This invention relates to a filament handling process and apparatus, and more particularly to an improved method and apparatus for joining together individual ends of thermoplastic filaments to form a continuous warp sheet.

In the preparation and utilization of filaments and yarns, it is both convenient and economical to treat a multiplicity of ends simultaneously. This is generally accomplished by treating the filament or yarn ends in the form of a knotted bundle. In some instances the warp is made up of individual ends from separate packages; however, it is generally preferred to have all of the ends wound onto a common package and unwound simultaneously from that package for the next treatment. For example, a number of separate yarn ends from individual spinning cells may be wound simultaneously onto a beam and then unwound from that beam for passage through stretching apparatus.

In most instances threading or stringing up a large number of yarn ends simultaneously through treating apparatus, e.g., stretching apparatus, is a time-consuming and tedious task. It is, therefore, highly desirable to be able to attach the lead-in ends of a fresh beam of yarns to the run-out ends of a preceding beam. At the present time this is accomplished by separately knotting each run-out end to a lead-in end from the new beam. These knots must be tied with special care so that the variation in tension between ends is kept to a minimum. The tying-in process is particularly difficult in the case of undrawn, solvent-laden yarns, for example acrylonitrile polymer yarns which are notoriously weak and difficult to handle. In addition, in most instances, the loose, trailing ends of filament or yarn are not secured for storage.

It is, therefore, an object of this invention to provide a process for simultaneously joining individual ends from one warp of yarns to the ends of a second warp of yarns. Another object is to provide a process for joining the ends of two warps of yarns in which the juncture of the yarns does not contain loose, trailing ends. A further object of this invention is to provide a process in which the joined strands are all of essentially equal length and under substantially the same tension. Still another object is to provide new and improved apparatus for joining yarns of one warp to the yarns of another warp. Other objects will be apparent from the description that follows.

The objects of this invention are accomplished by a process which comprises positioning the terminal portions of the lead-in ends of yarns of a first warp in overlapping relationship to the terminal portions of the run-out ends of yarns of a second warp, applying an essentially equal tension to all the ends while maintaining the overlapping relationship along at least a portion of the yarns, applying pressure to at least a part of the overlapping portion of the ends, and thereafter heating the yarns to a heat-sealing temperature whereby they are softened and fused together. The tension on the leading and trailing portions of the yarns which protrude from the overlapped portion is controlled to cause the loose terminal portion to separate from the fused portion when the yarns soften.

In general the apparatus is comprised of a pair of pressure members having opposed flat pressure faces.
to that shown in FIG. 1, and then passed into a stretching apparatus of the type described in Kinraide U.S. Patent 2,568,920. The ends of yarn were simultaneously unwound from the beams until the beams were almost empty, at which time the runout ends of the yarn were removed from the beams and directed into suction nozzle 22 as shown in FIG. 2. Three fresh beams of yarn were then moved into position and the leading ends were placed in overlapping relationship with the runout ends between corresponding pairs of guide pins 13 and 13'. The lead-in ends were then pulled toward the end of the comb assembly and directed into suction nozzle 22 as shown in FIG. 3. The tension on the yarn ends was approximately equal and the yarn ends were spaced approximately \( \frac{1}{4} \)" above heater plate 17. Pressure plate 19 was then placed into position against heater plate 17 and pressure applied through linkage 20. The rod and spring assembly 32 was adjusted to apply a pressure of approximately five pounds per square inch on the overlapping portion of the filaments disposed between heater plate 17 and pressure plate 19. Each of the pairs of yarn were held against the heater plate over a distance of approximately one inch. Heater control means 18 was actuated, and heater bar 17 was brought to a temperature of approximately 200° C. The overlapping portion of the yarn ends softened and fused together. As the ends softened, the tension exerted by suction nozzle 22 caused the loose end portions to separate from the fused portions of yarn. On signal from the heater control assembly indicating that a predetermined time-temperature relationship had been achieved, pressure plate 19 was moved away from heater plate 17. A uniformly welded continuous warp of yarns was obtained, and the stretching operation resumed.

Various modifications of the apparatus of this invention will be apparent to those skilled in the art. For example, the particular configuration of the elements in the embodiment illustrated may be varied to accommodate other types of tensioning devices and heating means. In an alternate embodiment of the apparatus, the yarn ends are collected in a suction device and are secured under uniform tension on anchor rods positioned at the side of the frame. After the heat-sealing cycle but before the yarns have cooled and solidified, the free ends may be separated from the fused yarns. Other modifications of the tensioning device which place the ends under substantially uniform tension during heat sealing and remove the free ends after the ends have cooled may be used. For example, a dielectric heater may be advantageously used. The heater plate in the particular embodiment illustrated may, of course, be displaced either above or below the path of the yarns. In addition, other suitable means for displacing the pressure members toward and away from each other as well as means for adjusting the pressure may be used.

Materials used for construction apparatus of the type illustrated are well known. In general, those portions of the apparatus in which the yarns come in contact should be fabricated from abrasion-resistant materials. One or both of the pressure members may be coated with materials such as a polytetrafluoroethylene resin to prevent sticking of the yarns. The insulating material surrounding the heated member may be asbestos, mica, or a similar insulating material.

The apparatus and process of the present invention are useful in producing continuous warp sheets prepared from yarns selected from a variety of materials. In general, any thermoplastic yarn which can be heat sealed may be used, e.g., polyamides, polyessters, solvent-containing poly-acryllics, polyhydrocarbons, etc. In some instances the use of an adhesive applied to the yarn ends may be required.

In joining the ends the temperature used must, of course, be controlled to prevent degradation or excessive flowing of the material. The optimum temperature and the time of exposure can be readily determined by those skilled in the art. The optimum combination of temperature, time and pressure will, of course, vary depending on the nature of the material being processed, e.g., the polymeric structure, solvent or plasticizer content of the material and denier. For acryllic fibers such as acryllic staple fiber on each of the yarns, temperatures in the range of 175° C. to 250° C. and pressures of five to twenty pounds per square inch have been found to be satisfactory.

Many advantages accrue from utilizing the process and apparatus of this invention. A plurality of yarn ends can be joined in a minimum amount of time as compared to that required for knotting individual ends. The resulting junctions are smaller in diameter than the knots and in many instances are actually stronger. In addition, the problem of severing loose ends is obviated. The process is particularly useful in joining fibers which are weak or brittle and would cause difficulty in tying knots therein.

It will be apparent that many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, and therefore it is not intended to be limited except as indicated in the appended claims.

I claim:

1. Apparatus for forming a plurality of continuous thermoplastic yarns from two separate warps comprising in combination a pair of pressure members having opposed flat pressure faces, a comb member disposed on each side of said pressure members for aligning the runout ends of one of said warps in essentially parallel overlapping relationship with the lead-in ends of the other warp in a zone between said pressure members, tension means for receiving, engaging, and applying a constant tension to the terminal portions of said ends positioned adjacent to said pressure members, means for displacing said pressure members toward each other to compress the overlapping portions of said yarns interposed between said faces, and heating means for heating said overlapping portions to a heat-sealing temperature.

2. Apparatus for heat sealing a plurality of thermoplastic yarns of a first and second warp to form a continuous warp sheet comprising in combination a pair of pressure members having opposed flat pressure faces, a comb member displaced on each side of said pressure members, a plurality of teeth in said comb members positioned to maintain the lead-in ends of the yarns of the first warp and the runout ends of the yarns of a second warp in essentially parallel overlapping relationship in a zone between said pressure members, vacuum means positioned adjacent to said pressure members to receive the terminal portions of said ends and maintain said yarns under substantially uniform tension sufficient to take up slack in the yarns before sealing and to remove said terminal portions after sealing, means for displacing said pressure members toward each other to compress the overlapping portions of said yarns interposed between said faces, and heating means for heating said overlapping portions to a heat-sealing temperature and softening the yarns so that the terminal portions may be detached and removed by said vacuum means.

3. Apparatus for heat sealing a plurality of thermoplastic yarns of a first and second warp to form a continuous warp sheet comprising in combination a pair of pressure members having opposed flat pressure faces, a comb member displaced on each side of said pressure members, a plurality of vertical pins in said comb members positioned to maintain a portion of the lead-in ends
of the yarns of said first warp and a portion of the run-
out ends of said second warp in essentially parallel over-
lapping relationship in a zone between said pressure
members, a suction nozzle positioned beneath said pres-
sure members to receive the terminal portions of said
ends and to maintain said yarns under substantially re-
form tension sufficient to take up any slack in said yarns
prior to sealing and to detach and remove said terminal
portions after sealing, means for displacing said pres-
sure members toward each other to compress the over-
lapping portions of said yarns interposed between said
faces, and heating means for heating at least one of said
pressure members to a heat-sealing temperature.

4. Apparatus for forming a continuous warp sheet from
two separate warps of thermoplastic yarns comprising in
combination a pair of pressure members having opposed
flat pressure faces, the first of said pressure members
being fixedly positioned on a frame, a comb member po-
tioned on said frame and displaced on each side of said
first pressure member, a plurality of vertical pins
extending upwardly from said comb member, said pins
being positioned to maintain the lead-in ends of yarns
of said first warp and the run-out ends of yarns of said
second warp in essentially parallel overlapping relation-
ship across said first pressure member, a suction nozzle
positioned beneath said first pressure member shaped to
receive the terminal portions of said ends and maintain
said yarns under substantially uniform tension sufficient
to take up slack in said yarns, heating means for heat-
sealing at least one of said pressure members to a heat-
sealing temperature, and means for displacing the other
of said pressure members toward said first pressure member to compress the overlapping portions
of said yarns interposed between said faces, and
heating means connected to said first pressure member
for heating said yarns prior to sealing and removing said terminal portions after said yarns are sealed

together.

5. Process for forming a plurality of continuous ther-
 moplastic yarns by joining together individual ends from
two separate warps which comprises positioning
a portion of the yarns of a first warp in overlapping
relationship to a portion of the yarns of a second warp,
applying an essentially uniform tension to the loose ends of
said portions while maintaining said overlapping rela-
tionship along said portions of said yarns, applying pres-
sure to at least a part of the said overlapping portions,
and thereafter heating said overlapping portions to a
temperature whereby said filaments soften and fuse to-
gether, said tension being sufficient to separate the loose
ends from said overlapping portions when said yarns
soften.

6. Process for forming a continuous warp sheet from
a plurality of thermoplastic yarns of a first and second
warp which comprises positioning a portion of the run-out
yarns of said first warp in overlapping relationship to a
portion of the lead-in yarns of said second warp, apply-
ing an essentially uniform tension to the terminal por-
tions of said yarns to remove slack while maintaining
said overlapping relationship along at least a portion of
said yarns, applying pressure to said overlapping portions
of said ends sufficient to hold them in position, and there-
after heating said overlapping portions to a heat-sealing
temperature, said temperature and said tension being con-
trolled to separate the terminal portions of said ends from
said overlapping portions after said yarns are sealed to-
gether.

7. The process of claim 6 wherein said yarns are com-
prised of acrylonitrile polymer.

8. The process of claim 7 wherein said temperature is
between about 175° C. and about 230° C., and said pres-
sure is between about five and twenty pounds per square

9. An improved apparatus for simultaneously bond-
ing a first group of separate yarns to a second group of
separate yarns and trimming off all excess yarn end
lengths, said apparatus comprising, in combination, a
supporting frame structure, a pair of parallel comb
members mounted on said structure and spaced a given
distance apart, each comb member comprising a row of
spaced parallel pin elements aligned with the set of cor-
responding parallel pin elements on said other spaced
member, each aligned pair of pins on said comb mem-
bers forming a yarn supporting and aligning arrange-
ment for holding a yarn of said first group in parallel
overlapping engagement with a yarn of said second group
for a portion of their lengths, movable press means mount-
ed on said structure constructed and arranged to engage
and apply pressure to said overlapping portions of said
yarns between said comb members, heating means op-
eratively associated with said press means to apply suf-
cient heat in conjunction with the pressure on said over-
lapping portions of said yarns to bond the overlapping
portions permanently together, a constant tension device
positioned on said structure adjacent said comb mem-
bers for engaging and exerting a constant tension on the
loose end portions of said overlapped yarns to first in-
sure a uniform bonding action in each laterally spaced
pair of overlapping yarns between said comb members
without slack in the overlapped bonded yarns and secon-
dly to detach said loose end portions upon their separa-
tion from the bonded overlapping portions of the yarn
under the softening action of the heat applied during the
bonding operation.

10. The improved apparatus of claim 9 in which said
constant tension device comprises an air suction nozzle.

11. An improved process for bonding together a run-
out yarn to feed-in yarn, said process comprising, in com-
bination, the steps of aligning and supporting a portion
of the length of the run-out yarn in parallel engagement
with a portion of the length of the feed-in yarn, apply-
ing a constant tension to the loose run-out end of one
yarn and the loose feed-end of the other to eliminate
slack, applying sufficient heat and pressure to said par-
allel engaged portions of the yarn to permanently bond
them together while continuing to maintain tension on
the ends of the yarn at a sufficient level to detach the
loose end portions from the bonded engaged portions
when the heat has sufficiently softened the yarns.

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