have a more powerful crimp than one having a cross-section comprising a spiral open at its inner end. The latter will, however, have substantially increased moisture transport and moisture holding capacity as compared to the former, which is itself superior to ordinary round filaments.

The second class of filaments may be spun from spinneret orifices selected such that, at the given common spinning speed, the filaments of the first class will have a higher shrinkage than those of the second class.

As a specific example, molten polyethylene terephthalate polymer of normal molecular weight for textile apparel yarns is extruded simultaneously through two spinnerets, one of which contains 34 combined orifices as above described and the other of which contains 17 spiral

5. The process of claim 1, characterized in that said spinning speed is between 5000 and 6000 yards per minute, and wherein each of said first type of filaments is polyester.

6. The process of claim 1, characterized in that said helical cross-section is open at its inner end.

7. A multifilament yarn comprising first and second classes of filaments characterized by:

a. each of said first class of filaments having a periodic variation in denier greater than ± 25% about a mean value and possessing latent crimp;

b. each of said second class of filaments having a helical cross-section and having lower shrinkage than the shrinkage of said filaments of said first class.

8. The yarn of claim 7 characterized in that each of said second class of filaments has a denier larger than the average denier of said first class of filaments.

9. The yarn of claim 7 characterized in that said first class of filaments are formed from polyester.

10. The process of claim 7 characterized in that said helical cross-section is open at its inner end.

11. A multifilament yarn comprising first and second classes of filaments characterized by:

a. each of the filaments of said first class having a periodic variation in denier of greater than ± 25% about a mean value and possessing a developed crimp;

b. each of the filaments of said second class having a helical cross-section and being longer than said filaments of said first class whereby said filaments of said second class protrude from said yarn in loops.

12. The yarn of claim 11 characterized in that each of said second class of filaments has a denier larger than the average denier of said first class of filaments.

13. The yarn of claim 11 characterized in that said first class of filaments are formed from polyester.

14. The process of claim 11, characterized in that said helical cross-section is open at its inner end.

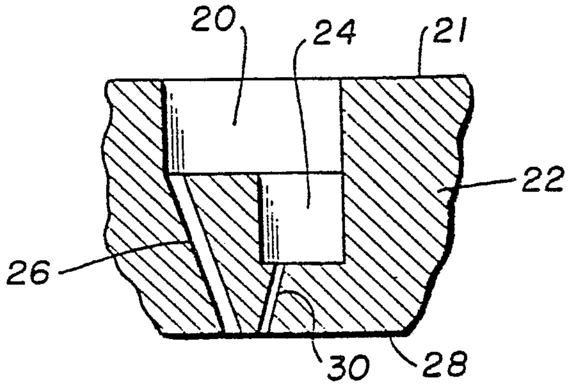

FIG. 1.

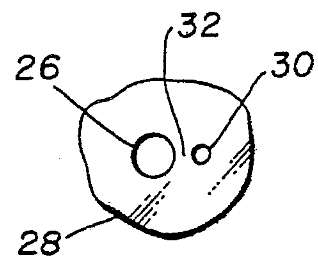

FIG. 2.

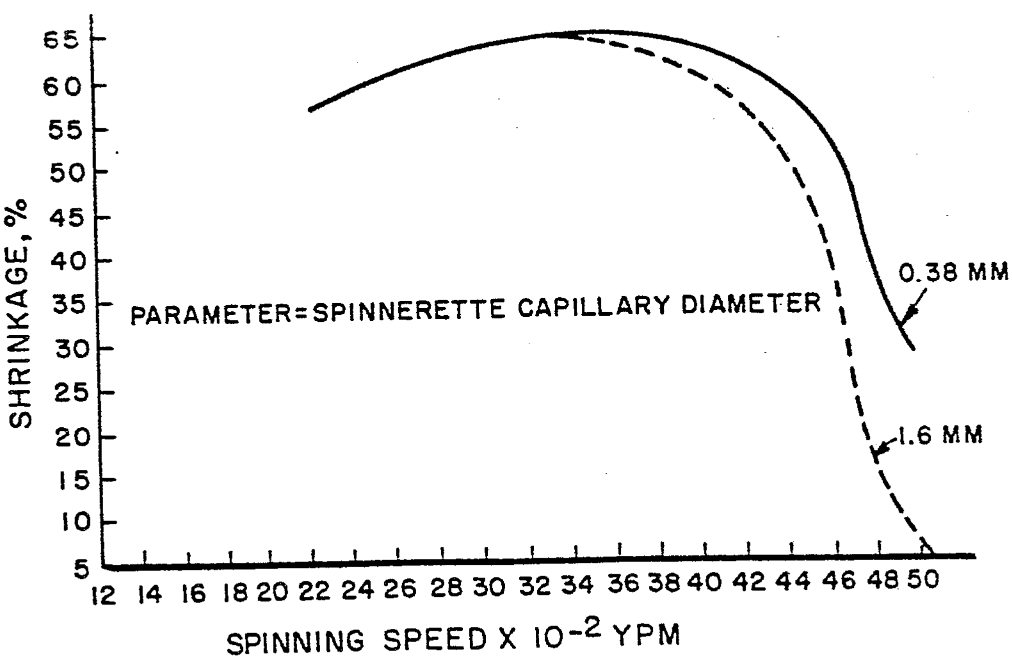

FIG. 3.

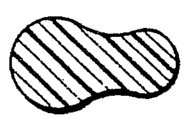

FIG. 4.

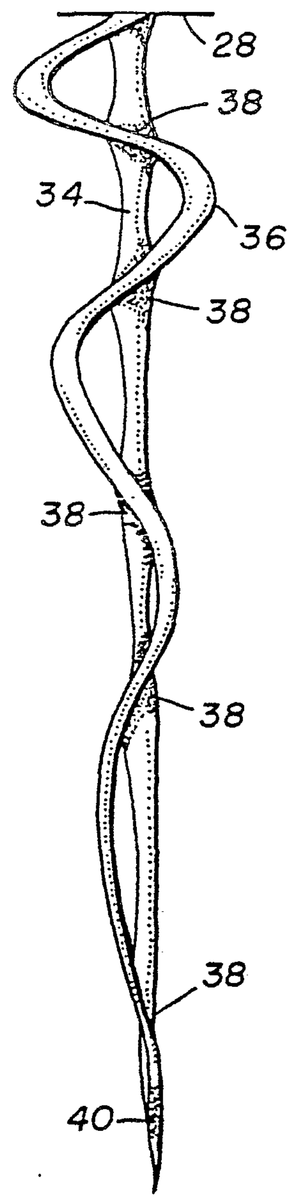

FIG. 5.

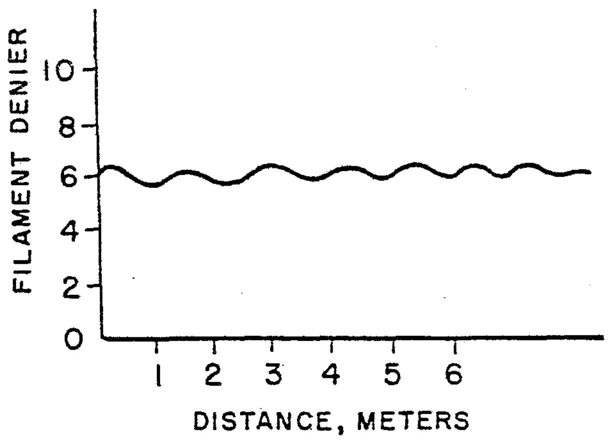

FIG. 6.

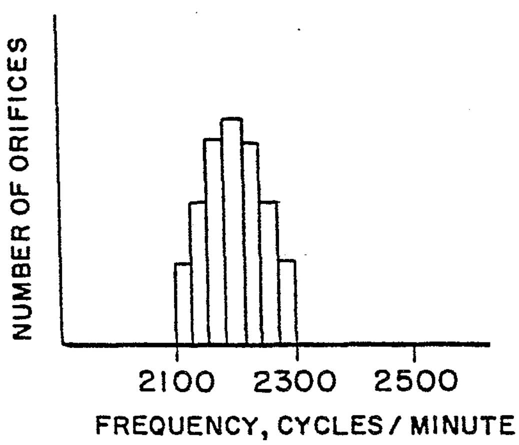

FIG. 7.

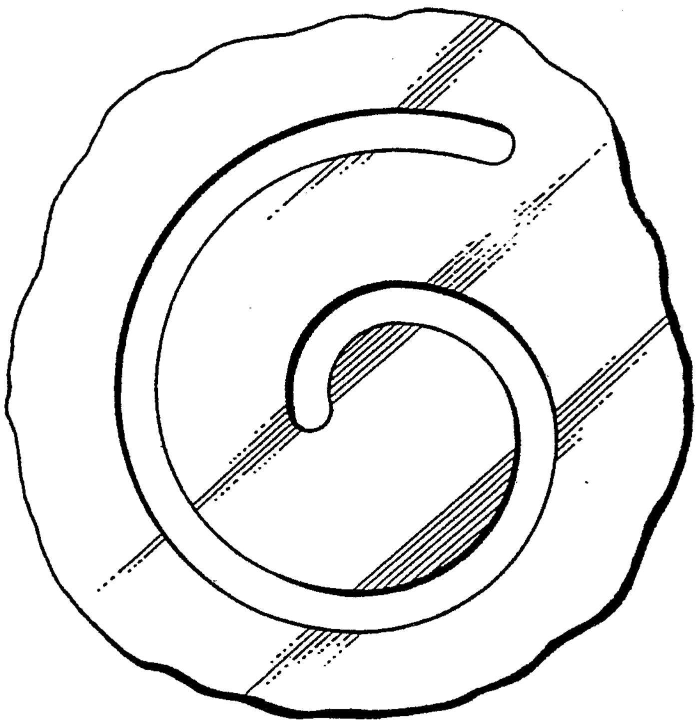

FIG. 8.

0013498

Application number

EP 79 30 2957

European Patent Office

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - A1 - 2 807 418 (TORAY) * complete document * --	1
	DE - A1 - 2 539 272 (VYZKUMNY USTAV PLETARSKY) * complete document * --	1
	DE - A1 - 2 811 794 (MONSANTO) * complete document * --	1
A	GB - A - 1 103 728 (SNIA VISCOSA) --	
A	GB - A - 1 454 522 (IMPERIAL CHEMICAL INDUSTRIES) --	
D	US - A - 3 444 681 (REESE) ----	

CLASSIFICATION OF THE APPLICATION (Int. Cl.3)

D 02 G 1/18
D 02 G 3/34

TECHNICAL FIELDS SEARCHED (Int.Cl.3)

D 01 D 5/22
D 02 G 1/00
D 02 G 3/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	25-03-1980	KLITSCH