

Jan. 31, 1939.

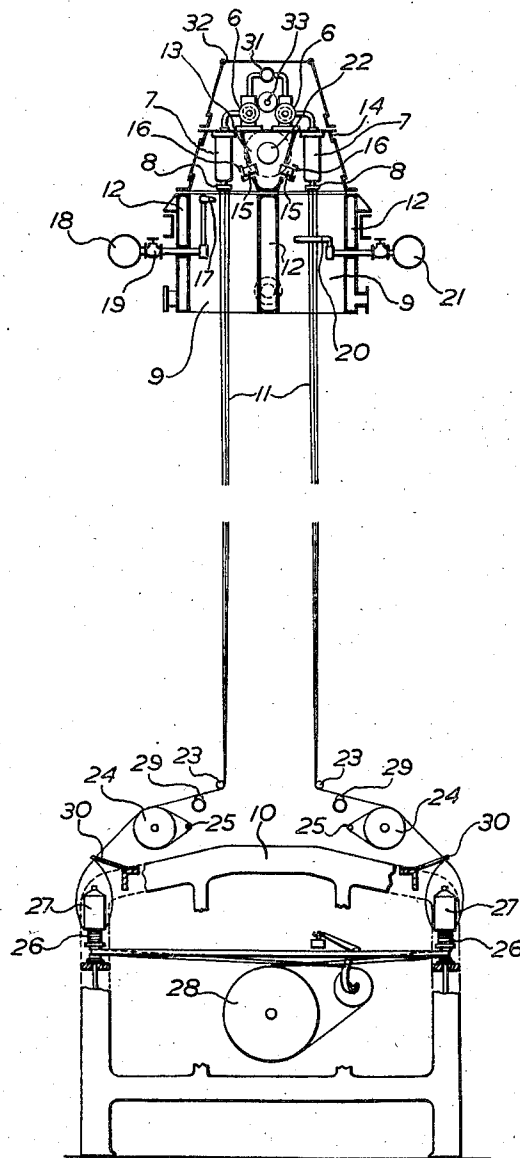
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2,145,290

MANUFACTURE OF ARTIFICIAL FILAMENTS AND OTHER PRODUCTS

Original Filed Aug. 14, 1933 3 Sheets-Sheet 1

FIG. 1



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MANUFACTURE OF ARTIFICIAL FILAMENTS AND OTHER PRODUCTS

Original Filed Aug. 14, 1933 3 Sheets-Sheet 2

FIG. 2

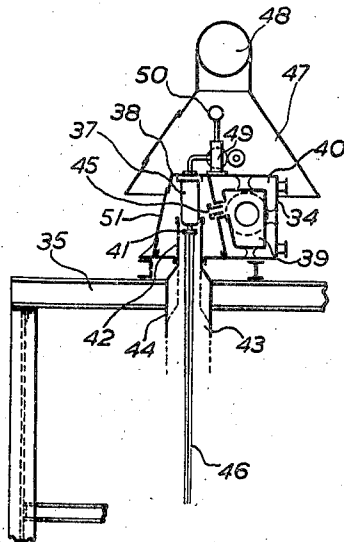
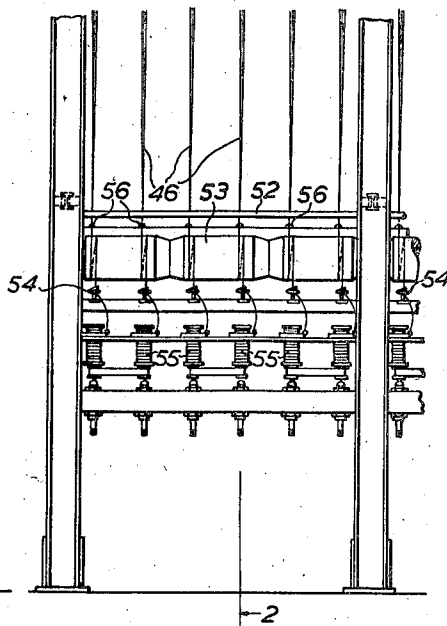
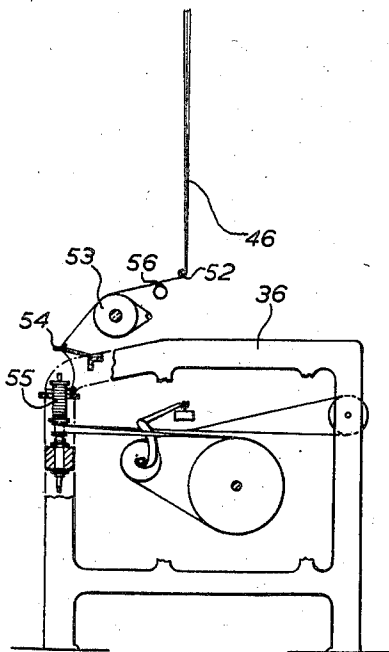
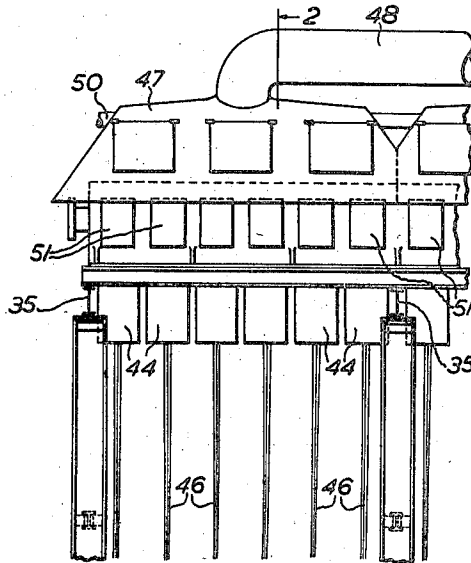


FIG. 3



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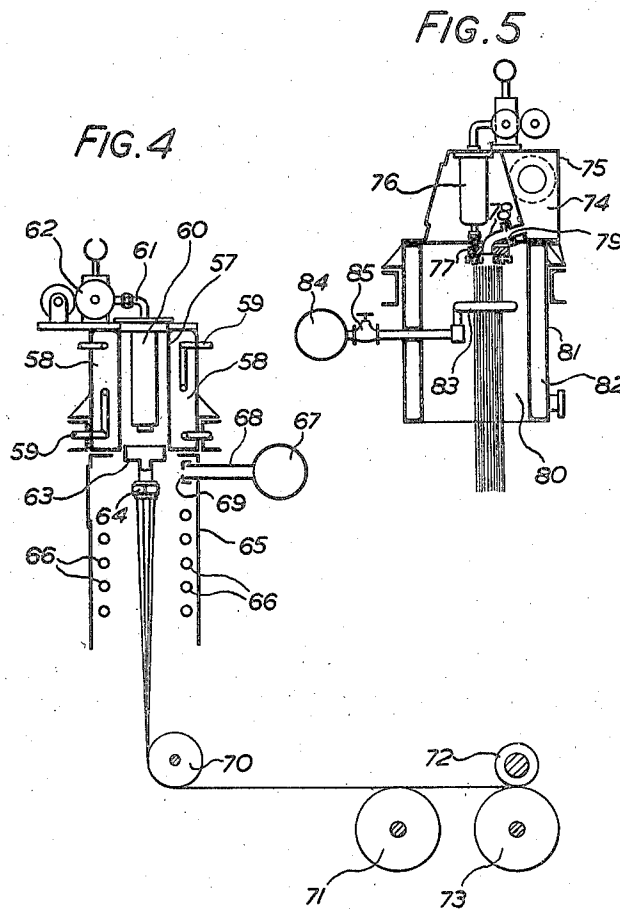
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MANUFACTURE OF ARTIFICIAL FILAMENTS AND OTHER PRODUCTS

Original Filed Aug. 14, 1933 3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,145,290

MANUFACTURE OF ARTIFICIAL FILAMENTS
AND OTHER PRODUCTSJoshua Bower, Spondon, near Derby, England, as-
signor to Celanese Corporation of America, a
corporation of DelawareOriginal application August 14, 1933, Serial No.
685,126. Divided and this application Decem-
ber 27, 1937, Serial No. 181,786

13 Claims. (Cl. 18—8)

This application is a division of my applica-
tion S. No. 685,126 filed August 14, 1933, as a con-
tinuation-in-part of my application S. No. 627,992
filed August 8, 1932, and is concerned with the
5 manufacture of artificial filaments and also col-
lections of filaments, such as yarns and threads,
and other filamentary materials, such as ribbons,
by dry methods.

Until my present invention the only dry spin-
10 ning method by which filaments and like products
of organic derivatives of cellulose had ever been
successfully manufactured involved extruding the
spinning solution downwards into cells which en-
closed the path of the filament for at least 5 feet
15 beyond the extrusion point and often for a great-
er distance. An upward current of hot air was
drawn through the cells at a constant rate and
it was considered essential with a view to obtain-
ing filaments of commercially acceptable quality,
20 particularly in respect of cross-section and uni-
formity of dyeing properties, to enclose the path
of the filaments for this considerable distance.

I have now discovered that the requisite uni-
formity and other desired properties in the fila-
ments may be obtained without enclosing the path
25 of the filaments for more than a small fraction
of the distance from the extrusion point to the
collecting device, provided that the evaporative
conditions in the zone immediately adjacent the
spinning nozzles are kept substantially uniform
30 and capable of converting the extruded products
from the liquid to the solid phase within the short
enclosed space. I have found in fact that it is
only the spinning zone immediately adjacent the
spinning nozzle which is really important in de-
35 termining finally the character of the filaments,
and hence that the enclosing of the filaments in
the spinning cell for a long travel is quite unnec-
essary. The present invention, therefore, com-
prises a dry spinning process for the production
40 of filaments, threads, ribbons and like products
of organic derivative of cellulose including the
steps of extruding the spinning solution down-
wards into an air space secluded from the atmos-
45 phere for a distance of not more than 14 inches
below the extrusion point, and through an air
stream in said air space, the evaporative condi-
tions within said air space being kept substan-
tially constant and such as to change the phase
50 of the extruded products from liquid to solid with-
in said space, subjecting the products leaving said
space to an air run in the open many times longer
than said distance and collecting them. The in-
vention further comprises apparatus for carrying
55 such process into effect.

The spinning nozzle is surrounded by a sleeve
or other member adapted to cut off the spinning
zone or part of the spinning zone from the sur-
rounding air and so form the secluded air space
60 referred to above. This sleeve or like device may

be substantially closed on the side of the nozzle
remote from the filaments, except for a pipe or
other duct connected to the suction device for
drawing the air in a controlled manner through
the spinning zone. The sleeve or like member 5
may, if desired, be substantially closed except for
a suitable passage for the filaments at the end
remote from the nozzle, but it is considerably
more advantageous to have it entirely open at
10 that end so as to provide complete accessibility to
the jets and/or filter candles. The sleeve or
other device may be adjustable and may be heated
if desired. For example it may be adjustable
along the filter candle or the pipe carrying the
15 spinning solution to the nozzle so as to obtain
ready access to the spinning nozzle, or alterna-
tively or in addition it may be telescopic so as to
admit of such ready access.

The controlled flow of evaporative medium
through the zone adjacent and below the level 20
of the spinning nozzles may be achieved by a
number of methods. For example a number of
suction devices may be arranged adjacent and
below the spinning nozzles, preferably one or
two devices adjacent each spinning nozzle or one 25
device adjacent to two spinning nozzles, and the
flow through these devices is rigidly controlled,
and preferably the direction of the suction of
the outer air into these devices is controlled so
that the flow of air through the zone adjacent the
30 spinning nozzle is at all times uniform. It is
especially convenient to control the flow of evap-
orative medium by means of such a suction device,
since the air carried through such suction device
may be taken directly to a plant for solvent re- 35
covery. However, it is possible to control the air
in the neighbourhood of the spinning nozzles by
suitable injector devices which inject through the
spinning zone and below the extrusion point a
controlled amount of air, and still more advan- 40
tageously the flow of the air through the spin-
ning zone may be controlled both by suitable in-
jector devices and by suction devices, such as al-
ready referred to.

The actual volume of air flowing through each 45
spinning zone may be controlled in any suitable
manner. Thus a duct carrying the air from the
spinning zone to a suction device, or carrying
air to the spinning zone from a pump or similar
means, may be provided with a valve or a dia- 50
phragm, fixed, removable or variable, or any other
device for providing a uniform, and preferably
regulable, flow therethrough. The ducts from or
to each spinning zone may be connected with a
relatively large conduit serving twenty, fifty or 55
other large number of spinning points, in which
case a fixed diaphragm serves to provide a definite
pressure drop and therefore a controlled flow of
air through the ducts serving the individual spin-
ning points. If desired, water gauges or other 60

flow meters (e. g. Venturi meters) may be used to measure the pressure drop across a diaphragm or other constriction and thereby indicate the volume of air flow. If desired, provision may be made for connecting such indicators temporarily to the ducts so that portable indicators may be used. The volume of air flowing through each of the spinning zones is preferably adjusted according to the denier being spun. The volume of air may be thus adjusted by means of a diaphragm having a number of graduated fixed holes or by means of a number of diaphragms having holes of different sizes or such adjustment or an adjustment between individual spinning points spinning the same denier may be effected by means of a valve or an iris diaphragm or similar adjustable device.

The flow of the air in the region of the spinning nozzles may be substantially parallel with the filaments, and preferably in counter-flow thereto, or may be across the line of the filaments either at right angles or at some other suitable angle. I have found that provided the flow is controlled, it is not of much moment in which direction the air flows through the spinning zone. If desired, the suction device or an injector device for injecting either a controlled flow of air through the spinning zone or for injecting air, the flow of which is controlled by a suitable suction device, may be so disposed that the air is either injected into the spinning zone or sucked from the spinning zone through the centre of the spinning nozzle, which for this purpose may be of the ring type and may be either constituted by a flat annulus suitably perforated for the spinnerettes, or may be in the nature of a ring-shaped pipe suitably perforated to act as the spinnerettes. The suction device for controlling the flow of air through the spinning zone, if not arranged so that it sucks the air from the centre of the nozzle, may be arranged in any suitable disposition in relation to the filaments. Thus, for instance, if the filaments are being spun downwardly the device may be arranged above or at the side or completely surrounding the spinning nozzle, while if the spinning nozzle is arranged to spin the filaments more or less horizontally it may be similarly arranged on the side of the nozzle remote from the filaments, above or below or to one side of the nozzles or again completely surrounding the nozzles.

It is important for the purposes of the present invention that sufficient heat is brought into the spinning zone, through which there is a controlled passage of air, so as to enable the base of the spinning solution, for example cellulose acetate, to be substantially set, that is to say so that the phase of the spinning solution has been reversed and the base is no longer actually in solution before the filaments leave the controlled zone. The input of heat may be produced by any suitable methods. It is highly desirable that as much heat as possible is put into the spinning solution before it is extruded from the spinning nozzle, and for this purpose the spinning solution may be heated in any desired manner, as for example by immersing the pumps or the filter candles or other parts of the apparatus for supplying the spinning solution to the spinning nozzle in suitable baths of heated fluid, as for example hot water, hot oil, hot air, steam or the like. The bath of heating fluid may extend the length of a whole bank of spinning nozzles and should then carry a sufficient volume of

liquid that the spinning solution proceeding to each of the spinning nozzles is maintained at substantially the same temperature. Thus, for example, the heating fluid may be contained in a long conduit of sheet iron, steel or other suitable material, which is preferably bored so as to admit the filter candles or other devices through which the spinning solution passes on its way to the spinning nozzles. The conduit may even be recessed so as to receive the spinning pumps themselves. A very suitable arrangement consists in a long box-like conduit, the width of which is traversed by tubes which constitute the outer casing of a filter candle. It is then merely necessary to attach the spinning nozzles to one end of the tubes traversing the heating conduit. Pipes from the spinning solution supply, perforated and covered with a suitable filtering material, may then be inserted in the tubes from the other end and suitably fixed thereto, as for example by a screw end, by flanges or other suitable means. Any other arrangement may be employed for the purpose of bringing the spinning solution to the desired temperature. It is preferable that means should be adopted to prevent undue loss of heat from the spinning solution subsequent to its leaving the heating means. Preferably the spinning nozzle itself is arranged as close to the heating conduit or other heating means as is convenient having regard to accessibility for cleaning or other purposes.

Instead of, but preferably in addition to, heating the spinning solution itself, as already described, the air which is drawn in a controlled manner through the spinning zone is itself heated. The heat thus supplied to the air may constitute the whole of the heat supplied to the filaments, that is to say the spinning solution need not necessarily be heated prior to spinning or need not be heated very much, particularly if filaments of matt appearance or of low lustre are required. It is desirable however to heat both the spinning solution and the air brought to the spinning zone. The air carried to the spinning zone may be heated by suitable banks of steam pipes or by other heating means adjacent the spinning devices themselves, but preferably the air is heated prior to bringing it to the spinning zone. Thus, for instance, ducts may be provided to bring the air to the spinning zone, and these may be provided with blowers or not as desired, and heating means may surround the ducts or may be contained therein. For instance the air may be passed over or through a bank of steam pipes and subsequently carried through suitable ducts into the spinning zone. A fan or other blower device may be used for this purpose. Alternatively the ducts carrying the air to the spinning zone may be passed through the same heating means as those used for heating the spinning solution itself. For instance the air may be passed through a duct immersed in the heating fluid already referred to. It is desirable to have a long passage of the air through such a duct, as it is difficult to heat air in comparison with heating the spinning solution and moreover the volume of air to be heated is much larger than that of the spinning solution. By this means the spinning solution and the air passing through the spinning zone may be heated to approximately the same temperature. For filaments of relatively high lustre and also of very round cross-section it is desirable to heat the spinning solution to a higher temperature than

the air in the spinning zone. For the production of hollow filaments the air in the spinning zone is preferably heated very considerably so as to produce the desired hollows inside the filaments, or alternatively the filaments immediately after leaving the spinning zone or in the last few inches of the spinning zone may be raised to the required temperature to produce hollows. It will be noted that it is quite easy to produce hollow filaments by having a very high air temperature in the spinning zone, and an ordinary or somewhat reduced temperature of the spinning solution. In addition a rapid flow of air through the spinning zone assists in the production of hollow filaments.

If desired, the air brought into the spinning zone may itself be the means of imparting heat to the spinning solution either in the spinning nozzle itself or on its way to the spinning nozzle. Thus the hot air, after passing through the spinning zone, may be caused to heat the spinning nozzle or the pipes, filter candle or other supply means thereto. Thus a suction device for controlling the air flow through the spinning zone may entirely surround the spinning nozzle and/or filter candle so that the hot air passes directly into contact with the nozzle or candle after passing through the spinning zone. Similarly the hot air may thus contact with the spinning nozzle, filter candle or other supply means before being passed to the spinning zone; such an arrangement being especially convenient where the air is to be passed through the spinning zone in the same direction as the filaments.

As already indicated after leaving the spinning zone the filaments are passed through the open air or at any rate through very large chambers which in effect are the open air of the spinning room, and the setting of the filaments is completed, if necessary, during their passage in this manner. The temperature of the air in the spinning room may be adjusted as required. Preferably when using acetone as solvent or a solvent of a similar degree of volatility the temperature of the spinning room is maintained at about 75° to 85° F. However ordinary atmospheric temperature may be maintained particularly if a very volatile solvent is employed or if the filaments have a comparatively long travel in the open air. One of the main advantages of the present invention is that during this final setting the filaments are readily accessible to the operative for any treatments which it is desired to apply to them. Thus, for instance, without any necessity for elaborate arrangements for withdrawing the filaments from the customary spinning cells, they may be wound on bobbins, for example by drum-winding apparatus or on swifts or other devices or may be twisted and wound, for example with the aid of a cap or ring spinning device. In all cases before winding it is desirable to contact the filaments with a feed roller or other device determining the draw-down. The actual length of travel of the filaments from the spinning nozzle to the winding device may vary with the number of heat units which are brought to the spinning solution prior to extrusion and to the filaments after extrusion and with the spinning speed. Usually with a spinning speed of about 300 or so feet per minute a total run of about 6 feet is sufficient, while with spinning speeds of 600 or more feet per minute it is desirable to extend the run of the filaments from nozzle to winding device to 9 feet or upwards, though of course the rate of evaporation

depends on the total heat units put into the spinning solution and the filaments in unit time. In most cases the length of the spinning zone through which a controlled supply of air is run and which is secluded from the outer air, in accordance with the present invention, is of the order of 10-14 inches or less. This again will vary with the speed of spinning and with the heat units put in before or after extrusion of the spinning solution. The spinning zone must extend sufficiently far below the spinning nozzle for reversal of phase of the spinning solution from liquid to solid to take place within said zone. At the spinning nozzle, the base of the spinning solution, for example cellulose acetate, is completely dissolved in the solvent, while at some distance from the spinning nozzle the cellulose acetate or other base is solid and the residue of solvent is dispersed through this solid. At an intermediate point the phase of the cellulose acetate or other base is changing and it may be stated that the end of the spinning zone for the purposes of the present invention is some short distance beyond the place at which this reversal of phase takes place, and it is most conveniently at the point where the filaments can be touched without undue damage thereto.

Since after leaving the spinning zone the filaments still contain substantial quantities of solvent and some or most of these solvents evaporate during their travel through the open air, the atmosphere of the spinning room becomes charged with the solvent vapour. It is therefore desirable to provide the spinning room with ventilating plant preferably situated towards the top of the spinning room so as to draw off the air which may then be carried to a suitable solvent recovery plant. Such an arrangement is especially necessary where the air flowing through the spinning zone itself is injected through said zone rather than drawn through by suction. Where suction is employed to draw the air through the spinning zone said air may be derived from the spinning room itself, so that it may be unnecessary to provide additional ventilating plant.

As already indicated the present invention is especially advantageous in that the filaments in their travel to the winding device and after leaving the spinning zone are completely accessible to the operative for any operations which he desires to apply to them. Thus, for instance, in the ordinary dry spinning of artificial silk it is comparatively difficult to put in a sufficient stretch to produce an appreciable orientation of the cellulose micelles owing to the fact that breakages tend to occur. The most advantageous place for applying stretch is in the plastic zone of the setting of the filaments. This plastic zone may be passed through while the filaments are in the open air in accordance with the present invention, so that a stretch or an additional stretch may be applied to this zone by carrying the filaments round or otherwise in contact with bars, rollers or other devices which prevent the tension or the whole of the tension acting upon the filaments all the way from the spinning nozzle and thereby causing breakages. The accessibility of the filaments after leaving the spinning zone is particularly important in relation to applying this additional stretch. For the purpose of putting in this stretch softening agents may be applied, e. g. by wicks or rollers, to the filaments if desired, though in general this is unnecessary, since it is quite convenient to ap-

ply the stretch to the filaments while they are still sufficiently plastic to take the stretch.

If desired the filaments either just inside the spinning zone, or just outside, or at any other suitable place, may be carried over bars or other arrangements adapted to stick them together, either so as to form artificial horse-hair, that is to say a product of more or less circular cross-section, or to obtain a ribbon, so that the filaments while stuck together are in a flattened formation. It is only necessary to cause the filaments to contact with each other while they still contain sufficient solvent to enable them to adhere. Alternatively the filaments may be caused to contact with each other at a later stage and in order to bring about the necessary adherence a solvent or softening agent may be applied thereto at this stage. During the run of the filaments through the open air any other desired treatments, as for example the application of effect materials, may be carried out.

The present invention may be utilized for the manufacture of artificial silk and like artificial materials from any desired base, and more especially of cellulose derivative bases, such as cellulose acetate and benzyl cellulose. The base may be present in the spinning solution in widely differing concentrations, as for example concentrations of 15 to 25 or even up to 30 or 35%. Concentrations of 25 to 35% may lead to slow operation in the main filters in the spinning factory, but these difficulties may be avoided by concentrating the spinning solution after its passage through the main filters and before actually spinning, the concentration being so carried out that a uniform evaporation of solvent takes place, and the formation of gels or other solidification of the base is avoided. The viscosity of the cellulose derivative may be in accordance with the present day practice. Thus for example the cellulose derivatives may have a viscosity of about 6 to 20 or even 25 up to 40 or more. Special additions may be made to the spinning solution, if desired, for the purpose of increasing viscosity or for any other purposes. For instance the addition of benzene or other hydrocarbons or ether, or even latent solvents, such as alcohol, especially in large proportions, or methyl acetate has the effect of increasing the viscosity and also may, if highly volatile as is the case with diethyl ether, promote evaporation in the early stages of spinning, so that the final form of the filaments is determined very easily and the spinning zone referred to above may be correspondingly decreased in length. Additions to the spinning solution, as for example additions of diluents boiling at a higher temperature than the main body of solvent or any other additions, such as pigments, either white or coloured, may be made for the purpose of producing filaments of low lustre or for other purposes.

The above description includes many new devices for operating the new processes and these all fall within the scope of the invention. Furthermore where air has been referred to for evaporating the solvent from the filaments, it will be understood that other gases may be used, for example nitrogen, especially in the spinning zone itself. Again where filaments have been referred to, it is obvious that products having another cross-sectional conformation, such as ribbons, may be manufactured.

The accompanying drawings illustrate by way of example several forms of apparatus accord-

ing to the invention arranged for downward spinning.

Fig. 1 is a vertical section of one form of apparatus;

Figs. 2 and 3 are a vertical section and front elevation respectively of another form of apparatus, the section in Fig. 2 being taken substantially on the line 2—2 of Fig. 3;

Fig. 4 is a vertical section of a further form of apparatus arranged for stretching the filaments; and

Fig. 5 is a vertical section of yet another form of apparatus.

Referring to Fig. 1, the apparatus comprises an upper unit comprising pumps 6, filters 7 and jets 8, and heated spinning zones 9, and a lower unit comprising a cap-spinning frame 10. The jets 8 are arranged centrally of the spinning zones 9 at a level which ensures that the extruded filaments 11 pass through the full length of the zones 9 before entering their run in the open air between the upper unit and the cap spinning frame. The zones 9 are heated by means of jackets 12 supplied with heating fluid maintained at the desired constant temperature by any suitable means. A flow of air is provided past the jets by means of suction applied to a central conduit 13 of large dimensions, this conduit conveniently being formed integrally with the casing 14 accommodating the filters 7 and supporting the pumps 6. Passages 15 connect the spaces of the casing 14 surrounding the filters 7 with the conduit 13 and are provided with interchangeable or controllable diaphragms 16, so that in accordance with the degree of suction maintained in the conduit 13 and the sizes of the apertures in the diaphragms, a predetermined and controllable flow of air is caused to pass each jet 8. This air may be wholly provided from the open air entering the open bottoms of the spinning zones, such air being heated as it proceeds towards the jet by means of the jackets 12. Alternatively, evaporative medium, conveniently air, can be admitted into the spinning zones by means of appropriately shaped and disposed nozzles in any desired proportion of the total amount of air drawn from each spinning zone through the diaphragms 16. On the left-hand side of Fig. 1 one form of nozzle for this purpose is shown, this comprising a mouth 17 arranged near the jet 8 and close to one side of the filaments 11 issuing therefrom so as to distribute evaporative medium supplied from a conduit 18 over a bundle of filaments. The medium is supplied under suitable pressure to the conduit 18 and controlled as to the amount supplied to each spinning zone by suitable means shown diagrammatically in the figure, this comprising a valve 19. On the right-hand side of Fig. 1 an alternative nozzle arrangement is shown, this comprising an annular tube 20 supplied with a controlled amount of evaporative medium from a conduit 21 and perforated so as to apply such medium close to the filaments 11 and preferably to discharge it towards the jet 8.

The controlled evaporation of the spinning solution extruded from the jets 8 results in the filaments losing a large proportion of their solvent content by the time they emerge from the spinning zones 9, and acquiring the desired characteristics, cross-section etc. while in the zone, the remaining content of solvent being largely removed by the run of the filaments through the open air. The length of the spinning zones 9 may be adjusted in accordance with requirements and particularly in relation to the rate of spin-

ning the filaments, their denier and the concentration of the spinning solution. Generally as indicated above it will be of the order of 10-14 inches. The solvent-laden evaporative medium is drawn through the diaphragms 16 and led through the conduit 13 to the outlet 22 to a solvent recovery plant. It will be understood that the extrusion unit contains as many spinning jets as desired, these being served by the common heating jackets 12 and the common suction conduit 13 in a manner similar to that to be described later with respect to the analogous arrangement shown in Fig. 3. In this way similar conditions are obtained with any desired number of spinning jets for the production of filaments having precisely similar characteristics.

The filaments 11, after travelling through the open air to complete their setting, pass round guide bars 23, and feed rollers 24 to determine the rate of production of the filaments and the extent of stretch, if any, applied to the filaments during setting. With each feed roller 24 is associated a guide 25 for convenience in seizing the filament bundle to enable it to be applied to the bobbin 26 in a cap spinner comprising a cap 27 mounted on a stationary spindle. The bobbin is rotated by means of a tin drum 28 and is moved up and down within the cap 27 by means, not shown, in order to traverse the yarn along the bobbin as it is twisted by the cap spinner. Lubricant is applied to the filament bundle between the guide bar 23 and the feed roller 24 by means of a wick 29. The height of the balloon guide 30 above the lower edge of the cap 27 may be adjustable in accordance with the thickness of the bundle, speed of operation, etc.

The arrangement of the filters 7 in the casing 14 permits the filters to be surrounded by heated air, the tendency being for air to rise by convection and occupy the spaces round the filters above the outlet diaphragms 16. Consequently, a considerable degree of heating of the spinning solution may be effected while it is passing through the filters 7, depending upon the size of the filters and the extent of their surface exposed to the air. The collection of heated air towards the top of the apparatus also serves to maintain the pumps 6 heated, and the pumps and the supply pipe 31 to the spinning solution may be surrounded by a casing 32 to assist in the preheating of the spinning solution before it reaches the filters 7.

While Fig. 1 shows a duplex arrangement of apparatus having two rows of jets 8 and spinning zones 9 served by a common suction conduit 13 on a common pump shaft 33, it will be understood that the apparatus, while incorporating the principal features described with reference to this figure, can be made with a single row of jets somewhat as shown in Fig. 5.

Referring now to Figs. 2 and 3, the apparatus there shown comprises an upper unit 34 mounted on a frame-work 35 and a ring spinning unit 36. The filters 37 are mounted within a casing 38 incorporating a duct 39 surrounded by a heating jacket 40. Surrounding each spinning jet 41 is a hood 42 which depends downwardly to form a spinning zone 43 for the reception of the filaments extruded from the jet. The hood 42 closely surrounds the filter 37 and jet 41 at its upper end, but it may be enlarged at its lower end as shown at 44. Air is supplied at a suitable constant pressure to the conduit 39 and is discharged therefrom through a diaphragm 45 having an aperture of predetermined dimensions, there being

one such diaphragm in connection with each filter 37 so that a predetermined and controllable supply of air heated by means of the jacket 40 may be supplied to the space surrounding each filter. This air serves to heat the spinning solution passing through the filter, and on being discharged through the hood 42 embracing the jet 41 passes in close contact with the filaments 46 issuing from the jet, and controls their setting within the zone 43.

Heated air escaping from the funnel 42 is carried away by means of hoods 47 connected to a suction conduit 48 leading to a recovery plant for the solvent contained in the air. The passage of the heated air through the hoods 47 serves to heat the pumps 49 and supply pipe 50 to the spinning solution. The hoods 42 may be slid downwardly as shown by the dotted lines to provide access to the jets 42, these being reached through the doors 51.

The drying of the filaments 46 after leaving the spinning zone 43, is completed or substantially completed by their passage through the open air and the filaments are then passed round a guide bar 52 to a feed roller 53 and thence by a lappet bar 54 to the spinning device 55. If desired a lubricant or other conditioning liquid may be applied to the filament bundle by means of a wick 56.

In the apparatus shown in Fig. 4 means are provided with a separate heating of the filters and the spinning zones. The filter casing is provided by a tubular member 57 of a heating unit comprising jackets 58 maintained at a controlled temperature by means of heating fluid supplied through pipes 59. The filter body 60 is secured in the upper end of the passage 57 and is provided with a short connection 61 leading from the spinning pump 62. The lower end of the passage 57 is closed by a cap 63 carrying the jet 64. The arrangement provides a filter body of large capacity and particularly one having a large surface exposed to the heating medium in the jackets 58 so that the spinning solution is uniformly heated to any desired temperature before it reaches the jet 64.

The spinning zone comprises a hood 65 depending from the under-side of a filtering and heating unit and provided with heating pipes 66 so as to bring the air surrounding the jet 64 to any desired temperature which may be the same as or different from the temperature of the spinning solution supplied to the jet. A flow of air is produced through the hood 65 by a suction conduit 67 common to a number of hoods and connected to each by a pipe 68 terminating in a diaphragm 69 having an aperture of appropriate size. A uniform and controlled flow of air is thus created through each spinning zone.

The filaments leaving the spinning zones have a run of any desired length through the open air for the further removal of solvent. During this run the filaments are subjected to stretch by passing in turn round rollers 70, 71, the increase of peripheral speed of the roller 71 over that of the roller 70 being adjusted in accordance with the stretch desired. Stretch may also be imparted to the filaments between the jet 64 and the roller 70 by suitably adjusting the peripheral speed of the roller 70.

The solvent content of the filaments in the stretching run depends upon the amount of solvent evaporated before the filaments reach the roller 70, and may be adjusted by a choice of spinning conditions so as to control the evaporation

up to the emergence of the filaments from the hoods 65, and also by adjusting the length of the filament run between the hoods and the roller 70. Likewise, the length of run between the rollers 70 and 71 may be adjusted as required. The stretched filaments may be collected without twisting, Fig. 4 showing them being wound on a bobbin 72 driven by a drum 73.

Fig. 5 shows an arrangement in which an upward current of air towards the jet is produced by means of a suction conduit 74 in a casing 75 containing the filters 76, the conduit 74 being connected to each jet 77 by a pipe 78 containing an apertured diaphragm 79. The pipe 78 is connected to the centre of a jet of annular form so that the air is drawn past the filaments to the centre of the filament bundle issuing from the jet. The spinning zone 80 is formed by a casing 81 supporting the casing 75 and provided with a jacket 82 for the heating of the air passing to the jet 7. Evaporative medium may also be supplied by means of a slotted or perforated ring 83 supplied from a pressure header 84 under the control of means such as a valve 85. The medium issuing from the ring 83 is brought into close contact with the outside of the filament bundle so that the filaments are brought into intimate contact with evaporative medium both outside the bundle and inside thereof by reason of the central withdrawal of evaporative medium through the pipe 78.

In the appended claims, the expression "cellulose derivative" is intended to include any cellulose ester or ether capable of being dissolved in a volatile solvent liquid to form a solution amenable to extrusion into filaments or other products and to setting by evaporation of said liquid.

Having described my invention what I desire to secure by Letters Patent is:—

1. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of organic derivative of cellulose into an air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an air stream in said air space, the evaporative conditions within said air space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air run in the open many times longer than said distance and then collecting said products.

2. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of organic derivative of cellulose into a heated air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an air stream in said air space, the evaporative conditions within said air space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air run in the open many times longer than said distance and then collecting said products.

3. In a dry spinning process for the manufac-

ture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of organic derivative of cellulose into a heated air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an upward air-stream drawn through said air-space, the evaporative conditions within said air space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air run in the open many times longer than said distance and then collecting said products.

4. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of organic derivative of cellulose into a heated air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an upward air-stream drawn through said air space into which additional air is injected across the path of the extruded products, the evaporative conditions within said air space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air run in the open many times longer than said distance and then collecting said products.

5. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of cellulose acetate into a heated air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an upward air-stream drawn through said air-space, the evaporative conditions within said air space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air-run in the open many times longer than said distance and then collecting said products.

6. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a basis of cellulose acetate into a heated air space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, and through an upward air-stream drawn through said air-space into which additional air is injected across the path of the extruded products, the evaporative conditions within said air-space being kept substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the products leaving said space to an air-run in the open many times longer than said distance and then collecting said products.

7. In a dry spinning process for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, the steps of extruding a dry spinning solution having a

basis of organic derivative of cellulose in the form of a hollow bundle of liquid filaments into a heated air-space secluded from the atmosphere for a distance of not more than 14 inches below the extrusion point, drawing an upward current of air from the interior of said bundle within said air-space, injecting additional air into said air-space across the path of the filaments, maintaining the evaporative conditions within said air-space substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, subjecting the filaments leaving said space to an air-run in the open many times longer than said distance, and then collecting said product.

8. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, means for extruding the spinning solution downwards, means for secluded an air-space round and for not more than 14 inches below the extrusion means, means for causing an air-stream to flow in said secluded space, said air-stream being adapted to contact with and evaporate solvent from the extruded products, means for maintaining the evaporative conditions within said secluded space substantially constant and such as to change the phase of the extruded products from liquid to solid within said space while leaving a substantial amount of solvent within the products, and means for collecting the products, said collecting means being so arranged with respect to the extrusion means as to give the products an air-run in the open many times longer than 14 inches.

9. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, means for extruding the spinning solution downwards, means for secluded an air-space round and for not more than 14 inches below the extrusion means, means for drawing an upward air-stream through said secluded space, said air-stream being adapted to contact with and evaporate solvent from the extruded products, heating means for said air-space, means for maintaining the evaporative conditions within said secluded space substantially constant and such as to change the phase of the extruded products from liquid to solid within said air-space while leaving a substantial amount of solvent within the products, and means for collecting the products, said collecting means being so arranged with respect to the extrusion means as to give the products an air-run in the open many times longer than 14 inches.

10. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, means for extruding the spinning solution downwards, means for secluded an air-space round and for not more than 14 inches below the extrusion means, means for causing an upward current of air to flow through said secluded air-space, means for maintaining said evaporative conditions within said secluded space substantially constant and such as to change the phase of the extruded products from liquid to solid within said air-space while leaving a substantial amount of solvent within the products, said means including heating means, and means for collecting the products, said collecting means being so arranged

with respect to the extrusion means as to give the products an air-run many times longer than 14 inches.

11. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, means for extruding the spinning solution downwards, means for secluded an air-space round and for not more than 14 inches below the extrusion means, means for drawing an upward air-stream through said space, said air-stream being adapted to contact with and evaporate solvent from the extruded products, heating means for said air-space, means for injecting additional air into said air-stream across the path of the products, means for maintaining the evaporative conditions within said secluded space substantially constant and such as to change the phase of the extruded products from liquid to solid within said air-space while leaving a substantial amount of solvent within the products, and means for collecting the products, said collecting means being so arranged with respect to the extrusion means as to give the products an air-run in the open many times longer than 14 inches.

12. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, a substantially horizontal ring-shaped die having numerous downwardly directed extrusion orifices, means for drawing an upward current of air through the central space in said die, means for secluded an air-space round and for not more than 14 inches below said die, heating means in said air-space, means for injecting additional air into said air-space and across the path of the extruded products, means for maintaining the evaporative conditions within said air-space substantially constant and such as to change the phase of the extruded products from liquid to solid within said air-space while leaving a substantial amount of solvent within the products, and means for collecting the products, said collecting means being so arranged with respect to the die as to give the products an air-run in the open many times longer than 14 inches.

13. In an apparatus for the manufacture of filaments, threads, ribbons and like products of organic derivative of cellulose, a filter candle for filtering the spinning solution immediately before extrusion, an extrusion die adapted to be supplied with spinning solution through said spinning candle, an upwardly tapering hollow member open at both ends adapted to enclose the air-space round and for a distance of not more than 14 inches below the die, a hood adapted to enclose a further air-space round the filter candle and the upper portion of the tapering member, means for causing heated air to flow into said further air-space and through said tapering member along the path of the extruded products, means for maintaining the evaporative conditions within said tapering member substantially constant and such as to change the phase of the extruded products from liquid to solid within said member while leaving a substantial amount of solvent within the products, and means for collecting the products, said collecting means being so arranged with respect to the extrusion die as to give the products an air-run in the open many times longer than 14 inches.

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