This invention relates to the production of staple fiber yarns and like products, and is particularly concerned with the manufacture of staple fiber yarns or like products from continuous filaments and is a continuation-in-part of my U. S. Application S. No. 297,670 filed October 3, 1939 (now Patent No. 2,227,911).

In U. S. Patents Nos. 2,219,356 and 2,220,024 methods are described for manufacturing staple fiber yarns or like products from continuous filaments in which a substantially twistless bundle of continuous filaments is fed forward, the filaments at the end of the bundle are separated from one another, and from the separated filaments at the end of the bundle a predetermined length is cut to yield a group of fibers, these operations being repeated so as to obtain a succession of groups of separated fibers which are assembled in such a manner that the forward ends of the fibers of each group extend beyond the rearward ends of fibers of the preceding group, so that the fibers may be formed into a staple fiber yarn or like product. The two specifications above referred to describe two different methods of forming the fibers arranged in this manner into a continuous staple fiber yarn or like product, Patent No. 2,219,356 describing the compacting of the fibers by passing them between a pair of rubbing bands which roll the fibers together, after which the fibers are twisted, and Patent No. 2,220,024 describing the holding of the fibers to the peripheral surface of a rotating drum and the withdrawal of the succession of groups of fibers through a passage leading to the axis of the drum, whereby the fibers are twisted together.

U. S. application S. No. 297,670 filed October 3, 1939 (now Patent No. 2,227,911) describes an improvement on the methods described above, in which successive groups of fibers are fed to the end of a rapidly rotating support either in the form of a needle-like spindle, or in the form of a tail of yarn protruding from a rapidly rotated twist tube, the yarn being fed in a direction across the axis of rotation of said support so that the ends of said fibers are taken up on the support by previously fed fibers, the free ends of each bunch of fibers so taken up being drawn away in one direction along said axis, and a staple fiber yarn, resulting from the twisting together of the successive groups of fibers by the rotation of said support, being continuously drawn in the other direction along said axis away from the place at which the fibers are taken up.

It is an object of the present invention to provide still further improvements upon the methods and apparatus described in U. S. application S. No. 297,670 filed October 3, 1939 (now Patent No. 2,227,911). According to the present invention, in its broadest aspect, a process for the manufacture of staple fiber yarn comprises feeding a succession of flat, wide groups of separated fibers to the tail of a staple fiber yarn being produced, rapidly rotating said tail whereby the ends of said fibers are taken up by said tail, said fibers being fed in a direction across the axis of rotation of said tail, and continuously drawing away said staple fiber yarn as said fibers are taken up whereby each of said groups of fibers in succession takes the place of the tail by which it was taken up and in turn takes up the next group of fibers.

When, as is described in U. S. application S. No. 297,670 filed October 3, 1939 (now Patent No. 2,227,911), the fibers are fed directly to the rotating tail of a yarn being produced, the tail is rotated, according to a specific aspect of the present invention, solely by means of an induced gaseous vortex near said tail at its axis of rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn along the axis of the vortex to form a new tail to the staple fiber yarn, which, as it is thus formed, is continuously drawn away against the drag of said axial component.

The fibers may however, according to a further aspect of the present invention be fed indirectly to the rotating tail, being supported on their way by intermediate means, whereby further fiber operations may be performed upon the fibers, and particularly the mechanical spreading of the fibers, and/or the mixing of additional fibers therewith. In this case the rotation of the tail may, in accordance with the present invention, be effected solely by a gaseous vortex, or alternatively or in addition by other means such as those particularly described in U. S. Application S. No. 297,670 filed October 3, 1939 (now Patent No. 2,227,911).

By way of example several forms of apparatus according to the invention will now be described in greater detail with reference to the accompanying drawings of which:

Fig. 1 is a side elevation showing the lay-out of one form of the apparatus;

Figs. 2, 4 and 6 are plan views of the operative part of the apparatus shown in Fig. 1 at three different stages of its operation.

Figs. 3 and 5 are side elevations in section of Figs. 2 and 4;
Figs. 7 and 8 are sectional plan views of a further form of apparatus at two different stages of its operation; 2
Fig. 9 is a sectional side elevation of Fig. 8; 3
Fig. 10 is a sectional side elevation of a third form of apparatus; 4
Fig. 11 is an end elevation partly in section of Fig. 10; 5
Figs. 12 and 13 show details of Figs. 10 and 11; 6
Fig. 14 is a side elevation of yet another form of apparatus according to the invention; and 7
Figs. 15 and 16 are a sectional side elevation and a sectional plan respectively of a detail of the apparatus shown in Fig. 14.

Referring to Fig. 1, a continuous filament yarn is supplied from a large drum-like package 2 having flanges 3 the package being rotated at a constant angular speed by the constant rotation of driving wheels 4 on which the flanges 3 of the package 2 rest. The package 2 is of the kind formed by the method described in U. S. Patent No. 2,234,922 and the yarn thereon varies in denier from the inside of the package to the outside in such a manner that by rotating the package at a constant angular speed the yarn is delivered therefrom at a constant rate in terms of weight per unit time. Leaving the package 2 the yarn passes through a guide 5 adjustable mounted in a holder 6 and over a roller 7 provided with a material, such as rubber, gutta percha or like substance, suitably removed in the electrostatic series from the basic material of the filaments in the yarn 2. The roller 7 is driven with a peripheral speed substantially in excess of the speed of the yarn by means of a belt 8 driven from a pulley 9 on the main driving shaft 10 from which the friction wheels 4 are driven.

On leaving the roller 7 the filaments enter a device 11 supplied with compressed air through a pipe 12 from a header 13, the compressed air emerging from a jet 14 and carrying with it the yarn 1 in the form of separated filaments. The jet 14 is of flat cross-section so as to facilitate the separation of the filaments, the said separation being also assisted by the electrostatic forces engendered by their rubbing contact with the surface of the roller 7. The filaments, loosened and separated in this manner, enter a further device 15 supplied with compressed air through a pipe 16 from the header 13 and emerge with the compressed air from a nozzle 17 of flat cross-section similar to the nozzle 14. Beneath the filaments as they emerge thoroughly separated and in a flat band from the nozzle 17 is disposed a cutter 18 of the hair-clipper type operated by means of a belt 19 and a driving wheel 20. The cutter is operated continuously and the filaments of the yarn 1 as they emerge from the nozzle 17 are pressed periodically into engagement with the cutter by means of two deflector rods 21 mounted on an arm 22 pivoted at 23 to the device 15 and alternately lifted and pressed down at the desired intervals.

The ends of the continuous filaments 1 are blown by the stream of air through the nozzle 17 into a device indicated generally at 24 and to be described in greater detail hereafter with reference to Figs. 2-6. They emerge, by a guide 25, in the form of a staple fiber yarn 26 which passes through a pigtail guide 27 to a traversing guide 28 mounted on a traversing bar 29 by means of which they are conducted to a package 30 which is carried in a bracket 31 and is driven by surface contact with a rotating drum 32. In this manner the yarn 26 is collected on the package 34.

Air valves 37, 38, 39 provided in the apparatus are operated by means of connecting rods 40, 41, 42 from a crank shaft 43 for a purpose to be hereinafter described. Referring to Figs. 2-6, it will be noted that the air valves 37, 38, 39 in these figures have been turned into the plane of the paper so as to show their operation, the true positions of these valves being as shown in Fig. 1.

In the operation of the device the filaments emerging from the nozzle 17 are blown, as shown in Fig. 2, along a channel plate 44 the air blast from the nozzle 17 proceeding via a conduit 45 into a suction main 46. The diverging section of the channel plate 44 causes the filaments, already separated by the diverging nature of the nozzle 17, to separate still further. When the ends of the filaments reach the end of the channel plate the air valve 37 opens and compressed air enters an ejector 47 lying beneath the channel plate 44 and communicating through perforations 48 in the channel plate. Air is thereby drawn into the perforations 48 and discharged into the suction conduit 46 with which the ejector 47 is in communication. This draws the ends of the filaments downwards in contact with the tail 49 of the staple fiber yarn 26 shown in Figs. 4 and 5. The tail 49 is rapidly rotated, as will be hereinafter described, and when the ends of the filaments are drawn into contact with it they become entangled on account of the rapid rotation of the tail 49. At this stage the deflector rods 21 carried on the arm 22 are depressed, and bring the filaments into engagement with the cutter 18 whereby the filaments are severed so that their ends form staple fibers 50. Then the air valve 38 and the air valve 39 open simultaneously and the rear ends of the fibers 50 are swept sideways through the flat channel 51 and into a tail pipe 52. The valve 38 communicates with a chamber 53 adjoining the side of the channel plate 44 and communicating with perforations 54 in the side of the channel plate so that when the valve 38 is opened air enters through the perforations 54 and blows the fibers 50 sideways. The valve 39 communicates with the ejector 55 in the tail pipe 52, which tail pipe also communicates by means of a pipe 55 with the suction main 46.

The tail pipe 52 tapers from the ejector 55 towards the channel plate 44 with which it is in communication, and the flat passage 51 communicates tangentially with the whole length of the tapered portion. Furthermore, a pipe 57 conveys compressed air through a small bore 58 in the body of the tail pipe 52, the bore 58 also leading tangentially to the tail pipe. By this means air entering the conical tail pipe 52, whether from the flat channel 51 or the bore 58, and in the former case whether from the influence of the ejector 53 or by mere suction from the conduit 56, forms a vortex in the tail pipe 52 rotating always in the same direction. The tail 49 of the yarn 26 extends into the tail pipe 52, and it is solely by means of the vortex of air thus induced in the tail pipe 52 that the rapid rotation of the tail 49 is effected.

As the yarn 26 is drawn away by means of the winding device 34, 35, 36 the tail 49 is, of course, drawn out of the tail pipe 52. The fresh bunches of fiber 59, however, which are successively attached to the tail 49 and swept laterally into the tail pipe 52 renew the tail 49, so that the said tail
always extends into the tail pipe 52. In this manner the yarn 26 is built up in the tail pipe 52 and the channel plate 44 as fast as it is drawn away.

In the form of apparatus described with reference to Figs. 1-6 the leading ends of the fibers 59 are fed directly into the tail pipe 52, the trailing ends, cut by the cutter 48, are swept sideways into the tail pipe 52. If desired, however, the freshly cut ends may be entangled with the tail of the yarn while the leading ends are swept into the tail pipe. An apparatus for carrying out this principle is shown in Figs. 7, 8 and 9. Fig. 7 is a sectional plan view of the operative part of the apparatus which comprises, in addition to the nozzle 17 the deflector rods 21 and the cutter 18, a curved channel plate 60 communicating by means of a pipe 81 with the suction main 48 and the ends of the filaments emerging from the nozzle are blown down the channel plate 60. When a sufficient length of filaments has emerged from the nozzle 17 the deflector rods 21 act to depress the filaments into engagement with the nozzle 17 by means of a deflector 15 and at the same time suction is applied to the perforations 62 in the channel plate 60 by means of an ejector device 63 shown in Fig. 9. This brings the rear ends of the freshly cut fibers 59 into engagement with the nozzle 17 of the yarn 26 so that the rapidly rotating tail takes up the rear ends of the fibers 59. At this stage, as shown in Fig. 8, compressed air is supplied to the ejector 65 in the tail pipe 52 and the leading ends of the filaments 59 (instead of the rear ends as in Figs. 1-6) are swept sideways from the channel plate 60 and blown tangentially with the tail pipe 52. As in Figs. 1-6 the tail pipe 52 communicates by means of a conduit 65 with the suction main 48 and further is provided with a compressed air pipe 87 communicating by means of a tangential passage 85 with the tail pipe 52.

In the above description, two forms of apparatus have been described in which the fibers cut from the ends of continuous filaments have been fed directly to the tail 49 of the yarn 26. In the remaining Figs. 10-15 are described two apparatus in which the fibers so cut are fed indirectly to the tail 49 being supported by intermediate means on their way to said tail. While the intermediate means are described as feeding fibers to a tail 49 rotated solely by a gaseous vortex they are also applicable to the feeding of fibers to a tail rotated by alternative, or with the aid of supplementary means.

In Figs. 10, 11, 12 and 13 is illustrated a form of apparatus according to the invention in which groups of separated fibers are cut from the end of a bundle of continuous filaments and the fibers are further separated from each other after they have been cut and before they are fed to the rotating tail of the staple fiber yarn being produced. In order to facilitate an understanding of these figures, stationary parts shown in sections are shaded closely and rotating parts are shaded more openly.

The filaments emerge in a separated condition from the nozzle 17 and, as shown in Fig. 11, when they are of sufficient length their ends reach over a drum indicated generally as 76, the drum constituting intermediate means on the surface of which the fibers are supported on their way to the tail of the staple fiber yarn.

The receiving surface of the drum 69 is formed by a series of sectors 70 set between end plates 71, 72, each sector having a slot, indicated at 73 in Fig. 11, containing a flat metal strip 74 which is surrounded by a flattened helical spring 75.

The spring 75 may be contracted as shown in the upper part of Fig. 10 or it may be expanded as shown in the lower part, and all the springs around the drum are worked in like manner. Two sectors are shown in Fig. 7, one section being contracted and the other expanded except for a period of time during which the contracted springs are caused to expand and the expanded springs to contract. In Fig. 11 the springs on the right-hand side of the drum 69 are in the contracted condition while the springs at the top of the drum as shown in Fig. 10 while those at the left-hand side of Fig. 11 including the spring at the bottom of Fig. 10 are in the expanded condition.

The ends of the filaments having reached the top of the drum 69 they are sucked down by means hereinafter to be described on to the first of the contracted springs 75 and thereafter the cutter 18 severs the filaments so as to form fibers 59, the filaments being deflected from the nozzle 17 by means of a deflector 15 as shown in Fig. 17 already reached in Fig. 11. After severing the fibers 59 suction is applied over the whole of the right-hand side of the drum 69 so that the fibers 59 are sucked down on to the surface of the drum as constituted by the contracted springs 75 on the right-hand side of the drum. The drum 69 is constantly rotating in an anti-clockwise direction as shown in Fig. 11, and before the ends of the fibers reach the bottom of the drum all the contracted springs 75 carrying the fibers 59 are expanded so that the filaments are spread out.

The expansion of the contracted springs is effected by the retraction of rods 77 of which one is provided in connection with each spring, fitting into a slot 78 in the strip 74, and projecting out of the slot at its left-hand end so as to abut against the end of the spring and to compress it. The rods 77 extend through the end plate 72 on the right of Fig. 10 into a drum 79 containing the actuating mechanism for the springs. Within the drum 79 each rod 77 is secured to one or other of two semi-circular angle pieces 80, one half of the rods being secured to one such piece 80 and the other half to the other piece. It should be observed that Fig. 10 shows a partial sectional side elevation of the drum 79 and its contents, Fig. 12 is a sectional plan and Fig. 13 is a sectional end elevation. The two pieces 80 are carried upon two members 81 each of which is bored longitudinally so that it may be threaded on a guide rod 82 extending from the wall 72 of the fiber-receiving drum 69 to the end wall 83 of the actuating drum 79. Each of the members 81 has two projecting end pieces 84 which are also bored so as to be threaded on a further guide rod 85 similar to the rod 82. Along the length and on each side of each of the members 81 is a toothed rack engaging with a large toothed wheel 86, of which two are provided, one on each side of each member 81. Each wheel 86 engages both of the members 81. The wheels 86 are freely mounted on a stationary shaft 87 carried in rods 88 extending from end to end of the drum 79 and are prevented from sliding along the shaft 87 by means of two collars 89 secured to the shaft. Between the wheels 86 is a small toothed wheel 90 secured to both of them, and the toothed wheel 90 is engaged by two racks 91 carried on members 82 which are guided in stirrup-shaped members 93 secured to the walls 72, 83 respectively. Each of the members 82
carries at its left-hand end a follower 94 engaging with a stationary cam 95, the form of the cam 95 being such that as one of the members 92 is pushed to the left the other is pushed correspondingly to the right.

In the operation of the actuating drum 78, the drum 79 rotates with the drum 69 and carries with it everything that is within the drum 79 with the exception of the stationary cam 95. The rotation of the cam 95 causes a longitudinal motion of the two members 92 simultaneously so that the racks 91 carried by the members 92 cause the small toothed wheel 90 to rotate to and fro alternately in opposite directions. In this way the large toothed wheels 96 are also caused to rotate to and fro so that a longitudinal to-and-fro motion of the members 81 is brought about. In this way the two semi-circular pieces 80 are caused to move to and fro together, with the rods 77 secured to the pieces 81. Thus the springs 75 are alternately expanded and contracted, the natural tendency of the springs 75 to expand acting through the rods 77, pieces 80, members 81, wheels 86 and 90, racks 91 and members 92 to hold the cam followers 94 in engagement with the stationary cam 95.

The mechanism above described is adapted to present the fibers, which are fed in a separated condition by the nozzle 17, in even more widely separated condition to a device of the general kind described with reference to Figs. 1-6. The tail pipe 33 and ejector 56 of this device are shown in Figs. 10 and 11. The members corresponding to the channel plate 44 and the flat passage 51 differ however from those shown in Figs. 1-6 in that instead of lying in a plane they are curved around the surface of the drum 69 as shown at 97 in Fig. 11. These portions are shown by the chain lines 58, 59 in Fig. 10, the chain line 98 indicating the boundary of the flat passage corresponding to 51 and the chain line 99 indicating the boundary of the part corresponding to the channel plate 44. The portion 59 is at the bottom of the drum 69, in a part-cylindrical portion 100 in which the tail 49 of the yarn 26 is disposed at right angles to the direction of motion of the drum 69, and at a point where the fibers 50 may be taken up by the tail 49.

The transfer of the fibers from the nozzle 17 to the tail 49 of the yarn is effected as follows:

As previously stated, at the stage shown in Fig. 11 all the springs on the right-hand side of the drum are contracted, the leading end of the freshly cut fibers 50 has just been sucked down to the drum or near the first of the contracted springs 78 and the remaining part of the fibers 50 is about to be sucked down on to the contracted springs 78 on the right-hand side of the drum.

The drum 69 is carried on a stationary spindle 101 which contains two passages 102 and 103, the passage 102 being connected to suction while the passage 103 is connected to a supply of compressed air. The passage 102 has a large opening at 104 which puts it into communication with a passage 105 in the inner surface of the drum 69. As these passages pass the edge 106 of the opening 104 the suction within the passage 102 is applied through the perforations 105 and through the spaces 107 between the sectors 18 to the surface of the drum and it is by this means that the leading ends of the fibers 50 are first sucked down on to the surface of the drum. After the four passages 105 have all been exposed to suction in this manner a series of passages 108 are also exposed, which apply suction to a small part-cylindrical chamber 109 in the inner lining of the drum 69 communicating by a large number of further passages 110 with the spaces 107 between the sectors 18. Thus when the passage 108 passes the edge 106 the whole of the chamber 109 is put into communication with the suction, and so suction is applied over the whole right-hand surface of the drum 69. In this manner the main part of the fibers 50 is sucked down on the contracted springs 76 on the right of the drum 69. During the next half-rotation of the drum 69 the contracted springs constituting the drum 69 are expanded laterally with reference to the fibers 50 by the means previously described within the actuating drum 79, the remaining or expanded springs being simultaneously contracted. As a result the fibers 50 which were already spread out by the nozzle 17 are spread out very much further by the expansion of the springs 76 upon which they are carried. As the leading ends of the fibers 50 reach the bottom of the drum the passages 106 come into communication with a passage 111 in the pressure conduit 103 and by this means the leading ends of the fibers 50 are blown off the surface of the drum and come in contact with the tail 49 of the yarn 26. When the rotation of the tail has taken up the leading ends of the fibers 50 the passage 108 comes into engagement with the passage 111 and pressure is applied over all that part of the surface of the drum carrying the fibers and in this way the fibers are blown off the surface of the drum and are free to be swept sideways by suction induced by the ejector 56 into the tail pipe 33.

During the next half-rotation of the drum the expanded springs 75, now relieved of their fibers which have been transferred to the tail 49 of the yarn 26, are contracted, simultaneously with the expansion of the remaining springs which have just received a further supply of fibers from the nozzle 17. In this way the supply of fibers 50 in a separated condition to the rapidly rotating tail 49 of the yarn is maintained.

In Figs. 14-16 is shown a form of apparatus in which the groups of fibers cut from the end of a bundle of continuous filaments are mixed with a preformed group of fibers from another source to form successive groups of mixed fibers which are formed into a yarn in the manner according to the invention.

In this apparatus, fibers 114, e.g., natural fibers such as wool, are drawn as a roving 115 from a package 116 carried on a spindle 117, the roving being drawn by means of nip rollers 118 and being forwarded thereby through a flax slot 119 serving to spread the fibers in the roving 115, to a pair of driving bands 120 mounted on rollers 121. The rollers 118 and the driving bands 120 are driven at a very slow rate so as to feed the roving 115 to a band, indicated at 122, 123, the part of the band 122 being constituted by a series of parallel bare rods, and the part 123 being constituted by similar rods over each of which a rubber sleeve has been slipped so as to form a gripping surface. The rods 122, 123 extend sideways from a chain 124, of which the said rods constitute the connecting links, the chain passing round two sprockets 125, 126, the sprocket 125 being of twice the diameter of sprocket 126. The rods 122, 123 are supported in their passage round the axes 127, 128 of the sprockets 125, 126 by drums 129, 130 connected to the sprockets. Over the drum 129 is disposed a roller 131 carried in
arms 132 mounted on a shaft 133 and operated by means of an arm 134 mounted on a spring 135 and a cam 136 acting upon the arm 134. When permitted to do so by the cam 136 the spring 135 presses the roller 131 down upon the band 130 indicated at 122, 123 and the cam 136 is rotated at a speed such that the roller 131 presses upon the covered rods 123 but does not press upon the uncovered rods 122. The roving 115 passes beneath the roller 131 and as the roller 131 is pressed down on the covered rods 123, individual fibers 14 from the roving 115 are pulled out from between the bands 123 and lie upon the rods 123, and if there are any trailing ends when the roller 131 is lifted as the covered rods 123 pass beneath it, these ends lie on the uncovered rods 122.

At the opposite end of the apparatus, beyond the roller 131, is disposed an air nozzle 17 of the kind previously described, and a cutter 18. Continuous filaments 137 emerging as a flat band from the nozzle 17 are deflected into engagement with the cutter 18 by means of a deflector rod 138 mounted on a continuously rotating shaft 139, the two ends of the rod 138 coming alternately into contact with the filaments 137 and deflecting them into engagement with the cutter 18. The rod 138 is timed to deflect the filaments 137 in such a manner that the freshly cut ends thereof will substantially coincide with the leading rod 123 of each group. It will be noticed that there are three groups of rods 123 alternating with three groups of bare rods 122. Thus for every revolution of the band indicated at 122, 123 the shaft 139 rotates three half revolutions, and deflects the filaments 137 three times. By these means groups of fibers 140 are cut from the ends of the continuous filaments 137 and are laid on the rods 123, together with the preformed groups of fibers 114 from the roving 115 their trailing ends extending beyond the rods 123 over the rods 122. In Figs. 15 and 16 the drum 130 is perforated at 141 over a part of its circumference with which the rods 123 engage and the drum 130 is carried on a hollow support 142 which is cut away at 143, on the side of the support remote from the drum 130. Suction is applied through a conduit 144 to the interior of the supporting member 142 and this suction is communicated to the perforations 141 of the drum 130. By these means the groups of mixed fibers constituted by the fibers 140 drawn from the ends of the filaments 137 are sucked down and held on the surface of the band 122, 123. The use of suction may be dispensed with, if the residual charge of static electricity induced by friction with the roller 7 (Fig. 1) on the filaments is sufficient to cause the cut fibers 140 to adhere to the surface of the drum 130.

As the rods 123 pass beneath the drum 130 they deposit the mixed fibers between two flat plates 145, 146 between which the band passes, the rods still engaging with the bands and drawing them along between the plates. Beneath the drum 130 is disposed an apparatus comprising a block 52, an ejector device 55 and a part-cylindrical member 108 of the kind described with reference to Figs. 10 and 11 and, concentrating the part-cylindrical member 108, is the tail 49 of a staple fiber yarn 26 being formed, the yarn 26 being drawn away round a guide 147. The groups of mixed fibers 114, 140 now lying between the rods 123 and the plate 145 are blown into engagement with the tail 49 by a blast of compressed air supplied from a conduit 148 on which the drum 129 rotates, the conduit 148 having a single row of perforation 149 therein with which flat passages 150 in the body of the drum 129 successively coincide. The passages 150 are disposed round those parts of the drum 129 which coincide, at each revolution of the drum 129, with the rods 123. In this manner the leading ends of the groups of mixed fibers 114, 140 are adequately blown into engagement with the rapidly rotating tail 49 of the yarn 26, and in the manner already described are incorporated in the yarn 26 and become the new tail 49 thereof. By these means there is built up a staple fiber yarn 26 comprising a mixture of the fibers 140 cut from the continuous filaments 137 and the fibers 114 drawn from the roving 115.

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

1. Process for the manufacture of staple fiber yarn, said process comprising feeding a succession of flat, wide groups of separated fibers to the tail of a staple fiber yarn being produced in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation so that said tail is rapidly rotated solely by the action of said vortex and the ends of said groups of fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, and continuously drawing away said staple fiber yarn, as it is formed, against the drag of said axial component.

2. Process according to claim 1, comprising the cutting of the groups of fibers successively from the end of a bundle of continuous filaments that are separated, at the end of the bundle, from one another.

3. Apparatus for the manufacture of staple fiber yarns, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for cutting successive groups of fibers from said end as the filaments are fed, a member presenting a movable surface for the reception of the successive groups of fibers, means for expanding said surface laterally with reference to the fibers so as to separate said fibers further after they have been cut, means for rotating the tail of a staple fiber yarn being produced, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates, and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

4. Apparatus according to claim 3, wherein the surface is constituted by a plurality of springs extending across the surface, said apparatus comprising means for contracting and expanding said springs.

5. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for cutting successive groups of fibers from said end as the filaments are fed, a member presenting a movable surface for the reception of the groups of cut fibers, a source of supply of additional preformed groups of fibers adapted to present such groups to the same parts of said movable surface as receive the groups of cut fibers, whereby said cut fibers and said
additional fibers are disposed together on said surface as groups of mixed fibers, means for rotating the tail of a staple fiber yarn being produced, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said groups of mixed fibers may be taken up by said tail as it rotates and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of mixed fibers from said surface by said tail.

6. Apparatus for the production of staple fiber yarn, said apparatus comprising means for inducing a gaseous vortex about the tail of a staple fiber yarn being produced whereby said tail is rapidly rotated, means for feeding successive groups of fibers to said tail in a direction across the axis of its rotation whereby the ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

7. Apparatus according to claim 6, comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another and means for cutting successive groups of filaments on each end of the filaments are fed.

8. Process for the manufacture of staple fiber yarn, said process comprising separating the filaments at the end of a bundle of filaments from one another, cutting groups of separated fibers from the end of said bundle, separating said fibers still further from each other after they have been cut, feeding successive groups of said further separated fibers to the tail of a staple fiber yarn being produced, in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation so that said tail is rapidly rotated by the action of said vortex and the ends of said fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, and continuously drawing away said staple fiber yarn against the drag of said axial component as said fibers are taken up, whereby each of said groups of fibers in succession takes the place of the tail by which it was taken up and in turn takes up the next group of mixed fibers.

9. Process for the manufacture of staple fiber yarn, said process comprising feeding a succession of flat, wide groups of separated fibers to the tail of a staple fiber yarn being produced in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation, so that said tail is rapidly rotated solely by the action of said vortex and the ends of said groups of fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, applying intermittent suction to said tail immediately after each group of fibers is taken up by said tail so as to assist said axial component, and continuously drawing away said staple fiber yarn as it is formed, against the drag of said axial component and said intermittent suction.

10. Process for the manufacture of staple fiber yarn, said process comprising feeding a succession of flat, wide groups of separated fibers to the tail of a staple fiber yarn being produced in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation, so that said tail is rapidly rotated solely by the action of said vortex and the ends of said groups of fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, applying intermittent suction to said tail immediately after each group of fibers is taken up by said tail so as to assist said axial component, and continuously drawing away said staple fiber yarn as it is formed, against the drag of said axial component and said intermittent suction.
its ends are taken up, to form a new tail to said yarn, and continuously drawing away said staple fiber yarn, as it is formed, against the drag of said axial component.

16. Process for the manufacture of staple fiber yarn, said process comprising feeding a succession of flat, wide groups of separated fibers to and beyond the tail of a staple fiber yarn being produced in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation, so that said tail is rapidly rotated solely by the action of said vortex and the trailing ends of said groups of fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, and continuously drawing away said staple fiber yarn, as it is formed, against the drag of said axial component and said intermittent suction.

17. Process for the manufacture of staple fiber yarn, said process comprising feeding a succession of flat, wide groups of separated fibers to and beyond the tail of a staple fiber yarn being produced in a direction across the length of said tail, inducing a gaseous vortex having said tail as its axis of rotation, so that said tail is rapidly rotated solely by the action of said vortex and the trailing ends of said groups of fibers are taken up by said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, and continuously drawing away said staple fiber yarn, as it is formed, against the drag of said axial component.
and applying additional suction to said tail immediately after the leading ends of said fibers are taken up by said tail so as to assist said axial component, and continuously drawing away said staple fiber yarn, as it is formed, against the drag of said axial component and said intermittent suction.

21. Apparatus for the manufacture of staple fiber yarns, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of filaments from said end as the filaments are fed, a member presenting a movable surface for the reception of the successive groups of fibers, means for applying suction over a fixed part of said surface for drawing said fibers into contact with said movable surface, means for expanding said surface laterally with reference to the fibers so as to separate said fibers further after they have been cut, means for rotating the tail of a staple fiber yarn being produced, means for supplying compressed air to said movable surface so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

22. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of fibers from said end as the filaments are fed, a member presenting a movable surface for the reception of the successive groups of fibers, means for applying suction over a fixed part of said surface for drawing said fibers into contact with said movable surface, means for expanding said surface laterally with reference to the fibers so as to separate said fibers further after they have been cut, means for rotating the tail of a staple fiber yarn being produced, stationary means within said drum for supplying compressed air through said surface so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

23. Apparatus for the manufacture of staple fiber yarns, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of fibers from said end as the filaments are fed, a rotatable drum presenting a movable surface for the reception of the successive groups of fibers, stationary means within said drum for applying suction through said surface to draw said fibers into contact with said surface, means for expanding said surface laterally with reference to the fibers so as to separate said fibers further after they have been cut, means for rotating the tail of a staple fiber yarn being produced, stationary means within said drum for supplying compressed air through said surface so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

24. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of fibers from said end as the filaments are fed, a pair of drums rotatably mounted on parallel axes, a permeable band passing round said drums and constituting a movable surface for the reception of the groups of cut fibers, a source of supply of additional preformed groups of fibers adapted to present such groups to the same parts of said movable and movable surface, means for rotating the tail of a staple fiber yarn being produced, means for supplying compressed air to said movable surface so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates and means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

25. Apparatus for the manufacture of staple fiber yarns, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of fibers from said end as the filaments are fed, a member presenting a movable surface for the reception of the successive groups of fibers, means for expanding said surface laterally with reference to the fibers so as to separate said fibers further after they have been cut, means for rotating the tail of a staple fiber yarn being produced, means for applying suction over a fixed part of said surface for drawing said fibers into said surface, so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates, means for rotating the tail of a staple fiber yarn being produced, stationary means within said drum for supplying compressed air through said surface so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates, means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.

26. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for feeding successive groups of fibers from said end as the filaments are fed, a member presenting a movable surface for the reception of the groups of cut fibers, a source of supply of additional preformed groups of fibers adapted to present such groups to the same parts of said movable and movable surface, means for applying suction over a fixed part of said surface for drawing said fibers into said surface, so as to remove said fibers from said surface and apply them to said tail, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates, means for continuously drawing away the staple fiber yarn resulting from the taking up of successive groups of fibers from said surface by said tail.
of said movable surface to receive the groups of cut fibers, whereby said cut fibers and said additional fibers are disposed together on said surface as groups of mixed fibers, means for inducing a gaseous vortex about the tail of a staple fiber being produced whereby said tail is rapidly rotated, said tail being disposed across the path of said filaments at a distance from said cutting means substantially equal to the length of the fibers being cut whereby the leading ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

27. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for cutting successive groups of fibers from said end as the filaments are fed, means for inducing a gaseous vortex about the tail of a staple fiber being produced whereby said tail is rapidly rotated, said tail being disposed across the path of said filaments at a distance from said cutting means substantially equal to the length of the fibers being cut whereby the leading ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

28. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for cutting successive groups of fibers from said end as the filaments are fed, means for inducing a gaseous vortex about the tail of a staple fiber being produced whereby said tail is rapidly rotated, said tail being disposed across the path of said filaments and close to said cutting means whereby the freshly cut trailing ends of said fibers are taken up by said tail in its rapid rotation as they are cut, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

29. Apparatus for the production of staple fiber yarn, said apparatus comprising a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being produced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, whereby a gaseous vortex is induced about the end of said tail rapidly rotated, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

30. Apparatus for the production of staple fiber yarn, said apparatus comprising a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being produced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, means for supplying compressed air through further passages communicating tangentially with said tapered passage, whereby a gaseous vortex is induced about the end of said tail, said passage and said tail is rapidly rotated, means for feeding successive groups of fibers to said tail in a direction across the axis of its rotation whereby the ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

31. Apparatus for the production of staple fiber yarn, said apparatus comprising means for inducing a gaseous vortex about the tail of a staple fiber yarn being produced whereby said tail is rapidly rotated, means for feeding successive groups of fibers to said tail in a direction across the axis of its rotation whereby the ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for supplying intermittent suction to said tail immediately after each group of fibers is taken up by said tail so as to assist said axial component, and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component and said intermittent suction.

32. Apparatus for the production of staple fiber yarn, said apparatus comprising a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being produced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, whereby a gaseous vortex is induced about the end of said tail within said passage and said tail is rapidly rotated, means for feeding successive groups of fibers to said tail in a direction across the axis of its rotation whereby the ends of said fibers are taken up by said tail in its rapid rotation, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers is taken up by said tail so as to assist said axial component and means for drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

33. Apparatus for the production of staple fiber yarn, said apparatus comprising a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being pro-
duced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, for applying compressed air through further passages communicating tangentially with said tapered passage, whereby a gaseous vortex is induced about the end of said tail within said passage and said tail is rapidly rotated, means for feeding successive groups of fibers successively drawn away after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn.

37. Apparatus for the production of staple fiber yarn, said apparatus comprising a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being produced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, for applying compressed air through further passages communicating tangentially with said tapered passage, whereby a gaseous vortex is induced about the end of said tail within said passage and said tail is rapidly rotated, means for feeding successive groups of fibers successively drawn away after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn, means for intermittently augmenting said suction after each group of fibers successively is drawn away, after its ends are taken up, to form the new tail to said yarn.
direction of motion of said surface, and at a point where said further separated groups of fibers may be taken up by said tail as it rotates, stationary means within said drum for supplying compressed air through said surface so as to remove said fibers from said surface and apply them to said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, means for intermittently augmenting such suction after each group of fibers is taken up by said tail so as to assist said axial component, and means for continuously drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

39. Apparatus for the production of staple fiber yarn, said apparatus comprising means for feeding a bundle of continuous filaments and for separating the filaments at the end thereof from one another, means for cutting successive groups of fibers from said end as the filaments are fed, a pair of drums rotatably mounted on parallel axes, a permeable band passing round said drums and constituting a movable surface for the reception of the groups of cut fibers, a source of supply of additional preformed groups of fibers adapted to present such groups to the same parts of said movable surface as receive the groups of cut fibers, whereby said cut fibers and said additional fibers are disposed together on said surface as groups of mixed fibers, means within one of said drums for applying suction to the surface of said band, a tapered passage into the narrow end of which the end of the tail of the staple fiber yarn being produced may project, means for applying suction to the wide end of said passage, a flat passage communicating tangentially with said tapered passage along its length for the admission of a current of air induced by said suction means, means for supplying compressed air through further passages communicating tangentially with said tapered passage, whereby a gaseous vortex is induced about the end of said tail within said passage and said tail is rapidly rotated, said tail being disposed near said surface, at right angles to the direction of motion of said surface, and at a point where said groups of fibers may be taken up by said tail as it rotates, stationary means within the other of said drums for supplying compressed air through said surface so as to remove said fibers from said surface and apply them to said tail, said vortex having an axial component away from said tail whereby each group of fibers successively is drawn away, after its ends are taken up, to form a new tail to said yarn, means for intermittently augmenting such suction after each group of fibers is taken up by said tail so as to assist said axial component, and means for continuously drawing away the staple fiber yarn, as it is thus formed, against the drag of said axial component.

WILLIAM POOL.