

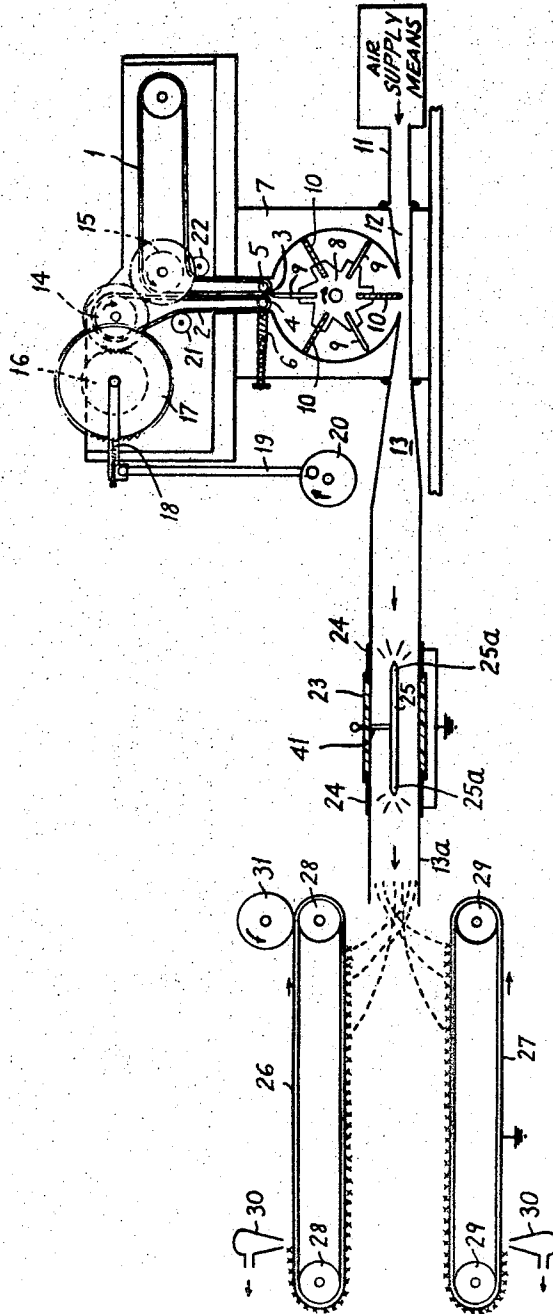
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SEPARATION OF MIXTURES OF TEXTILE FIBRES

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SEPARATION OF MIXTURES OF TEXTILE FIBRES

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This invention relates to the separation of mixtures of textile fibres by electrostatic means.

Such mixtures are obtained, for example, when textile fibres are recovered or reclaimed for further use by the process known as rag-grinding or rag-pulling, in which used textile fabrics, primarily consisting of wool, are reduced by mechanical means to a mass of loose fibres suitable for re-use by the textile industry. In the original fabrics contained fibres other than wool, as is now very generally the case, the reclaimed mass also consists of a mixture of wool fibres with a greater or less proportion of non-wool fibres, which may be of a number of different types.

The presence of these fibres limits the value of the reclaimed material from a textile point of view, by causing difficulties in the re-manufacturing processes of spinning, weaving, dyeing, and finishing.

The present invention has for an object the separation of a mixture of textile fibres, more particularly of a mixture of wool and non-wool fibres.

The invention consists in a process for the separation of a mixture of textile fibres comprising the steps of dispersing the fibres in a stream of air, simultaneously or subsequently electrostatically charging at least some of the fibres, and separating the different fibres in the mixture in an electrostatic field.

The invention also consists in apparatus for the separation of a mixture of textile fibres comprising means for dispersing the fibres in a stream of air, means for simultaneously or subsequently electrostatically charging at least some of the fibres, and means for separating the different fibres in the mixture in an electrostatic field.

The different fibres in the mixture may acquire charges of opposite sign or the same sign, and some fibres may remain uncharged. The different rates of decay of like charges on different fibres may be used to separate the fibres.

The electrostatic separation of a fibre or particulate mixture takes advantage of the fact that an electrically charged particle, when placed in an electrostatic field, tends to move along the lines of force of the field towards the field electrode having a charge opposite in polarity to the charge carried by the particle, and ultimately to reach and be deposited on this electrode. Thus, a mixture of particles of two kinds, of which one kind can be made to carry a positive charge whilst the other kind carries a negative charge, is easily separated into its constituents by simply dispersing the mixture in an electrostatic field, whereupon the positively charged particles will migrate to, and be deposited upon the negative field electrode, and vice versa.

In order that the invention may be more clearly understood, an embodiment thereof will now be described with reference to the accompanying drawing, which is a longitudinal section of apparatus for dispersing, electrostatically charging and separating a mixture of textile fibres.

Referring to the drawing, a moving belt 1 has the textile fibre blend which is to be separated placed upon its upper surface by hand, as evenly as possible.

As the belt 1 travels in the direction shown, the blend

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is fed to the nip formed by the belt 1 with another belt 2, and thus is trapped between the two belts 1 and 2 and passed vertically downwards until it emerges at the point 3, in the form of a short fringe of protruding fibres. Two small-diameter rollers 4 and 5, forming the exit nip of the belts 1 and 2, are spring-loaded against one another by an adjustable spring 6, so that the emergent fibre fringe is firmly gripped at the point 3. Rollers 4 and 5 are situated as close as possible to the periphery of a cylindrical cavity machined in a metal block 7, so that the fibre fringe enters this cavity as soon as it clears the belts 1 and 2. A six-bladed rotor 8 rotates within the cavity in the direction shown. The rotor 8 has three metal blades 9 with sharply, but not deeply, serrated edges (approximately 16 teeth per inch, $\frac{1}{16}$ " deep). The other three blades 10 are made of polytetrafluoroethylene (P.T.F.E.) with plain, non-serrated, but slightly rounded edges. The blades are set so that the serrated edges of the metal blades 9 just clear the bore of the cavity as the rotor 8 revolves, while the Teflon blades 10 just lightly rub the inner surface of the cavity. As the fibre fringe emerges from the nip of rollers 4 and 5, and enters the cavity, it is alternately beaten and combed by the six blades of the rotor 8, and individual fibres are withdrawn from the fringe and carried round by the blades to the bottom of the cavity, where they encounter an air-blast, from an air stream generator (11'), which is introduced by way of an air duct 11 and an air-way 12 machined in the block 7, and are thus removed from the blade tips and ejected by the air through an exit nozzle 13.

The belts 1 and 2 are driven by rollers 14 and 15, which are geared together and turned by a gear 16 situated on a common shaft with a ratchet wheel 17 which in turn is actuated by a spring-loaded pawl 18 driven by a connecting rod 19 from an eccentric 20. Tensioning rollers 21 and 22 are provided for adjusting the tension in the feed belts 1 and 2. The rate of feed can be varied over a wide range by varying the speed of the eccentric 20, or by varying the throw of this eccentric so as to cause the pawl 18 to move the ratchet wheel 17 one, two, or three teeth per revolution of the eccentric 20, or by varying the thickness of the layer of fibres initially placed on the belt 1. The rotor 8 is driven by a belt and a pulley from an electric motor (not shown) at a speed of approximately 1500 revs./min. (25 revs./sec.). At this speed the fibre fringe will undergo 75 beating actions and the 75 combing actions per second, thus ensuring that the fibres from the fringe will be well dispersed in the exit air-stream.

The use of three P.T.F.E. blades in the rotor has a dual purpose. First, they aid dispersion of the fibre by beating out any loose fibres left by the previous passage of one of the metal combing blades through the fibre fringe. Second, they serve to prevent air from blowing back past the rotor. The air pressure in the air-way 12 is normally greater than atmospheric, and this would tend to cause blow-back through the rotor cavity. The three P.T.F.E. blades are therefore placed at angles of 120° to one another, so that at all positions of the rotor at least two of them always form an effective seal preventing such blow-back.

The fibres emerging from the exit nozzle 13 are normally charged, without the application of any specific device for this purpose. This charge is derived from the beating and combing actions of the rotor blades on the fibre fringe, and the fibre-to-fibre friction as individual fibres are forcibly removed from the fringe by the combing blades 9. This charge is in itself sufficient in many cases to enable the subsequent separation to be performed with ease and certainty. Thus, for example, when a 50:50 mixture of wool and polyester fibres is dispersed

in the above-described apparatus, the wool fibres in the dispersion carry a positive charge and the polyester fibres a negative charge, both of sufficient magnitude for separation purposes.

If, however, greater charge is required, the exit nozzle 13 may be fitted with means for ionizing the fibres. To this end, a hollow cylinder 23 of insulating material (for example polyethylene or polystyrene) is mounted between two sections of metal tubing 24, which are connected together and to earth. A thin metal post 41 passes through the wall of the insulating cylinder 23 and supports a short rod 25 with sharply-pointed ends 25a. The length of the rod 25 is such that the pointed ends 25a lie within the earthed metal tubes 24. If the post 41 and rod 25 are maintained at a potential of about 15 kilovolts, positive or negative, relative to the earthed tubes 24, a corona discharge takes place between the points 25a and the inner surface of the tubes 24, and the air in the vicinity of the discharge is ionised. Any fibres traversing this ionised zone will then become charged by picking up gas ions. A field strength of at least about 3 kv. per inch is preferred. All fibres become charged with the same sign by this method, and subsequent separation procedures must be adjusted accordingly.

Beyond the means for ionising the fibres is illustrated an electrode arrangement which is suitable for separating a mixture of positively and negatively charged fibres, for example a mixture of positively charged wool fibres and negatively charged polyester fibres dispersed and spontaneously charged by the apparatus already described. As will be described later, the electrode arrangement can, however, be used for separating fibres which have passed through the ionising means and which all initially carry the same sign.

The dispersed mixture is discharged through a duct 13a between two electrodes comprising two endless belts 26 and 27, supported and driven by rollers 28 and 29.

The lower belt 27 is made of conducting material such as thin sheet steel, metal-coated fabric or metallised plastic sheet, and is kept always at earth potential. The rollers 29 may thus rotate in ordinary non-insulated metal bearings. The upper belt 26 may also be of conducting material, or it may be a non-conductor such as thin polymethylmethacrylate or polytetrafluoroethylene. It will normally operate at about 10-15 kv. above or below earth potential, and the rollers 28 supporting it must therefore be effectively insulated to withstand such voltages.

The belts 26 and 27 are moved slowly by the rollers 28 and 29 in the directions indicated, so that fibres deposited on the inner surfaces of the belts by the electrostatic field between them are brought to the suction nozzles 30 and sucked off the belts. The fibres may be removed from the suction air-stream by filtration through wire gauze or by centrifugal separation.

In separating a mixture of wool and polyester fibres, it is preferable to earth the lower electrode, upon which the wool fibres are being deposited, as fibres with a lesser charge or no charge at all tend to fall on to the lower electrode, and wool fibres have a higher density than polyester fibres.

If the upper belt 26 is made of conducting material, its potential relative to earth will normally be maintained by some form of electrostatic generator. In certain cases, however, the provision of an external generator is unnecessary. If the belt 26 is made of some flexible non-conducting material which is easily electrified by friction, such as polymethylmethacrylate or polytetrafluoroethylene, it can be made to function as its own generator by simply providing a rapidly-revolving roller 31 at the position shown, the roller 31 being covered with animal fur or soft raised woollen fabric (blanket), and lightly brushing against the belt 26 as it passes. In this way sufficient frictional charge is generated on the belt to enable the separation of, for example, a mixture of wool

and polyester fibres, dispersed and spontaneously charged as described above, to be carried out successfully.

The advantages of this variation in procedure are that the cost of an external electrostatic generator is eliminated, the safety factor of the whole apparatus is greatly increased, and the construction is simplified in that the rollers supporting and driving the upper belt need not be as carefully insulated as in the case when a conducting belt is used.

The disposition of the collecting electrodes may vary considerably according to the nature of the fibre mixture and the magnitude and sign of the charge carried by its constituent fibres. If for example conditions were such that one of the constituents was charged whilst the other was not, then the uncharged constituent would not be deposited on either electrode, but would remain suspended in the air-stream. It would then be necessary to enclose the electrode system completely, so that the uncharged constituent could be recovered from the air-stream after it left the enclosure.

In the case of a dispersed fibre mixture the fibres of which have all been given charges of the same sign, for example by ionising means as described, separation of the fibres may take advantage of the fact that different kinds of textile fibres show marked differences not only in the sign of the charge generated on them by friction on metals or other fibres, but also in the length of time such charges are retained by the fibre when the charging action has ceased. Broadly speaking, fibres with high internal conductivity, such as wool, retain electrostatic charges very poorly, whilst those with low internal conductivity such as nylon, and the polyester and acrylic fibres, retain them tenaciously and for long periods. The differences are due mainly to the differing regains or moisture contents of the different classes of fibre. The normal (65% relative humidity, 70° F.) regain of wool is about 16% whereas that of polyester fibre is of the order of 0.4% under the same circumstances. If therefore a dispersion of fibres is charged, and then a short period of time is allowed to elapse, say by blowing the dispersion through a fairly long length of ducting, the charge on the wool fibre constituents tends to disappear whereas that on any synthetic fibre constituents remains relatively unchanged. If, then, after the decay period has elapsed, the dispersion is passed between two parallel electrodes as before, the upper electrode having a charge opposite in sign to that carried by the synthetic fibre constituents, these fly up to this electrode quickly, and are deposited near the entry port; the wool fibres, however, having little or no charge by now, either pass on through the electrode region, or are attracted upwards with so slight a force that, if they reach the upper electrode at all, the site at which they are deposited is much further from the entry port. In this way a separation is effected even although the fibres in the dispersion initially carry the same sign of charge.

The disposition, width, length, and charge on the collecting electrodes may be varied within very wide limits to take advantage of the particular magnitude, sign, and duration of the charges communicated to the individual constituents of a fibre mixture, with a view to obtaining the clearest possible separation.

It is found particularly convenient to operate the method and apparatus of the present invention continuously, but too great a throughput in the dispersion stage should be avoided, as it may lead to a certain degree of reaggregation of fibres, and consequent imperfect electrostatic separation.

Within limits, the same increase in throughput can be obtained either by increasing the speed of the feed belt 1, or by keeping this speed constant and increasing the weight of the material fed in unit time. Tests indicate that a lighter feed at a faster speed of the feed belt is preferable, but not critical.

The speed of the rotor 8 is closely connected with the

rate of production, and its peripheral speed is more significant than the actual number of revolutions per minute. In one test, increasing the rotor speed from 2250 r.p.m. to 3000 r.p.m. caused an increase of 50% in the rate of production.

For any particular apparatus, there is a critical upper value for air velocity which, if exceeded, results in the separated fibres being blown off the collecting electrodes. There is also a critical lower value below which charged fibres tend to coat the inside walls of the air passages of the apparatus, eventually losing their charge and being blown out as unseparated clumps of fibres. In tests with one apparatus, the critical upper and lower values were found to be 18 cu. ft./min. and 12 cu. ft./min. respectively.

Ideally, the dispersion produced is such that each individual fibre floats in the air-stream without contact with any of its neighbours—i.e., the fibre cloud is monodispersed. In practice, such dispersion is probably never attained, and the cloud contains, in addition to individual fibres, small clumps and aggregates of fibres which have not been completely dispersed. For purposes of electrostatic separation, it is of course desirable that the dispersion shall be as complete as possible.

It is found that the separation process is more efficient if the fibre mixture contains small amounts (e.g. 1–5% by weight) of oil. The type of oil appears to be unimportant.

Up to 10% by weight of oil can be used, but if more than 10% is used, the oil tends to gum the fibres together and prevent separation.

The oil can be applied by spraying on to the fibre mixture.

Mineral (hydrocarbon) oils, vegetable oils, for example olive oil, and silicone oils have all been successfully used. The viscosity of the oil is preferably below approximately 100 centistokes at room temperature.

It is also found that the presence of an antistatic agent, either in the presence of oil or in its absence, increases the efficiency of the separation. Up to 0.5% by weight, and preferably 0.05–0.2% of antistatic agent may be used. Suitable types of antistatic agents include the non-ionic ethylene oxide condensates known under the trade names Lubrol W and Cirrasol SF200. The antistatic agent can be applied in aqueous solution by spraying, and if it is used in the presence of an oil, it can be applied in admixture with the oil.

The relative humidity of the surrounding atmosphere and the regains or moisture contents of the fibres themselves do not appear to play any significant part in controlling the separation efficiency.

The invention is not limited to the separation of wool-polyester mixtures as described, but can be applied to the separation of other binary mixtures, such as wool-nylon or wool-acetate, or ternary mixtures such as wool-nylon-polyester.

Even in the case of fibre mixtures such as wool-cotton or wool-viscose rayon, which can normally be separated satisfactorily by chemical methods such as carbonisation, it may still be advantageous to apply the electrostatic method, since its use does not involve the least damage or loss of quality on the part of the separated wool, and it will almost certainly be cheaper and quicker to apply, since carbonisation is a wet process and involves subsequent drying of the material, and drying is, in general, a relatively expensive process.

The foregoing details and explanations have been given by way of example only, and are not intended to be construed in a limiting sense.

We claim:

1. A process of separating textile fibres of one kind from a mixture of different kinds of textile fibres, which consists in dispersing the mixture of fibres in loose form in a stream of air, pneumatically conveying the loose fibres by said air stream at a controlled velocity into an electrostatic separation zone, creating differential electrostatic charges on the different kinds of fibres prior to their conveyance into said zone, and creating an electrostatic field in said zone whereby to cause the fibres in said controlled velocity air stream to move along different paths in said zone in accordance with the charges thereon and thereby effect separation of the different kinds of fibres.

2. Process as claimed in claim 1, wherein the differential electrostatic charges on the different fibres are created by conveying the loose fibres through a zone of ionization and controlling the pneumatic conveying time of the fibres after passing the ionization zone whereby the different kinds of fibres become differentially charged before being conveyed into the electrostatic separation zone.

3. Process as claimed in claim 1, which consists in depositing at least one of the different kinds of fibres after separation in the electrostatic separation zone upon a moving surface, and continuously removing the deposited fibres from said surface while it is moving.

4. Apparatus for separating textile fibres of different kinds from a textile fabric containing a mixture of said different kinds of textile fibres, comprising means for pulling the textile fabric apart into individual fibres of different kinds and differentially charging said fibres, an air passage into which said fibres are discharged, means generating a stream of air in said air passage for entraining the fibres discharged therein and conveying the fibres along said passage to an electrostatic separator at a controlled velocity, said electrostatic separator comprising electrodes charged to different potentials whereby to cause the fibres in the air stream to move along different paths in accordance with the charges thereon and thereby effect separation of the different kinds of fibres.

5. Apparatus as claimed in claim 4, said electrodes comprising endless belts on which the fibres are selectively deposited by the field of the electrodes, means for moving said belts, and means for removing deposited fibres from said belts while they are moving.

6. Apparatus as claimed in claim 4, and including ionizing means operative in the air passage to charge the fibres as they are being conveyed in the air stream to the electrostatic separator, the air passage between the ionizing means and the separator being of a length which is sufficient for the like charges on the fibres to dissipate for a sufficient period of time to yield the relative different charges required for electrostatic separation in the separator.

7. Apparatus as claimed in claim 4, wherein at least one of the electrodes comprises a moving endless belt of insulating material which is charged to the desired potential by friction by rubbing its surface while it is moving.

References Cited by the Examiner

UNITED STATES PATENTS

1,663,863	3/1928	Royster	209—129
2,445,229	7/1948	Masse	209—127
2,738,067	3/1956	Cook	209—127
2,839,189	6/1958	Johnson	209—127
3,037,248	6/1962	Callaghan	19—156.4

FOREIGN PATENTS

870,831 3/1953 Germany.

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