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METHOD AND APPARATUS FOR SEPARATING TEXTILE MATERIAL FROM RUBBER

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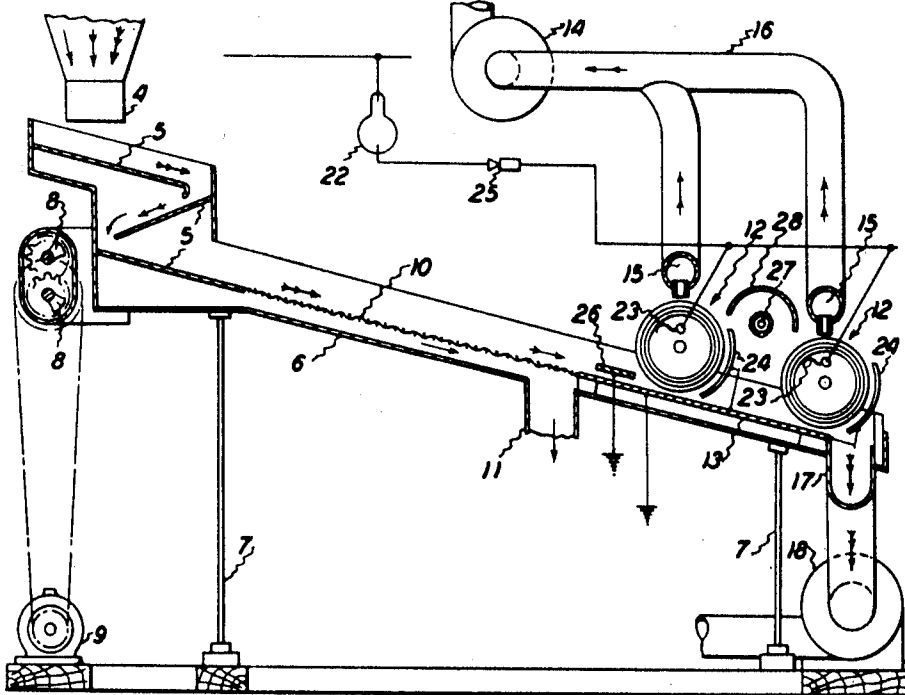


FIG. 1.

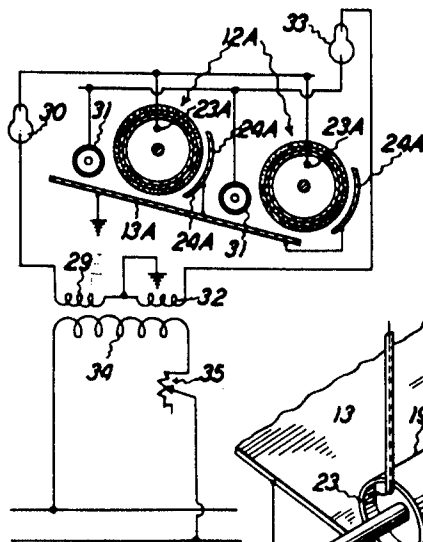


FIG. 3.

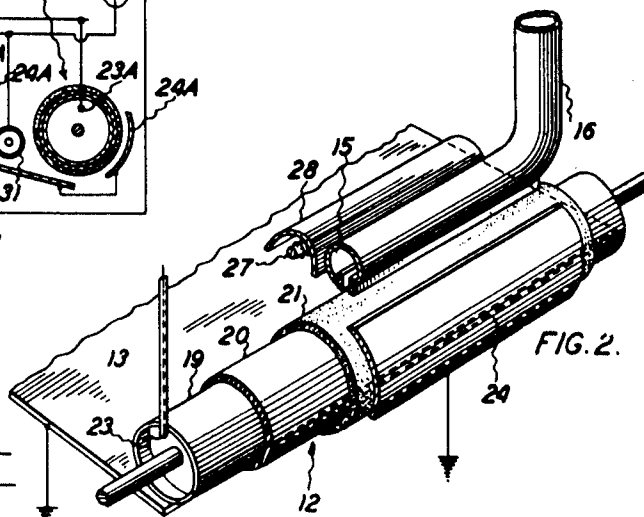


FIG. 2.

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## METHOD AND APPARATUS FOR SEPARATING TEXTILE MATERIAL FROM RUBBER

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10 Claims. (Cl. 209—127)

This invention relates to the separation of textile material or fabric from rubber, and has particular application in the removal of textile fibres from disused or worn rubber articles, to enable the rubber and the fabric to be separately employed in a commercially valuable manner.

Many articles such as worn tyres, footwear, and the like, which constitute a major source of old rubber or stock, suitable for reclamation or re-use, have fabric insertions therein. In some cases, no attempt is made to separate the fabric from the rubber prior to reclamation or other treatment, but such a procedure results in a low grade reclaimed product of restricted application; also, the fabric is irrevocably lost.

The known methods of separating fabric from rubber are of two kinds, which may be roughly grouped as chemical and mechanical. The chemical methods are usually characterised by the disintegration of the stock followed by the destruction of the fabric fibres by chemical agents, or by transforming the fibres into water soluble compounds which may be washed away from the rubber. Although these methods are efficient, they are both complex and expensive and the fabric is destroyed.

Very fine disintegration of the stock is a prerequisite in mechanical separation, and the finely divided mixture is screened, centrifuged, or subjected to an air blast, which is intended to take up the fabric fibres more easily than it does the rubber particles. These mechanical methods are comparatively cheap and simple to perform, but they are not efficient, because in each case a high proportion of rubber is carried off with the fabric and/or much fabric is left with the rubber.

The object of this invention is the separation of fabric from rubber in a manner which is highly efficient, cheap, and simple to carry into practical effect. A further object is to effect the said separation in a manner whereby the fabric is retrieved and isolated in a form having an average thread length and an unimpaired tensile strength whereby it is of considerable commercial value, for example, as a bonding agent for inclusion in articles manufactured out of new or reclaimed rubber.

According to this invention, the rubber stock is first cut into pieces of convenient size which are fed to a disintegrating mill. The mill is of any known type capable of fragmenting the stock into a mixture consisting entirely or largely of free rubber fragments and free fabric fragments. The fragmented mixture is then

passed into a high tension electrostatic field of force, either as a continuously moving stream or in intermittent batches. The field is furnished by a pair of electrodes onto one of which (a repelling electrode) the mixture is fed. The other electrode is an attracting electrode or a "collector" for the fabric fragments.

The fabric fragments entering the field become inductively charged to a different degree than the rubber fragments, and this difference is sufficient to cause the fabric fragments to leave the mass and adhere to the collector. The fabric fragments remain adhered to the collector for a sufficiently long period to enable them to be either continuously or periodically removed therefrom by mechanical means.

The repelling electrode may take the form of a vibrating table, the continuous movement whereof facilitates departure of fabric fragments therefrom. The collector may be in the form of a rotating roller whereby the fabric fragments are picked up and carried towards the top thereof where they may be continuously removed by a scraper or brush, having a receiver chute associated therewith, or by an air suction trunk. Alternatively, the collector may be in the form of a stationary plate having one lap of an endless band positioned in close proximity thereto. The fabric shreds moving towards the collector are intercepted by the band to which they adhere, and continuous endwise movement of the band carries the fabric fragments out of the region of maximum field intensity where they are removed, for example, by a scraper blade which transfers them to a discharge trough or conveyor.

According to one manner of practising the invention, the stock is cut into pieces small enough to be dealt with by a known disintegrating mill which is constructed, so that the mass which issues therefrom comprises an intimate mixture of comparatively free rubber fragments, and free fabric fragments or shreds. The disintegrated mass is then fed to a fine mesh vibrating screen to remove the rubber of very fine or powder consistency. The remaining coarse mixture is then fed between the electrodes.

The field is formed by a rotatable cylindrical collector electrode and a flat conductive repelling electrode which lies beneath the collector and is preferably height adjustable relative thereto. The repelling electrode is slightly inclined downwardly from its receiving end and is preferably continuously vibrated so as to transfer the mass

deposited thereon towards and into the field. The repelling electrode may have a field extension plate electrically connected thereto. This plate is curved correspondingly to the collector and is positioned on the rising side of it and in close proximity thereto, so that high field intensity extends from near the lowest part of the collector to or near to the top thereof.

Separation may be effected with a potential difference between the electrodes of the order of 25,000 volts; the collector being connected to the positive terminal of a uni-directional current source and the repelling electrode being earthed. The electrodes are positioned as closely as possible to each other without allowing brush discharge or sparking. With a bare metal collector electrode only a small proportion of fabric is lifted out of the mass. Increased fabric lift is secured by constructing the collector of a metal core and a dielectric material wrapping which envelops and forms part of the collector. An optimum spacing of the collector is readily located whereby practically all of the fabric is lifted from the mass into adhesion with the collector. A smooth dielectric surface on the collector is not wholly efficient, however, because it does not furnish sufficient frictional lift to carry all of the fabric from the lowest point of the collector. This defect may be met by encasing the dielectrically wrapped collector core within a sheet of felt or other mat of closely compacted hairs or strands. The mat encasement forms a part of the collector and retards neutralisation of the induced charge on the fabric shreds by holding these shreds off the surface of the collector and by contacting them on only a small fraction of their surface area.

If the electrode spacing is greater than the experimentally determined optimum, the smaller fabric shreds tend to remain with the rubber, and when the electrode spacing is less than the optimum, the smaller rubber particles are attracted to the collector in addition to the fabric. In this latter case, complete separation may then be effected by screening the collector output to remove the small rubber particles therefrom.

Should a single pass through the field not effect the required degree of separation, a re-pass may be resorted to, or alternatively, a plurality of sequential fields may be employed.

Experimental practisings of the invention herein described have shown that under some conditions considerable loss of fabric pick-up efficiency may occur, and although my experiments up to date have not conclusively established the nature of these adverse conditions, it is believed that they may be due to varying ambient humidity, which, of course, varies the dryness of the collector encasements onto frictional charging of the fragments in the disintegrating mill. For example, for periods of as long as four consecutive working days the pick-up efficiency of the collector is such as to remove practically all of the free fabric from the rubber fabric mixture. Such a period may be followed by a period of a few hours or a day or so in which only about half or even less of the free fabric is picked up; the rate of mixture feed, field intensity, ambient temperature and other conditions being practically similar throughout the two periods. Without determining the absolute causes of this efficiency disparity, I have found that it may be remedied partly or entirely in several ways, and in a practical embodiment of apparatus to perform the present invention

it is preferable that means to effect the mentioned remedies be incorporated, as described later herein, in such manner as to enable pick-up efficiency shortcomings to be optionally counteracted whenever a falling away of efficiency is observed.

During periods of low pick-up efficiency it was observed that the motion response of the fabric shreds was greatest when the collector was first charged, and that the efficiency fell away when the field had been established for some time. For example, with a steadily rotating cylindrical collector, the quantity of material picked up per revolution is almost twice as great in the first three or four revolutions as it is subsequently. In order to utilise this effect advantageously, the collector circuit is furnished with a switch whereby it is periodically interrupted. If desired, this switch may be of the rotary type adapted to periodically bridge one or more pairs of contacts.

By experiment one suitable timing for the interrupter switch has been found to be 45 seconds closed circuit, alternating with 15 seconds open circuit. Under these conditions, the particular apparatus employed was able to separate 225 lbs. of fabric per hour by interrupted operation as against 150 lbs. per hour with continuous operation.

Low efficiency conditions can be counteracted to some extent by repassing the incompletely separated material through the field until the required degree of separation is attained; by controlling the ambient humidity, in order to ensure complete dryness of the collector encasement, in any known manner as by providing heating devices placed near the electrodes, or by employing a plurality of sequential separative fields.

Experiment directed to the employment of a plurality of sequential fields disclosed that, apparently, in some cases, fabric fragments are not picked up by a particular collector owing to their inability to effectually earth their induced charge, of like sign to that on the collector, through the repelling electrode. This impairment of pick-up efficiency may be overcome, to some extent, if several collectors are employed, providing the distance, or the time of travel between them is sufficiently great to enable dissipation of the acquired like charge, or earthing of it through the repelling electrode. The difficulty just referred to may be more readily met or partly met by the provision of counter-charging electrodes of opposite polarity to the collector electrodes. The construction employed is as follows.

A plate repelling electrode, which is preferably inclined downwardly from its receiving end and is preferably equipped with jiggling mechanism to keep the fed particles moving, has a plurality of height-adjustable collector electrodes and counter-charging electrodes positioned above it. Each collector is rotatable and is constructed and positioned in the manner previously described herein. The counter-charging electrodes are placed, one between each pair of collectors, and one just ahead of the first collector. They are adjusted as to height above the plate electrode, so as to just avoid or largely avoid attraction thereto of any of the particles under treatment.

Where current supply is from ordinary A. C. lines the counter-chargers and the collectors are respectively connected to a pair of series-connected transformer secondaries having a common primary which is furnished with rheostat

control devices in order to enable variations of field intensity. Suitable rectifiers are incorporated as well understood.

The plate electrode is earthed or, if a transformer is employed, it may be connected to the neutral tap between the secondaries.

It would appear that the counter-charging electrodes give rise to an effect somewhat as follows. Assuming the counter-charger to be negatively charged and the collector positively charged (these polarities may be interchanged without appreciable variation in the function of the apparatus), fabric fragments first arrive in the counter-charger field and are inductively charged thereby. Those fragments which are effectively in contact with the repelling electrode lose their free negative charge to earth and consequently they exhibit a certain degree of motion response to the influence of the field. They may even arrive on the surface of the counter-charger but that is not of moment as the surface thereof is not felted and, consequently, they more or less speedily become negatively charged and repelled therefrom either directly towards the collector or back into the mass of fragments. In either case, the effect of the motion response is to agitate the fragments or remove some of them thus clearing the way for the previously unearthed fragments to make a good or more effectual contact with the repelling electrode. It will thus be seen that all or a large proportion of the fabric fragments which are still on the repelling electrode and which are leaving the counter-charger field are positively charged, and, consequently, as these fragments enter the positive field due to the collector electrode they are strongly repelled thereby and thus have an increased prospect of being forcibly thrust into good earthing contacts with the repelling electrode or retarded against entering the region of maximum positive field intensity until they have been effectively earthed. This enhanced earthing contact facilitates good get-away for the entire positive charge (which in the positive field becomes a free charge) on the fabric fragments, and consequently the bound negative charge induced by the positive field causes transfer of the fabric fragments to the collector electrode.

Where counter-chargers are not employed pick-up efficiency may be somewhat improved by the provision of an earthed electrostatic shield plate positioned just ahead of the first collector so that oncoming fragments are not influenced by the field until they are more or less suddenly exposed to a portion thereof of high intensity.

The accompanying drawing, which is more or less schematic, illustrates suitable apparatus for carrying the invention into practical effect.

Fig. 1 is a sectional side elevation of one form of the apparatus;

Fig. 2 is a perspective fragment of the mechanism shown in Fig. 1; and

Fig. 3 is an incomplete sectional side elevation of a pair of collectors having counter-charging electrodes associated therewith.

Fragments which are to be separated are fed to the hopper 4 from the disintegrator mill (not shown). The plain arrows (in Fig. 1) indicate rubber fragments which are small enough to be practically entirely disassociated from fabric fragments, the single barbed arrows indicate free fabric fragments, and the double barbed arrows indicate rubber fragments which have been insufficiently dimensionally reduced by the mill and

consequently are of a size likely to still contain embedded fabric fragments.

Fragments descend from the hopper 4 onto spreader boards 5 lying athwart a box framing 6. This framing is mounted on flexible legs 7 which enable it, together with the integers mounted thereon, to freely vibrate under the influence of out of balance weights 8 which may be rotated by any suitable means such as the motor 9.

From the lowest of the spreader boards 5 the fragments pass on to a wire mesh screen 10. The fine rubber fragments pass through this screen and they are gathered at chute 11. The fabric fragments and the incompletely milled fragments pass into the field formed by the collector electrodes (indicated generally by numeral 12) and the conductive repelling electrode 13. Free fabric fragments are attracted to the collectors and are suctionally removed therefrom by fan 14 through the agency of slotted headers 15 and conduits 16. Incompletely milled fragments fall into trough 17 whence they may be restored to the mill by operation of fan 18.

The collectors 12 consist of metal core cylinders 19 which are enwrapped by a sleeve 20 of dielectric material and an outer covering 21 of felt or other like material consisting of a mass of matted strands. The collectors 12 are charged through a rectifier valve 22 and brushes 23, and the repelling electrode 13 is earthed.

Although Fig. 1 of the drawing shows an arrangement employing two collectors, it will be clear that only one or more than two may be used. When only one collector is used separation is somewhat less complete than is the case with two, and when three or more are used it is found that the number in excess of two, for all practical purposes, amounts to an economically wasteful duplication of parts as only a very small quantity of free fabric remains in the fragment mass after it has negotiated the first two fields.

It will be appreciated that a moderate pick-up efficiency may be realised in the operation of the apparatus thus far described even during those periods, referred to previously herein, when conditions of "low pick-up efficiency" prevail. However, to improve efficiency in a general manner, it is preferable to include field extension plates as indicated at 24. These plates are wired to the repelling electrode or they are independently earthed according to convenience.

To counteract low efficiency conditions the apparatus preferably includes an interrupter switch 25 an electrostatic shield plate 26 and a heating element 27 having a reflector 28.

The heater 27 is simply a localised air conditioning unit whereby the atmosphere in the separative region is dried, with the object of maintaining the collector encasement felts in a dry condition. The heater 27 could, of course, be replaced by an air conditioning system whereby the felts are kept dry by reducing the atmospheric humidity throughout the factory or apartment in which the separation is carried out; alternatively steam or other heating elements may be enclosed within the collector cores. The heater 27 is, however, a preferred device on account of its simplicity and inexpensiveness, moreover it is highly effective in controlling the humidity in the required restricted area and thus ensuring complete dryness of the felts.

Fig. 3 illustrates an embodiment of the apparatus which includes counter-charging electrodes. In this construction the integers marked

12A, 13A, 23A and 24A are similar to those respectively marked 12, 13, 23 and 24 in the remaining figures of the drawing. The collectors 12A are charged through secondary 29 and rectifier 30, and the counter-chargers 31 are connected to the secondary 32 through the rectifier 33. The circuit of primary 34 includes a rheostat 35.

It will be appreciated that Fig. 3 is not intended to be a complete representation of a separator, as the construction would, of course, preferably include integers such as those numbered 4 to 11, 14 to 18, 25, 27, and 28, in Fig. 1. Although Fig. 3 illustrates the counter-chargers and the collectors as being connected to the twin secondaries of a single transformer, it will be appreciated that separate transformers, each with or without a control rheostat such as 35, may be employed; so that, if desired, the potential difference across the counter-charger field may be different to that across the collector field.

The uses to which a practically textile free rubber may be applied will be apparent to those skilled in the art to which this invention relates. Useful applications of textile fragments, which are approximately of the dimensions herein stated, and which are free of rubber except for that originally impregnated between the constituent strands, may be less apparent, as it is believed that such fragments when derived from the source or by the method herein described constitute a novel product incapable of isolation in commercially valuable quantities by previously known methods of separation.

As previously stated herein, the textile fragments are a useful bonding agent; alternatively they may be milled or teased to form cotton waste or a padding material; again, they may be used as an ingredient or as the basic material in the manufacture of needled felts or the like.

I claim:

1. Apparatus for separating fabric fragments from rubber fragments comprising a flat repelling electrode, at least one rotatable collector electrode which is positioned above said repelling electrode and which consists of a cylindrical metal core and a wrapping of dielectric material on said core, means for establishing a high tension unidirectional electrostatic field between said electrodes, means for passing a mixture of fabric fragments and rubber fragments on said repelling electrode into said field, and a felt encasement which externally covers said wrapping and inhibits the acquisition by fabric fragments attracted to said collector electrode of an electric charge of the same polarity as that of said collector electrode.

2. Apparatus according to claim 1 which includes a field extension plate electrically connected to said repelling electrode, said field extension plate being concentrically shaped and positioned relative to said collector electrode, and spaced from said collector electrode by a distance which is substantially equal to the least distance between said electrodes.

3. The method of separating fabric fragments from rubber fragments which comprises passing a mixture of the fragments over an electrically grounded table through a unidirectional high tension electrostatic field between the table and a bare countercharging electrode spaced thereabove and then passing the mixture into another unidirectional high tension electrostatic field of opposite polarity between the table and

an attracting electrode spaced thereabove, selectively lifting fabric fragments from the mixture in said other field toward the attracting electrode and collecting and holding the lifted fragments away from the mixture on a carrier of dielectric material under the attraction of the attracting electrode but out of contact therewith, continuously traversing the carrier and fragments so held thereon out of said other field, removing fabric fragments from the carrier, and discharging and recovering rubber fragments from said table.

4. The method of separating fabric fragments from rubber fragments which comprises feeding a disintegrated mixture of the fragments into a unidirectional high tension electrostatic field between a repelling electrode and an attracting electrode having a travelling dielectric carrier for attracted fabric fragments overlying the same, selectively lifting fabric fragments away from the mixture in said field under the attraction of the attracting electrode and collecting and carrying such lifted fragments out of said field on said carrier while maintaining the fragments under such attraction, removing fabric fragments from the carrier beyond said field, and periodically interrupting and re-establishing said electrostatic field at short intervals in the course of the separating operations.

5. The method of separating fabric fragments from rubber fragments which comprises feeding a disintegrated mixture of the fragments over an electrically grounded metal table through a plurality of alternate countercharging and collecting zones respectively corresponding to unidirectional high tension electrostatic fields of opposite polarities established between the table and oppositely charged countercharging and attracting electrodes arranged in alternating series thereabove, in each collecting zone selectively lifting charged fabric fragments from the mixture toward the attracting electrode and collecting and holding the lifted fragments on a carrier of dielectric material under the attraction of the attracting electrode but out of contact therewith, traversing each carrier and fragments so held thereon out of its collecting zone, removing fabric fragments from the carriers beyond said collecting zones, recovering rubber fragments from said table beyond said zones, and periodically interrupting and reestablishing the electrostatic fields in said collecting zones at short intervals in the course of the separating operations.

6. Apparatus for separating fabric fragments from rubber fragments comprising electrically grounded repelling electrode means including a metal feed table, means for feeding a mixture of the fragments to and over the surface of the table, an attracting electrode of extended surface area spaced from said repelling means and above said table, means for charging the attracting electrode with unidirectional current of high voltage to establish a high tension unidirectional electrostatic field in a zone between the same and the repelling means, a countercharging electrode spaced above said table ahead of said attracting electrode and means for charging the countercharging electrode with unidirectional current of high voltage and of a polarity opposite to the polarity of the attracting electrode to subject the fragment mixture on the feed table to a countercharging high tension electrostatic field just before the mixture passes into said zone, a carrier of dielectric material

overlying said attracting electrode in said zone and having a fragment collecting surface in spaced relation to the attracting electrode surface, means for traversing said carrier through and out of said zone in said relation, means for removing fabric fragments from said carrier beyond said zone, and means for recovering rubber fragments from said table beyond said zone.

7. Apparatus for separating fabric fragments from rubber fragments comprising electrically grounded repelling electrode means including a metal feed table, means for feeding a mixture of the fragments to and over the surface of the table, an attracting electrode of extended surface area spaced from said repelling means and above said table, means for charging the attracting electrode with unidirectional current of high voltage to establish a high tension unidirectional electrostatic field in a zone between the same and the repelling means, a carrier of dielectric material overlying said attracting electrode in said zone and having a fragment collecting surface in spaced relation to the attracting electrode surface, means for traversing said carrier through and out of said zone in said relation, means for removing fabric fragments from said carrier beyond said zone, means for recovering rubber fragments from said table beyond said zone, and means operative periodically to interrupt and thereafter renew the operation of said charging means.

8. Apparatus for separating fabric fragments from rubber fragments comprising an electrically grounded metal table, means for feeding a mixture of the fragments over said table, a cylindrical fabric collector mounted above said table in predetermined spaced relation thereto, means for rotating said collector, said collector comprising a cylindrical metal core enveloped by dielectric material having a surface in the form of minute strands and operative to limit the area of contact and retard the neutralization of charged fabric particles attracted electrostatically to the surface of the collector, means for charging said metal core with unidirectional current of high voltage to establish a high tension

electrostatic field in a zone between the same and said table, and means for recovering fabric fragments from said collector beyond said zone.

9. Apparatus for separating fabric fragments from rubber fragments comprising an electrically grounded metal table, means for feeding a mixture of the fragments over said table, a cylindrical fabric collector mounted above said table in predetermined spaced relation thereto, means for rotating said collector, said collector comprising a cylindrical electrically conducting core enveloped by dielectric material having a fabric wrapping with a surface in the form of minute strands and operative to limit the area of contact and retard the neutralization of charged particles attracted electrostatically to the surface of the collector, means for charging said electrically conducting core with unidirectional current of high voltage to establish a high tension electrostatic field between the same and said table, and means disposed above said collector for removing fragments therefrom.

10. Apparatus for separating fabric fragments from rubber fragments comprising an electrically grounded metal table, means for feeding a mixture of the fragments over said table, a cylindrical fabric collector mounted above said table in predetermined spaced relation thereto, means for rotating said collector, said collector comprising a cylindrical metal core enveloped by dielectric material operative to retard the neutralization of charged particles attracted electrostatically to the surface of said material, means for charging said metal core with unidirectional current of high voltage to establish a high tension electrostatic field between the same and said table, an electrically grounded metal extension plate above said table in predetermined spaced relation to said collector to extend said field above the table in the path of movement of fragments carried by the collector, and means adjacent to said collector above said extension plate for removing fabric fragments from the collector.

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