



(86) Date de dépôt PCT/PCT Filing Date: 2000/03/07
(87) Date publication PCT/PCT Publication Date: 2000/09/21
(45) Date de délivrance/Issue Date: 2008/12/30
(85) Entrée phase nationale/National Entry: 2001/09/11
(86) N° demande PCT/PCT Application No.: US 2000/005872
(87) N° publication PCT/PCT Publication No.: 2000/054885
(30) Priorités/Priorities: 1999/03/12 (US60/123,926);
1999/12/22 (US09/469,596)

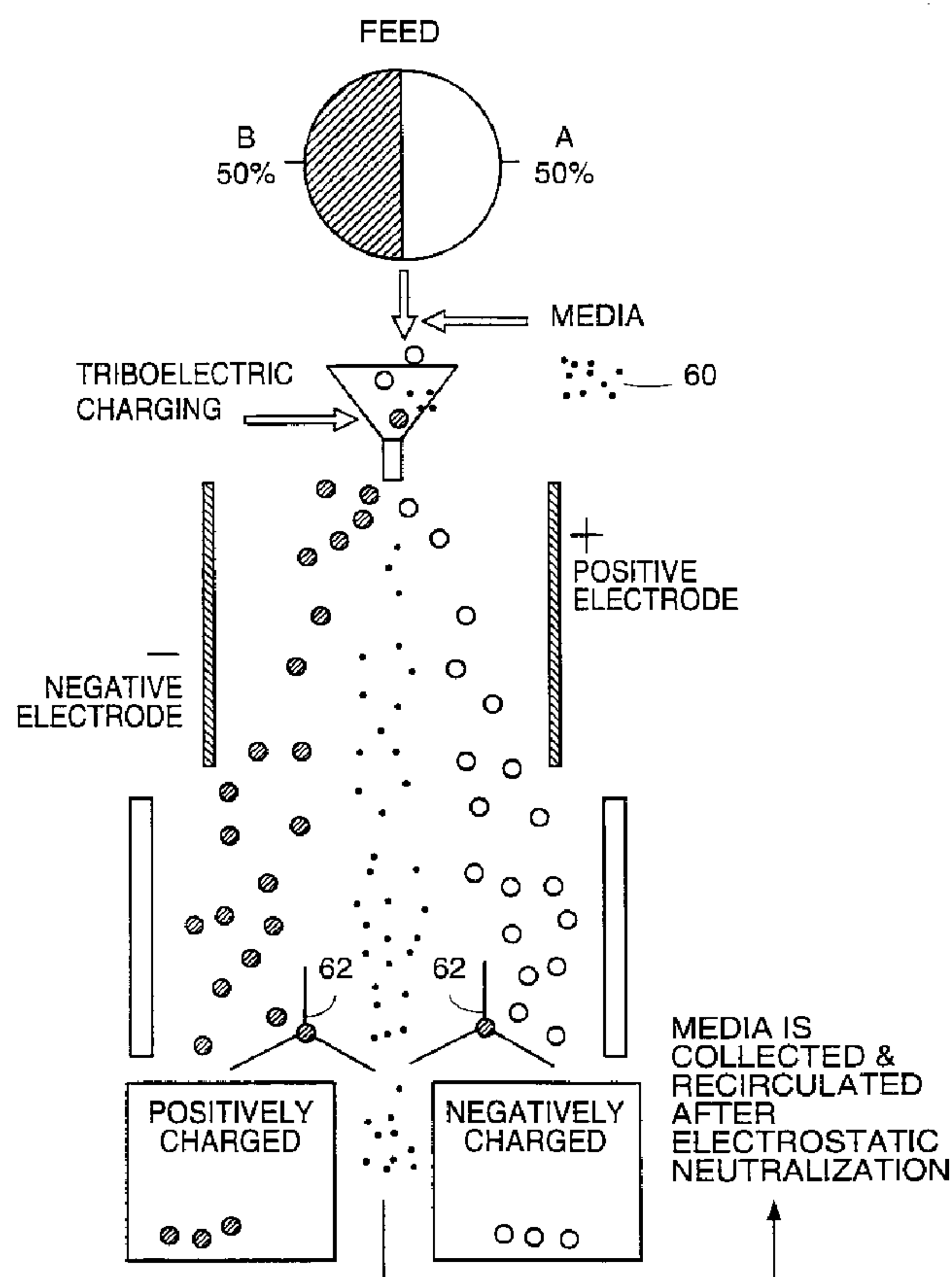
(51) Cl.Int./Int.Cl. *B03C 7/00* (2006.01)

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(54) Titre : SEPARATION ELECTROSTATIQUE AMELIOREE PAR L'AJOUT D'UN MILIEU
(54) Title: ELECTROSTATIC SEPARATION ENHANCED BY MEDIA ADDITION



(57) Abrégé/Abstract:

This invention relates to improving the separation efficiency in a triboelectric separator (44) by adding media (60) against which the components of the mixture will charge. As a result, random charging between the components of the mixture is reduced and controlled, and predictable charging is achieved.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

CORRECTED VERSION

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
21 September 2000 (21.09.2000)

PCT

(10) International Publication Number
WO 00/54885 A1

- (51) International Patent Classification⁷: **B03C 7/00**
- (21) International Application Number: PCT/US00/05872
- (22) International Filing Date: 7 March 2000 (07.03.2000)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/123,926 12 March 1999 (12.03.1999) US
09/469,596 22 December 1999 (22.12.1999) US
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- (81) Designated States (*national*): AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- Published:
— *With international search report.*
- (48) Date of publication of this corrected version:
14 June 2001
- (15) Information about Correction:
see PCT Gazette No. 24/2001 of 14 June 2001, Section II
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: ELECTROSTATIC SEPARATION ENHANCED BY MEDIA ADDITION

(57) Abstract: This invention relates to improving the separation efficiency in a triboelectric separator (44) by adding media (60) against which the components of the mixture will charge. As a result, random charging between the components of the mixture is reduced and controlled, and predictable charging is achieved.

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ELECTROSTATIC SEPARATION ENHANCED BY MEDIA ADDITION

FIELD OF THE INVENTION

5 This invention relates to electrostatic separation and triboelectric charging.

BACKGROUND OF THE INVENTION

The goal of durable goods plastics recycling is to separate the various types of plastic in a waste stream so that the plastics can be reused. This task is daunting because of the complexity of waste feed stocks, which typically have waste products as diverse as electronic goods, automotive parts, and consumer products, such as
10 containers. The variety of plastics include polycarbonate (PC), polypropylene (PP), polystyrene (PS), acetylene-butadiene-styrene (ABS), high-impact polystyrene (HIPS), polyvinyl chloride (PVC), polyamide (PA), high-density polyethylene (HDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), polyurethane (PUR), polyesters, polyphenylene oxide (PPO) and polybutylene terephthalate (PBT)
15 and others. In addition, the products can include various grades of these polymers and the blends of polymers such as PC/ABS, PVC/ABS and others.

One technique that has been suggested for separating plastic waste streams is electrostatic separation. In this technique, the plastic particles in the waste stream are charged and passed through high voltage electric fields where they are differentially
20 deflected based on the polarity of the charge or the magnitude of the charge. One method for charging the materials is triboelectric charging. Triboelectric charging occurs when two dissimilar materials are allowed to rub together and electrons are transferred from one material to another. The direction of electron transfer and the magnitude of the relative voltage can be obtained by rubbing materials together and
25 measuring the electrostatic voltages.

Triboelectrostatic separation has gained some successful applications in separating waste plastics from beverage bottles, PVC from PET, and packaging plastics, PE from PP. The separation efficiency can dramatically decrease when processing mixtures consisting of more than two materials, or when the relative
5 composition of the two components is not constant.

SUMMARY OF THE INVENTION

This invention relates to improving the separation efficiency in a triboelectric separator by adding media against which the components of the mixture will charge. As a result, random charging between the components of the mixture is reduced and
10 controlled, and predictable charging is achieved.

In general, the invention features a method of triboelectric treatment of a polymer mixture that includes charging the mixture with a media. The media may contain a single or multiple components. It is selected in accordance with the electrostatic charging sequence of the components in the mixture, and the expected
15 products from the mixture. The charging sequence is generally described in Chen C. Ku and Raimond Liepins, Electrical Properties of Polymers (1987).

Preferred embodiments may include one or more of the following features. The media component may be composed of a material, e.g., a polymer material, that is substantially the same as a component in the mixture. Alternatively, the media
20 component may be substantially composed of material that is dissimilar from the components of the mixture. The terms "same" and "dissimilar" refer, for example, to chemical composition, grade, etc. The media component may be provided in an amount that is at least about 50% of the mixture by volume or mass, or in an amount that is less than 50% of the mixture by volume or mass. For example, the amount of
25 media component may be at least about 3 times the mass or volume of the mixture. The particle size of the media may be selected such that it is the same as, or substantially different from, the particle size of the components of the mixture. The position on the charging sequence of the media may be the same as, or different from, the components of the mixture.

30 The media may be combined with the mixture to effect charging and then separated from the mixture after charging. Suitable separation processes include dry

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processes (e.g., air classification, screening, and combinations thereof) and wet processes (e.g., gravity concentration, froth floatation, and combinations thereof). Separation may occur either before or after the media has
5 passed through an electric field. The separated media may be recycled, e.g., in a continuous loop.

The mixture may be a two component mixture or a multi-component mixture, e.g., having three or more components. An example of a suitable mixture is a durable
10 products waste stream such as an electrical component waste stream.

According to one aspect of the present invention, there is provided a method for separation of polymeric components, the method comprising providing a mixture
15 including polymeric components; adding to the mixture a particulate media having a selected position within an electrostatic charging sequence, the media having a chemical composition different from the chemical compositions of individual components in the mixture; and triboelectrically
20 charging the mixture with the media.

Embodiments of the invention may also include one or more of the following advantages. The media can completely control the triboelectric charging of the mixture. Any component in the mixture could charge against
25 the media, while charging between components of the mixture is negligible. Therefore, the variation in component percentages would not significantly affect the charging or the separation. In other words, any material, whatever its percentage in the composition, would charge against the
30 media to the same extent. In this way, random charging is minimized, and improved separation is achieved by controlled charging. Highly complex polymer mixtures that do not

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include a primary component that dominates the mixture can be effectively separated. The technique may enable a ternary separation that generates three products simultaneously in one pass, so as to reduce the number of separation steps required to produce multiple products. The technique is adaptable to waste streams in which the component concentrations in the mixture vary over time. The media is generally non-polluting and can be recycled in a continuous stream.

10 Further aspects, features and advantages follow.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an overview of a waste polymer separation plant;

15 Fig. 2 illustrates triboelectric separation of two component mixture without media addition;

Fig. 3 illustrates triboelectric separation of two component mixture with media addition;

Fig. 4 illustrates triboelectric separation of a three component mixture with media addition;

Fig. 5 illustrates the charging sequence of certain plastics;

Fig. 6 is a side view schematic of a triboelectric separation unit including
5 provisions for media recycling;

Fig. 6a is a front view of the apparatus in Fig. 6;

Fig. 7 is a flow chart of plastics separation with media addition;

Fig. 8 is a flow chart of an alternate media addition separation process;

Fig. 9 illustrates the separation results for a mixture containing ABS, HIPS,
10 PC, PP, and PVC without media addition;

Fig. 10 illustrates the separation results for a mixture containing ABS, HIPS, PC, PP, and PVC with the addition of ABS media;

Fig. 11 illustrates the separation results for a mixture containing ABS, HIPS, PC, PP, and PVC with the addition of PC media;

15 Fig. 12 illustrates the separation results for a mixture containing ABS, HIPS, PC, PP, and PVC with the addition of PP media.

DETAILED DESCRIPTION

Referring to Fig. 1, a plastics recycling plant 2 includes bulk waste treatment stage 4, a plastics purifying stage 6, and a pelletizing and formulation stage 8. In the
20 bulk treatment stage 4, bulk durable goods waste 10, which may include, for example, computer components, auto part components, furniture, telecommunications components, and containers, is first subject to a grinding apparatus 12, e.g. a shredder, to reduce the waste to a shredded material feed 14. The shredded material feed is then treated by a magnetic separator 16 to remove ferrous metals. The resulting feed is
25 then ground by a granulator 18, and separated by a screen 20, which is followed by air classifiers 22 that produce a mixed plastic feed with a particle size in the range of about 0.01 to 0.5 inch suitable for treatment in the plastic purification stage 6.

The goal of the plastic purification stage is to separate the feed stock mixture into substantially pure plastic components or predetermined plastic mixtures. The purification stage includes a series of gravity concentrators 24-30 which provide a rough separation based on material density. An example of a suitable separator is a hydrocyclone.

The output of these separators is then fed to a series of first stage electrostatic separators 32-36, which provide separation of some components, while leaving others in mixture form. These mixtures may then be treated in further stage separators 38-42. The resulting separated components are then individually blended, for uniformity, and pelletized in stage 8.

Referring to Fig. 2, the general operation of a triboelectric separator in the separation of a two component mixture is illustrated. The separator 44 includes a charging region 46, in which polymer flakes are contacted with each other to induce electron transfer. The flakes are then distributed into an electrostatic separation region 48 which includes positive and negative electrodes 50, 52. As the flakes fall by gravity through the separation region, the positively charged flakes deflect toward the negative electrode and the negatively charged flakes deflect toward the positive electrode. At the end of the separation region, a baffle 54 is arranged to deflect the original particle stream into different collection containers 56, 58. The baffle is sized and positioned to separate the polymers based on the predicted charge differential characteristics. The separation is binary in nature in that it splits a single stream into two component streams.

Because the charging step relies on random contact between the particles, the magnitude of the charge transfer among particles varies and there is a possibility that substantial numbers of particles will not charge or will neutralize. These phenomena can result in an inefficient separation. For example, neutralized flakes may be distributed in either bin. This problem becomes more acute as the composition of the waste feed stock changes over time since the separator operating parameters optimized for a given mixture may not produce an effective separation for a different mixture. Moreover, the charging possibilities become significantly more complex with mixtures having more than two components.

Referring to Fig. 3, the predictability and efficiency of the separation is enhanced by the addition of a triboelectric media that has a known charging sequence position. The media 60 is used to charge both components of the mixture. As a result, the two components are effectively separated. The majority of the media, in
5 this example, remains neutral. A baffle system 62 includes two baffles which separate the positively and negatively charged particles into separate bins. In addition, the media can be collected, and then be recirculated.

Referring to Fig. 4, the separation of a three component mixture is illustrated. For the case of a three component mixture without media addition, the resultant
10 charging of each plastic would be dictated by contact directly preceding entry into the electric field. If, for example, plastic A, B, and C (supplied in equal amounts) were mixed together and had a charging sequence, A, C, and B from more negatively charged to more positively charged, material C could either be positive if it contacted A, or negative if it contacted B, prior to entry into the electric field. In a media
15 addition separation, this can be avoided. For example, if media were added with a charging property equal to C, which dominated the particle-particle contacts, it would ensure that A and B attained a charging potential relative only to C. This would promote a ternary separation.

Referring to Fig. 5, a triboelectric series for polymers common to waste
20 streams is illustrated. For a mixture including these components, and a media with a position in the charging sequence between HIPS and ABS, plastics with a charging sequence position lower than the position of the media would provide electrons to the media. The media would transfer electrons to plastics with a charging sequence position higher than the media. If the media dominated the other plastics on a surface
25 area basis, the media would experience an insignificant change in electrostatic voltage, whereas the other materials would attain high voltages. Electrostatic separation of the materials with a charging sequence position lower than the media from the plastics with a charging sequence position higher than the media would thus be possible. If a three component feed were used, the media could be selected to have
30 the very same charging property as the intermediate component. In this case, the media would be neutral with respect to the other components, providing a ternary separation and a total of three products.

In some cases, it may be possible to select a polymer as the media which is similar or identical to one of the components in the mixture to be separated. For example, if the objective was to recover PA and PC from the other components in the table, PA media should be added in quantities sufficient to enable PC to report to the negative electrode, the PA would fall to the center since it would be neutral, and the PVC, PET, PP, HDPE, HIPS and ABS would report to the positive electrode. The remaining components could again be separated by using HDPE media and PET media respectively. Hence, an eight component mixture would be separated in only four separators.

While the media may be used to effect subtle changes in the charging characteristics, typically, the media controls the charging by charge domination. In this case, the amount of media is typically provided at least 50% by mass of the waste mixture, more typically 3 to 5 times the mass of the waste mixture, so that all components of the mixture charge against the media. Typically, the large mass of the media provides the greatest charging surface area. Thus surface area can also be controlled by altering particle size. Particles coarser than the largest particle of the mixture to be separated can also be used. For example, the media is preferably sized about 3/8 inch and the waste stream flake size is about 5/16 inch.

Since, in terms of nonconductors, charging is a function of surface area rather than mass, a smaller quantity of media would generally be required to retain the same amount of charge if the media had a smaller particle size. Smaller particles have a higher surface to mass ratio at a given geometry.

Referring to Figs. 6 and 6A, a continuously operating mediated triboelectric separation unit 70 includes an inlet 72 which receives a polymer flake mixture to be separated. The feed is optionally treated in a pretreatment unit 74 which may be a drying unit such as a heated conveyor.

After pretreatment, the flakes are deposited into a hopper 76 which also includes the media. A conveyor 78 takes the media and the flakes to a charging/conveyor device 80, such as a variable speed mixer auger with cut and folded flight (available from SCC Industries of Visalia, CA). The flakes and media are thoroughly contacted in the auger so that charge differentials are generated based

on triboelectric charging. The speed of the auger can be controlled to vary the residence time and degree of mixing.

The charged mixture is then provided to a screener spreader 82, e.g. a trommel. The trommel removes the media by size differentiation. Typically, the media is sized larger than a 3/8 inch through hole screen aperture. The trommel also spreads the flakes across the opening of a separation stage 84. Finally, the trommel enhances charging efficiency as the flakes interact with the media just prior to introduction to the separation unit.

Referring to Figure 6A, the separation unit includes electrodes 86 and baffles 88 to produce a ternary separation. The unit is about 15 feet high, by 9 feet long by about 7 feet wide. The electrodes operate at about 50KV or more, e.g. 100-125KV. Conveyors 90 collect the products. These conveyors may be, for example, screw augers, which may turn in one direction to discharge all three products, or alternatively the center conveyor may turn in an opposite direction to recirculate middlings. The middle product may represent incompletely separated flakes in a one or two component feed, and can be recycled by deposition in the hopper. In mixtures of three or more components, the middle product is typically separated in a further stage. The recycled middle fraction and the media are optionally neutralized by an electrostatic neutralizer (e.g., an Aerostat Phoenix extended range ionizing air blower available from SIMCO) and recirculated.

Referring to Fig. 7, a flow diagram illustrates operation of the apparatus shown in Figs 6 and 6a. As shown in Fig. 7, the media may be recirculated to either a pretreatment stage or to a stage between pretreatment and neutralization. The middle fraction can also be processed in further stages or re-circulated to a pretreatment stage or to a stage between pretreatment and neutralization.

Referring to Fig. 8, in an alternate operational embodiment the media may be separated after passing through the separation stage. Separation of the media from products afterwards might reduce the throughput of the separator. On the other hand, it also might be helpful for target materials to retain charges in separation fields. In addition, it may simplify the systems setup.

Referring to Fig. 7 and Fig. 8, the middling may be optionally recirculated. Such recirculation could meaningfully increase the product purity with a reduction of separator's throughput. Moreover, the middling may be recirculated with the separation media as shown in Fig. 7. In this case, the media to middling mass ratio
5 should be adjusted to retain the effect of separation media and to perform a controlled separation.

The invention will now be described further by way of the following examples.

EXAMPLES

10 **Example 1**

This example describes separating PMMA from a mixture of PMMA, ABS, and HIPS with the aid of ABS media.

A mixture having equal parts PMMA, ABS, and Flame Retardant HIPS ("FR HIPS") was prepared. The size of the particles in the mixture ranged from 1.59 mm to
15 4.06 mm. Varying amounts of ABS identical to the ABS in the mixture and having a particle size ranging from 5.08 mm to 9.53 mm was used as the separation media. The separation was conducted using an electric field strength of 400 kV/m and humidity of 35%±2%. The mixture was charged up with the ABS media for about 2.5 minutes. The mixture was then distributed using a spreader to allow the mixture to
20 pass through the electric field evenly along the electrode.

The charging sequence of the individual components of the mixture was determined in a separate experiment by rubbing the materials on one another and then measuring their electrostatic voltage and polarity immediately after the rubbing. The results demonstrated that FR HIPS was the most negatively charged and thus would
25 be expected to report towards the positive electrode. Conversely, PMMA was the most positively charged and thus would be expected to report towards the negative electrode. The ABS in the mixture would be expected to report towards either electrode.

The results of the separation performed using the PMMA, ABS, and FR HIPS
30 mixture, set forth in Table 1, confirmed this observation and demonstrated the utility

of including ABS separation media. As shown in Table 1, in the absence of ABS media, PMMA purity at the negative electrode side was only 49.01%, with the remainder being ABS. However, when ABS media in an amount equal to 100% of the mixture mass was combined with and charged with the mixture, 85.41% PMMA
 5 purity at the negative electrode was obtained in one pass, with the remainder of the mixture being driven towards the positive electrode. Even greater purity (98.15%) was obtained when ABS media was added in an amount equal to 200% of the mixture mass.

TABLE 1

Media Amount (% of total mixture mass)	PMMA Purity
0	49.01%
100	85.41%
200	98.15%

10

Example 2

This example describes separating PVC from a mixture of ABS, PC, and PVC with the aid of HIPS media.

A mixture having equal parts ABS, PC, and PVC was prepared. The size of
 15 the particles in the mixture ranged from 2.36 mm to 4.75 mm. An amount of HIPS equal to 400% of the mixture mass and having a particle size ranging from 8 mm to 12.7 mm was used as the separation media. The separation was conducted using an electric field strength of 506 kV/m and humidity of 35%±2%. The mixture was charged up with HIPS media for about 10 minutes and then passed through the
 20 electric field. Products were collected in a chamber under the electric field and between the two electrodes. The chamber was split into 10 equally sized compartments. From the negative electrode to the positive electrode, the compartments were numbered from 1 to 10. Product from each compartment was collected, weighed, and identified.

25 The results of the separation are set forth in Table 2. For the sake of convenience, the material from compartments 8 to 10 was combined. As shown in Table 2, after adding HIPS media, the PVC purity in the last three compartments

increased from 95.81% to 99.74%, and the recovery increased from 87.45% to 96.29%.

TABLE 2

Separation Results	Without Media	With HIPS Media
PVC purity, %	95.81	99.74
PVC recovery, %	87.45	96.29

5 **Example 3**

The procedure of Example 2 was repeated except the mixture consisted of HIPS, PC, and PVC, and the separation media was ABS. The results are shown in Table 3. They demonstrate that using ABS as a separation media significantly increases the purity of the recovered PVC with only a slight decrease in PVC
10 recovery.

TABLE 3

Separation Results	Without Media	With ABS Media
PVC purity, %	48.99	91.32
PVC recovery, %	95.48	93.76

Example 4

The procedure of Example 2 was repeated except the mixture consisted of
15 ABS, HIPS, and PVC, and the separation media was PC. The results are shown in Table 4. They demonstrate that using PC as a separation media significantly increases the purity of the recovered PVC with a slight increase in PVC recovery.

TABLE 4

Separation Results	Without Media	With PC Media
PVC purity, %	48.61	99.76
PVC recovery, %	92.25	92.53

20

Example 5

The procedure of Example 2 was repeated except the mixture consisted of 45% HIPS, 45% PC, and 10% PVC, and the separation media was HIPS. The contents of the middle split (compartments 4-7) were analyzed. The results are shown in Table 5. They demonstrate that using HIPS as a separation media significantly increases the amount of HIPS recovered in the middle compartments (4-7) with a moderate decrease in HIPS purity.

TABLE 5

Separation Results	Without Media	With HIPS Media
HIPS purity, %	95.28	88.61
HIPS recovery, %	39.57	88.75

Example 6

The procedure of Example 5 was followed except that the mixture consisted of 45% ABS, 45% HIPS, and 10% PVC. In addition, the % recovery and % purity were determined for each component of the mixture. ABS was recovered in compartments 1-3 nearest the negative electrode, HIPS was recovered in compartments 4-7, and PVC was recovered in compartments 8-10 nearest the positive electrode. The results are shown in Table 6. The results demonstrate that by using HIPS media, overall purity increased for each component of the mixture. In addition, with the exception of ABS recovery, the amount of recovered material increased.

TABLE 6

Separation Results	Without Media	With HIPS Media
ABS purity, %	60.12	94.47
ABS recovery, %	88.80	78.57
HIPS purity, %	71.43	81.48
HIPS recovery, %	44.78	94.70
PVC purity, %	97.25	97.89
PVC recovery, %	89.88	94.90

Example 7

The procedure of Example 2 was followed except that the mixture consisted of equal amounts of ABS, HIPS, PC, PP, and PVC. The particle size of the mixture ranged from 2.36 mm to 4.75 mm. Initially, separation was performed without the
5 addition of media. The results are shown in Fig. 9. Three additional separations were then performed, each using a different media. The amount of media in each case was equal to 400% of the mass of the mixture. The particle size of the media in each case ranged from 8 mm to 12.7 mm.

Fig. 10 illustrates the results of a separation performed using ABS media.
10 Comparison of Figs. 9 and 10 reveals that unlike the separation performed without media, in the separation employing ABS media, HIPS fully reported toward the positive electrode, while only ABS and PC reported toward the negative electrode. Accordingly, inclusion of ABS media significantly simplifies second stage separation when ABS and PC are the desirable products.

15 Fig. 11 illustrates the results of a separation performed using PC media. Comparison of Figs. 9 and 11 reveals that unlike the separation performed without media, in the separation employing PC media, HIPS was driven toward the positive electrode, whereas ABS and PC reported toward the negative electrode. These results demonstrate that if PC is not the major component in the mixture, ABS near the
20 negative electrode can be collected as a final product after one pass.

Fig. 12 illustrates the results of a separation performed using PP media. Comparison of Figs. 9 and 12 reveals that unlike the separation performed without media, in the separation employing PP media, PP tends to drop into the middle compartment, while PVC of 99% or greater purity is produced in the compartment
25 near the positive electrode. Thus, the final PVC product may be obtained after only one pass. Fig. 12 also demonstrates that PP tends to concentrate in the middle compartments (nos. 5 and 6). Accordingly, it is possible to perform a ternary separation.

Further embodiments are in the following claims.

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CLAIMS:

1. A method for separation of polymeric components,
the method comprising

providing a mixture including polymeric
5 components;

adding to the mixture a particulate media having a
selected position within an electrostatic charging sequence,
the media having a chemical composition different from the
chemical compositions of individual components in the
10 mixture; and

triboelectrically charging the mixture with the
media.

2. The method of claim 1 wherein the media is
provided in an amount of at least about 50% of the mixture
15 by volume or mass.

3. The method of claim 1 wherein the media is
provided in an amount less than 50% of the mixture by volume
or mass.

4. The method of claim 1 wherein the media is
20 provided in an amount of at least about 3 times the volume
or mass of the mixture.

5. The method of any one of claims 1 to 4 wherein the
media has a particle size substantially different from the
particle size of the mixture.

25 6. The method of any one of claims 1 to 5 comprising
separating the media from the mixture after charging.

7. The method of claim 6 comprising recycling the
separated media.

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8. The method of claim 7 comprising recycling the separated media in a continuous feed loop.

9. The method of any one of claims 1 to 8 wherein the media is substantially a dissimilar material from the
5 components of the mixture.

10. The method of any one of claims 1 to 9 wherein the mixture is a two component mixture.

11. The method of any one of claims 1 to 9 wherein the mixture has three or more components.

10 12. The method of any one of claims 1 to 9 wherein the mixture is a durable products waste stream.

13. The method of any one of claims 1 to 12 wherein the position of the media in the charging sequence is different from the position of the components of the mixture
15 in the charging sequence.

14. The method of any one of claims 1 to 4 wherein the particle size of the media is the same as the particle size of the mixture.

15. The method of claim 6 wherein the media is
20 separated from the mixture using a dry process.

16. The method of claim 15 wherein said dry process comprises at least one of air classification and screening.

17. The method of claim 16 wherein separation of the media from mixture is by screening.

25 18. The method of claim 6 wherein the media is separated from the mixture using a wet process.

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19. The method of claim 18 wherein said wet process comprises at least one of gravity concentration and froth floatation.

20. The method of claim 6 wherein the media is
5 separated from the mixture before passing through an electric field.

21. The method of claim 6 wherein the media is separated from the mixture after passing through an electric field.

10 22. The method of any one of claims 1 to 21 wherein the media has a charge that is adjusted such that it is positive with respect to a ground state prior to being added to the mixture.

23. The method of any one of claims 1 to 21 wherein
15 the media has a charge that is adjusted such that it is negative with respect to a ground state prior to being added to the mixture.

24. The method of any one of claims 1 to 21 wherein the media is at ground state prior to being added to the
20 mixture.

25. The method of any one of claims 1 to 9, further comprising electrostatically separating the mixture into three components.

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PATENT AGENTS

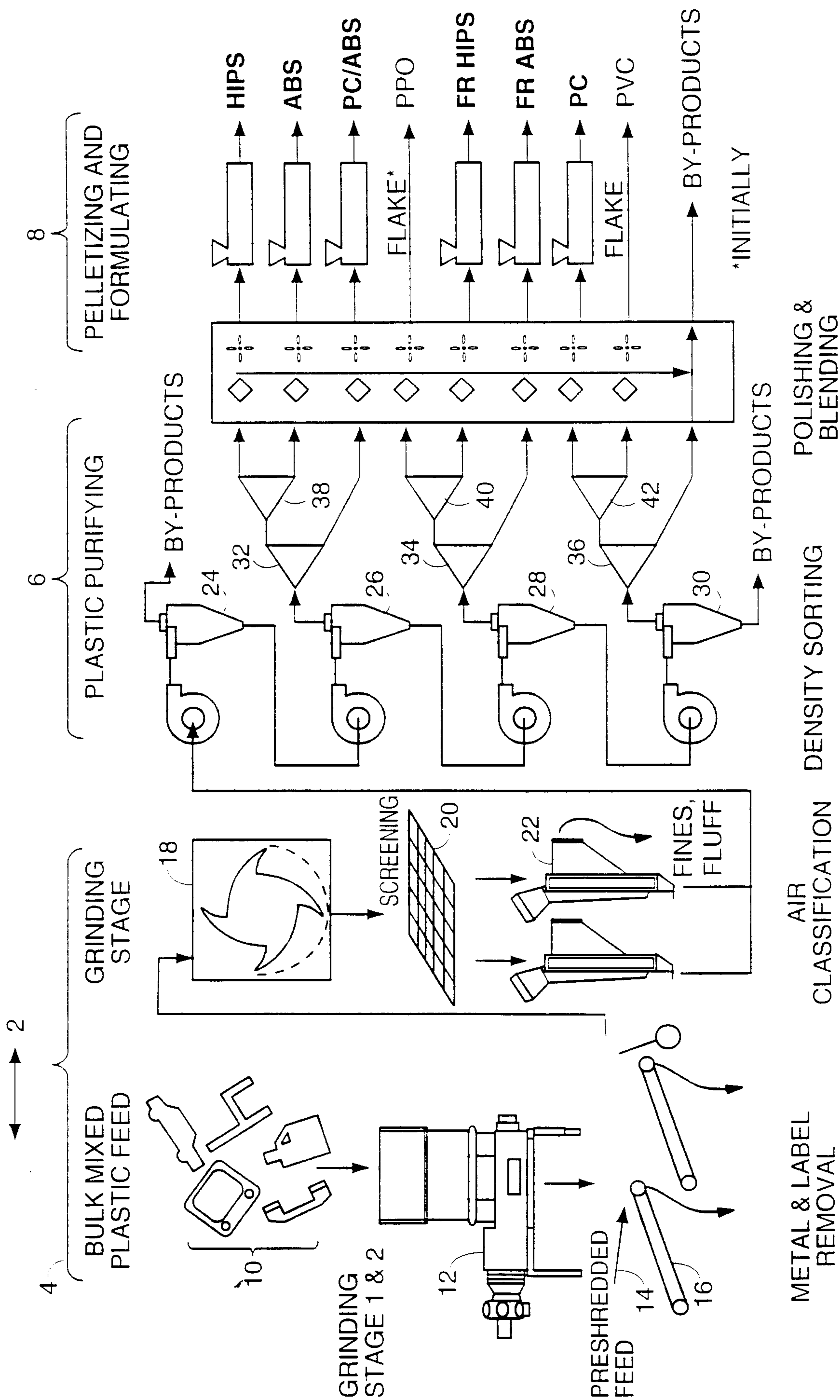


FIG. 1

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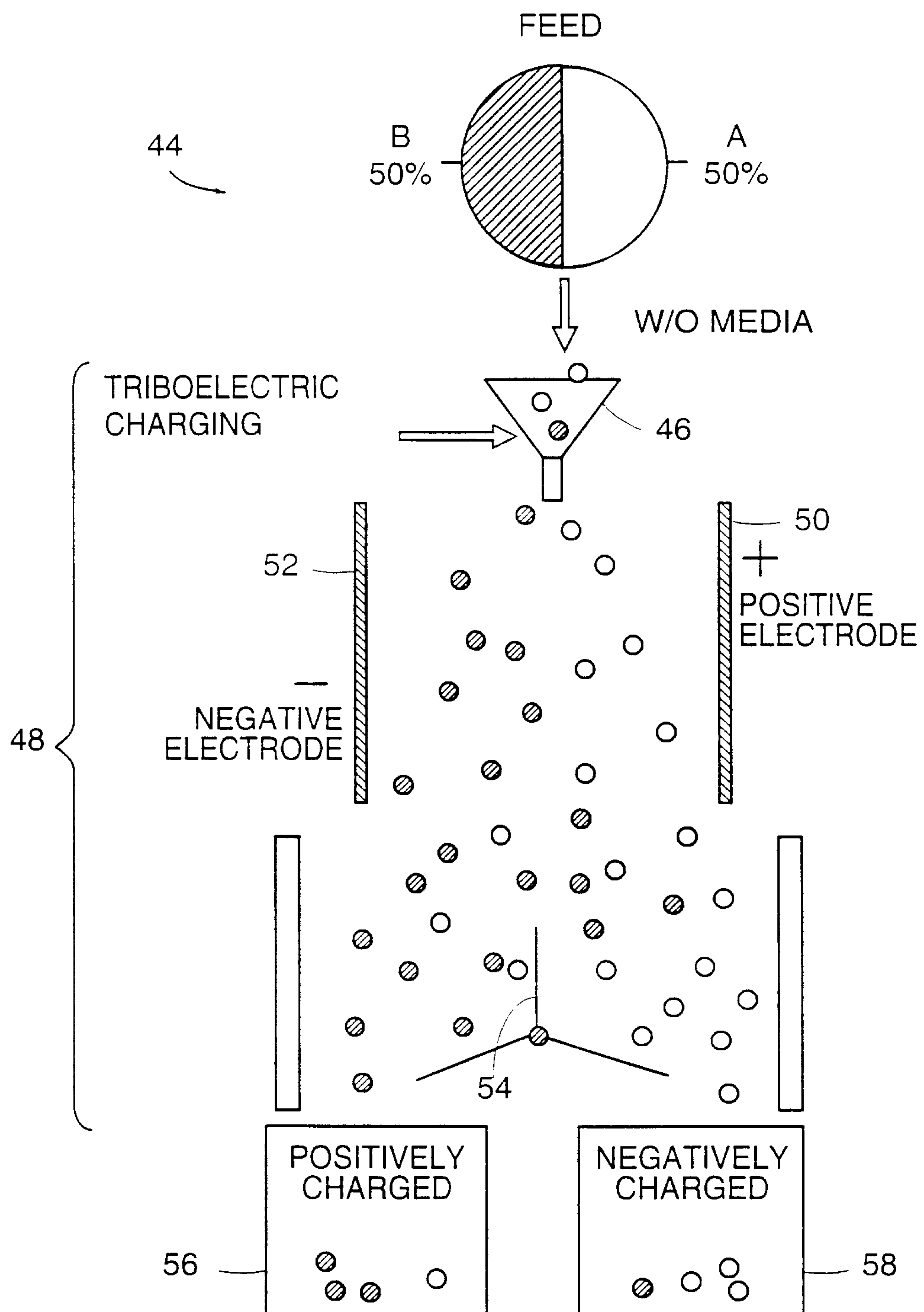


FIG. 2

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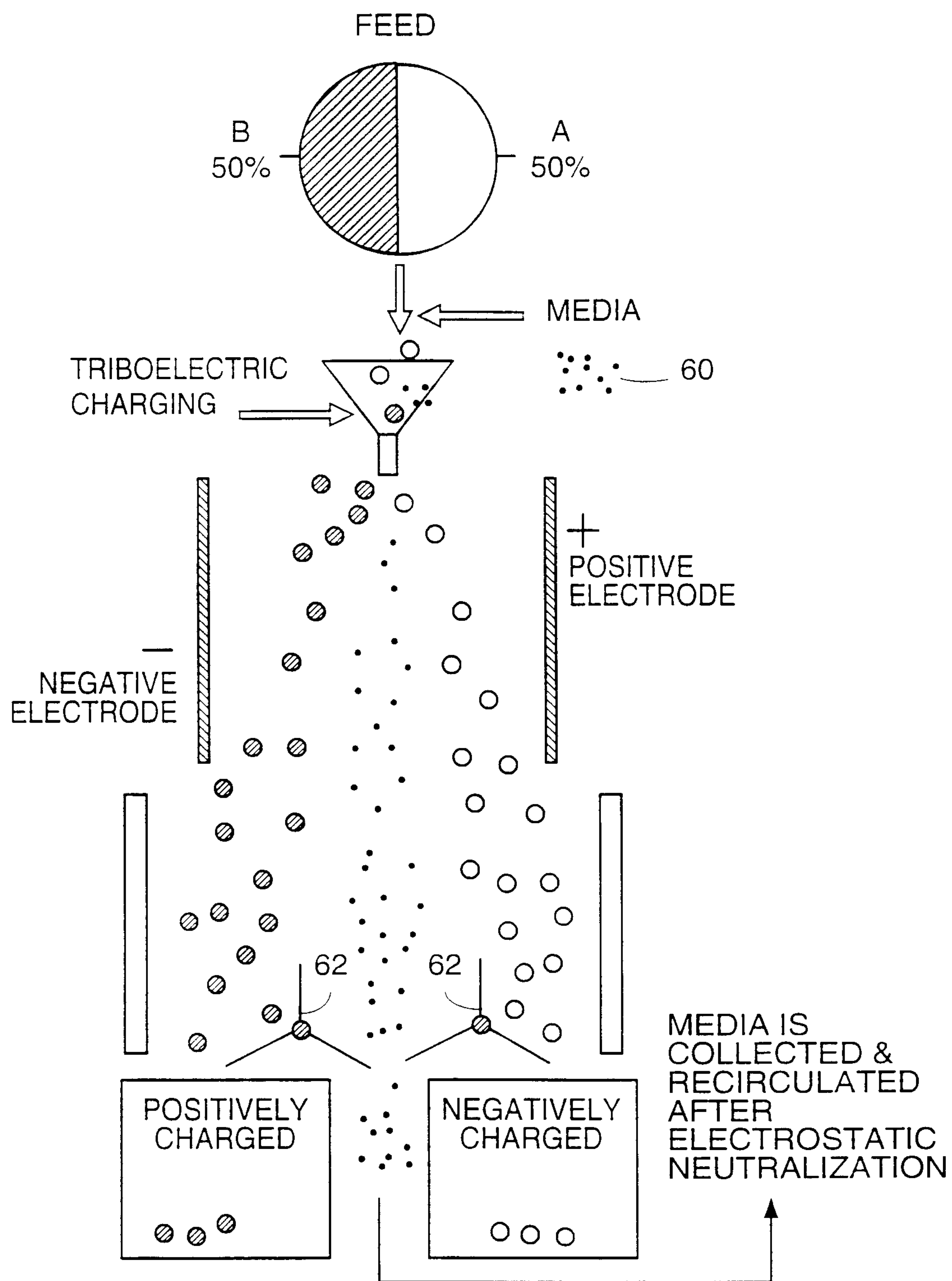


FIG. 3

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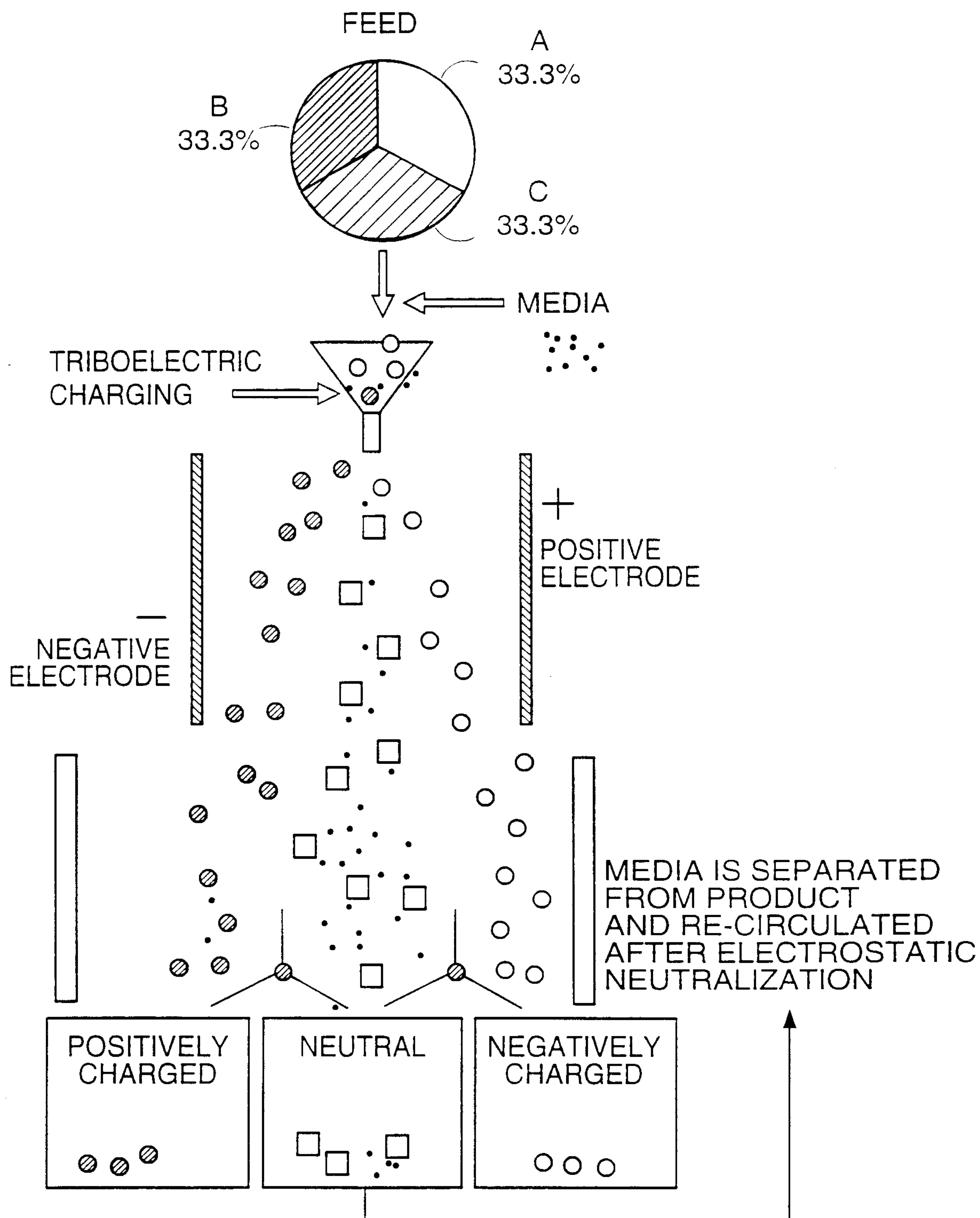


FIG. 4

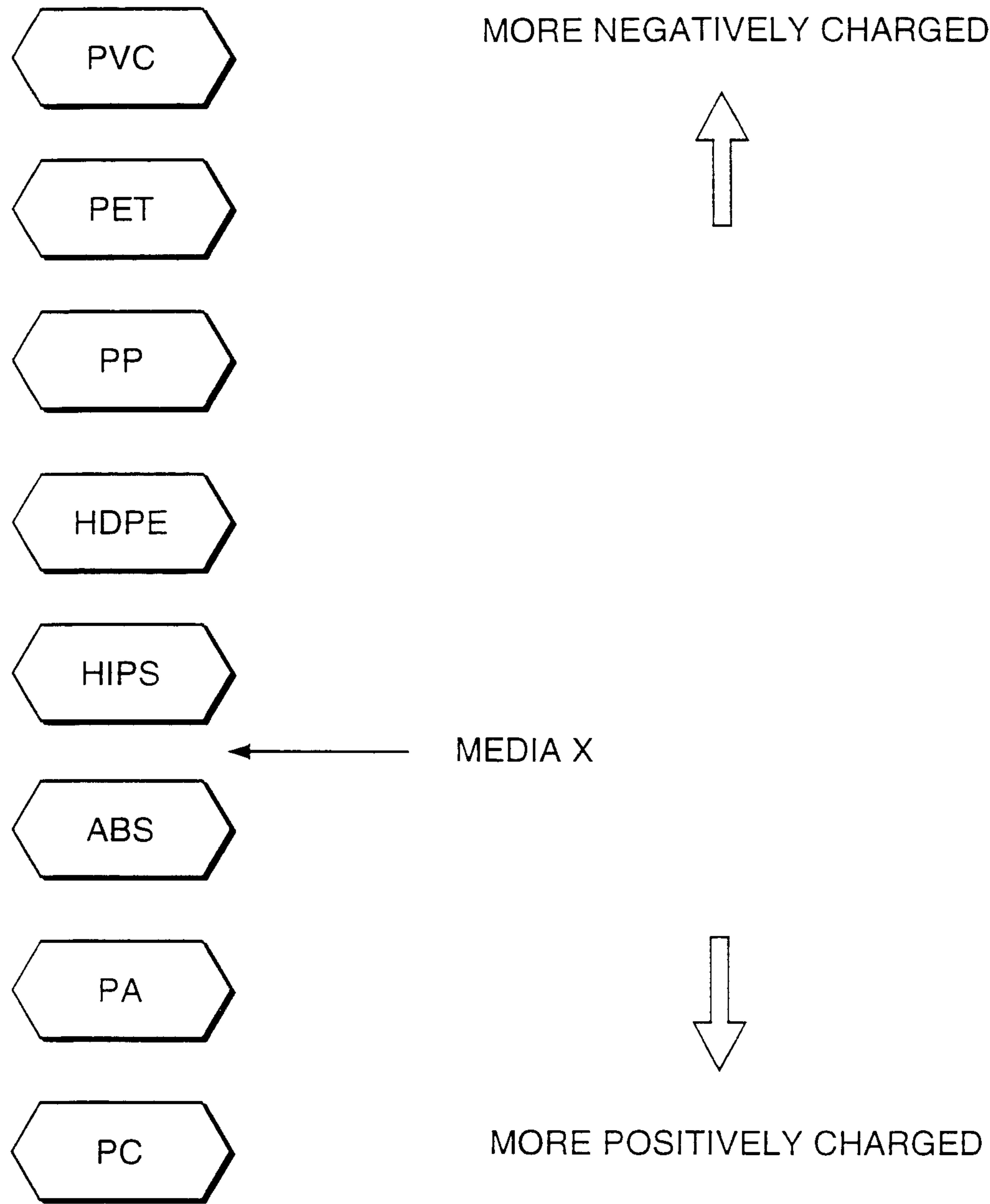


FIG. 5

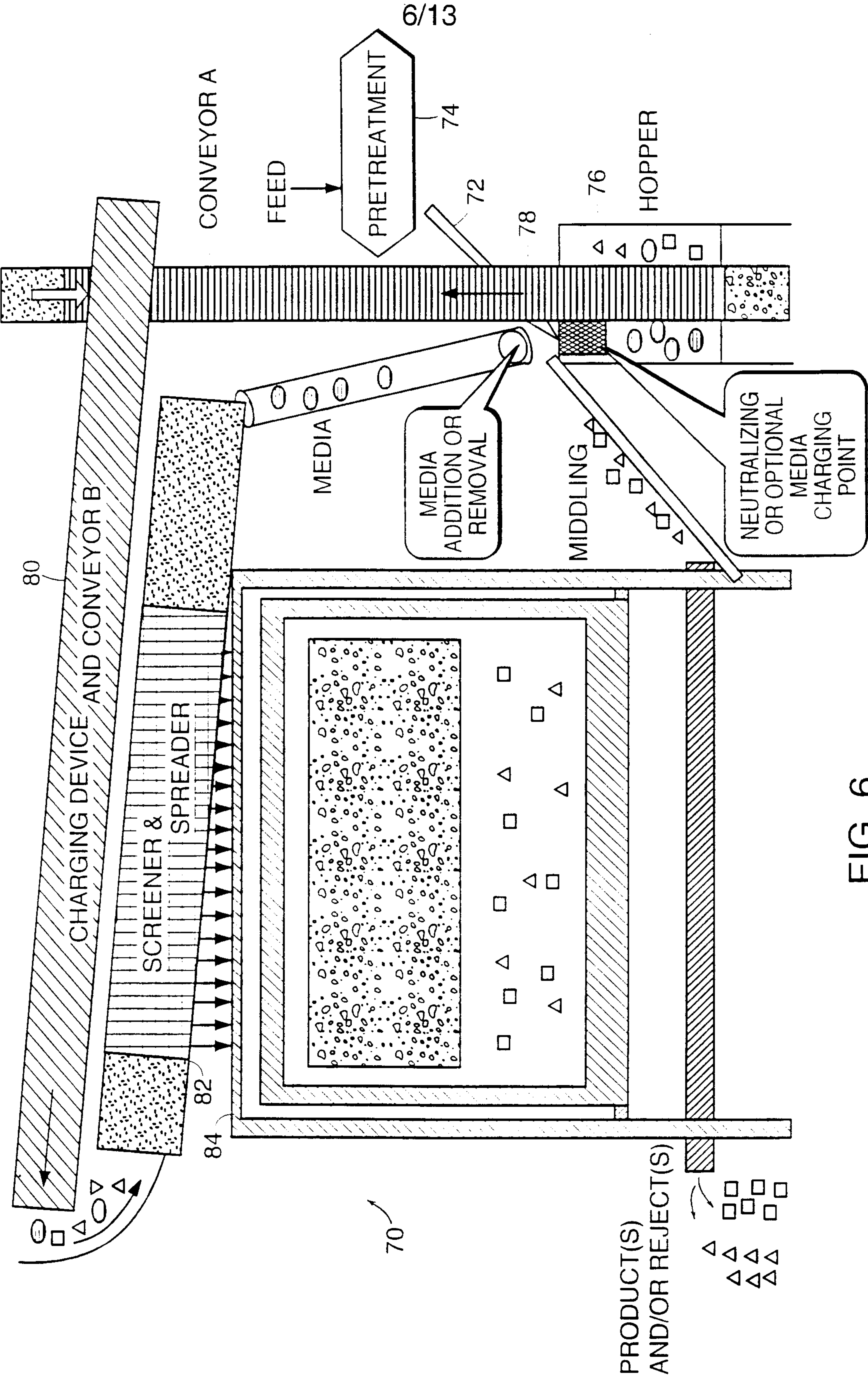


FIG. 6

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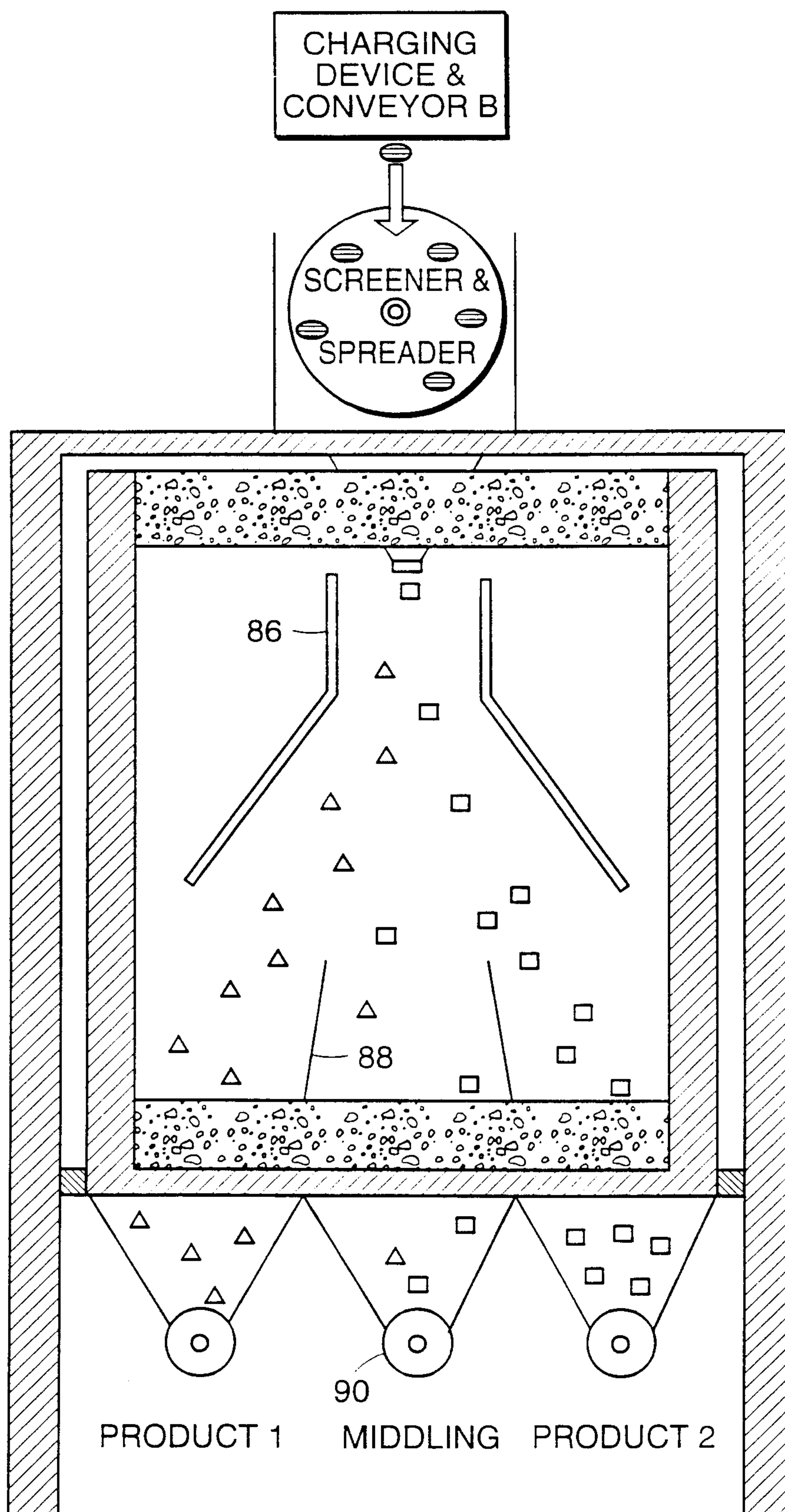


FIG. 6A

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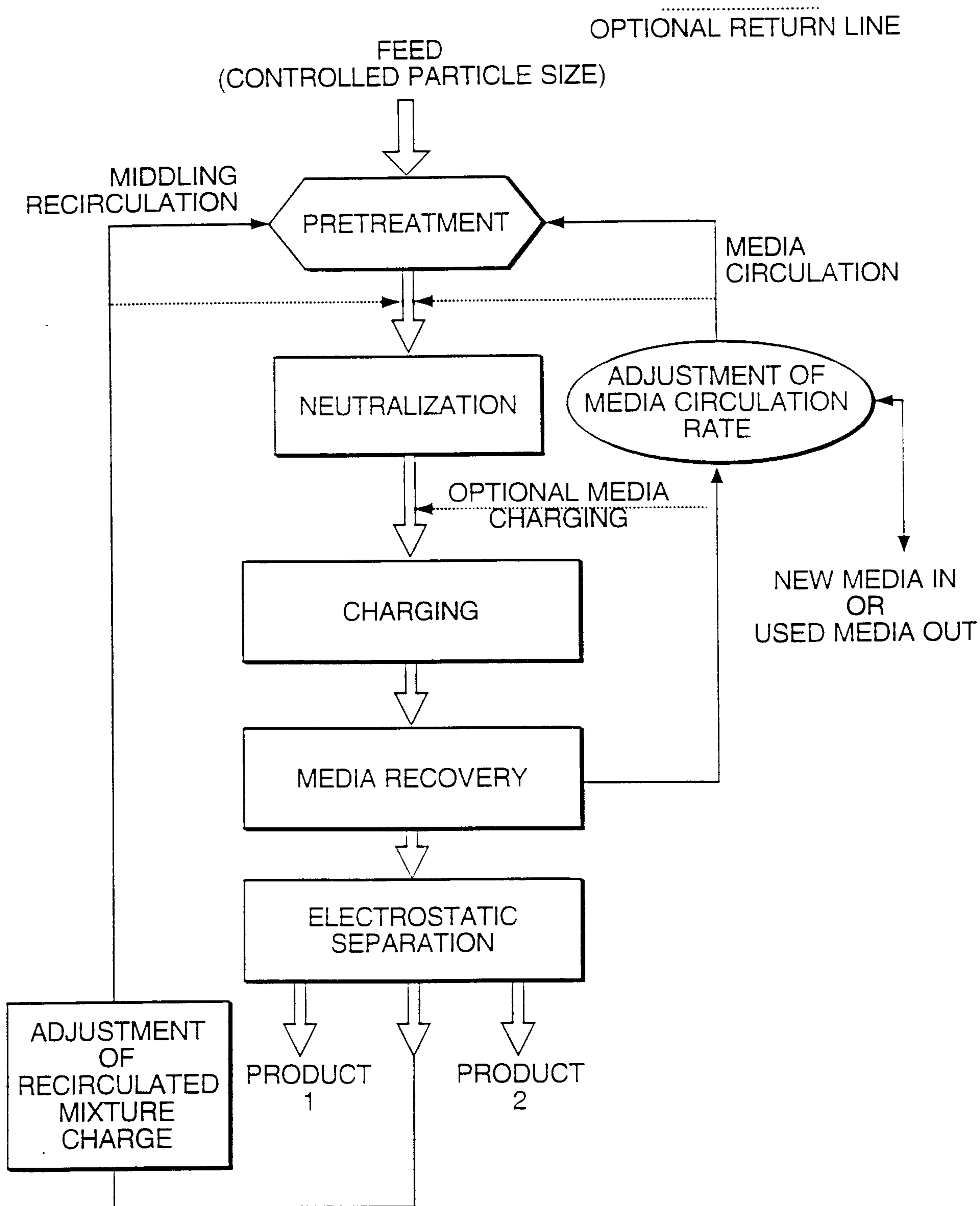


FIG. 7

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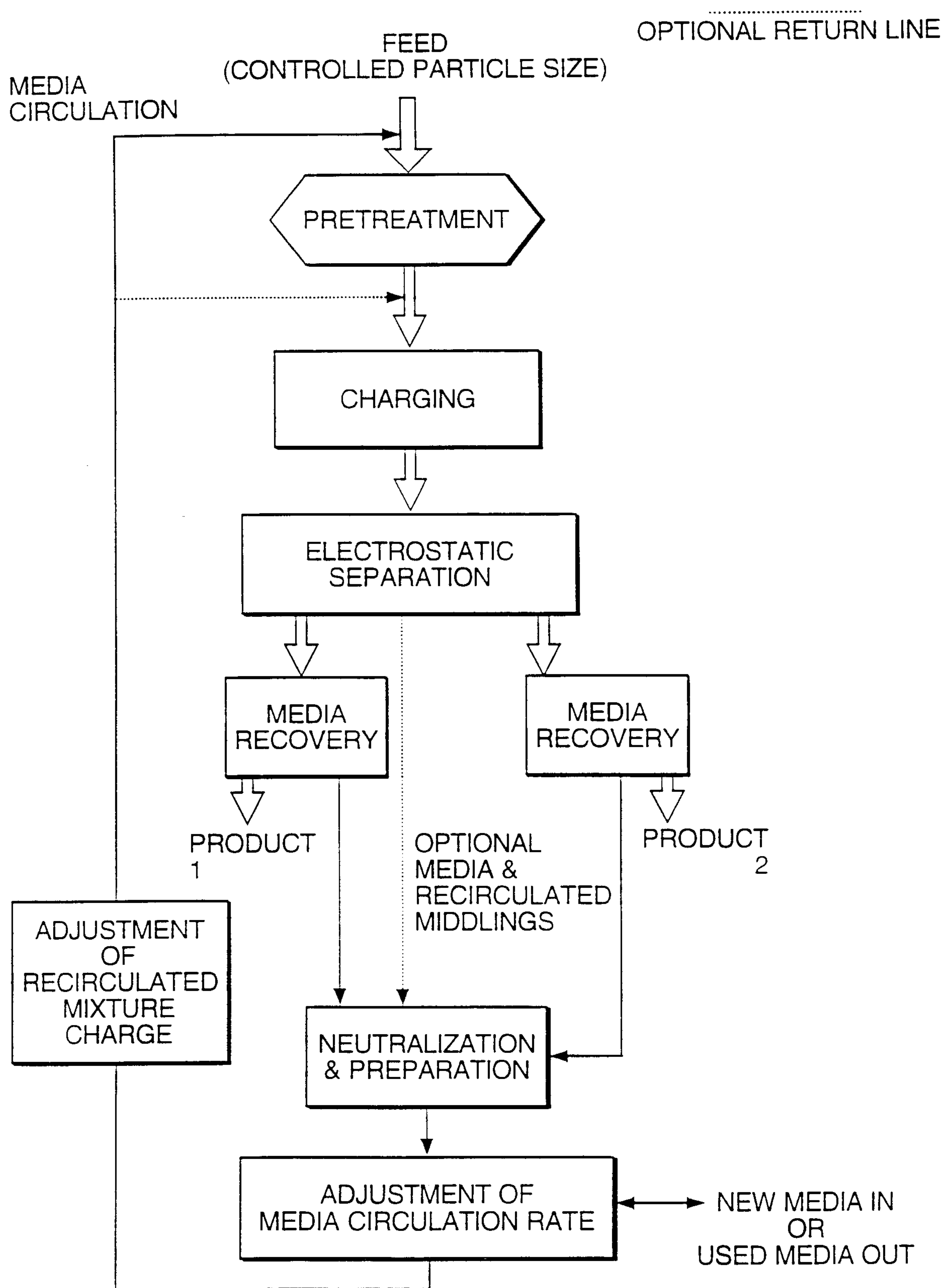


FIG. 8

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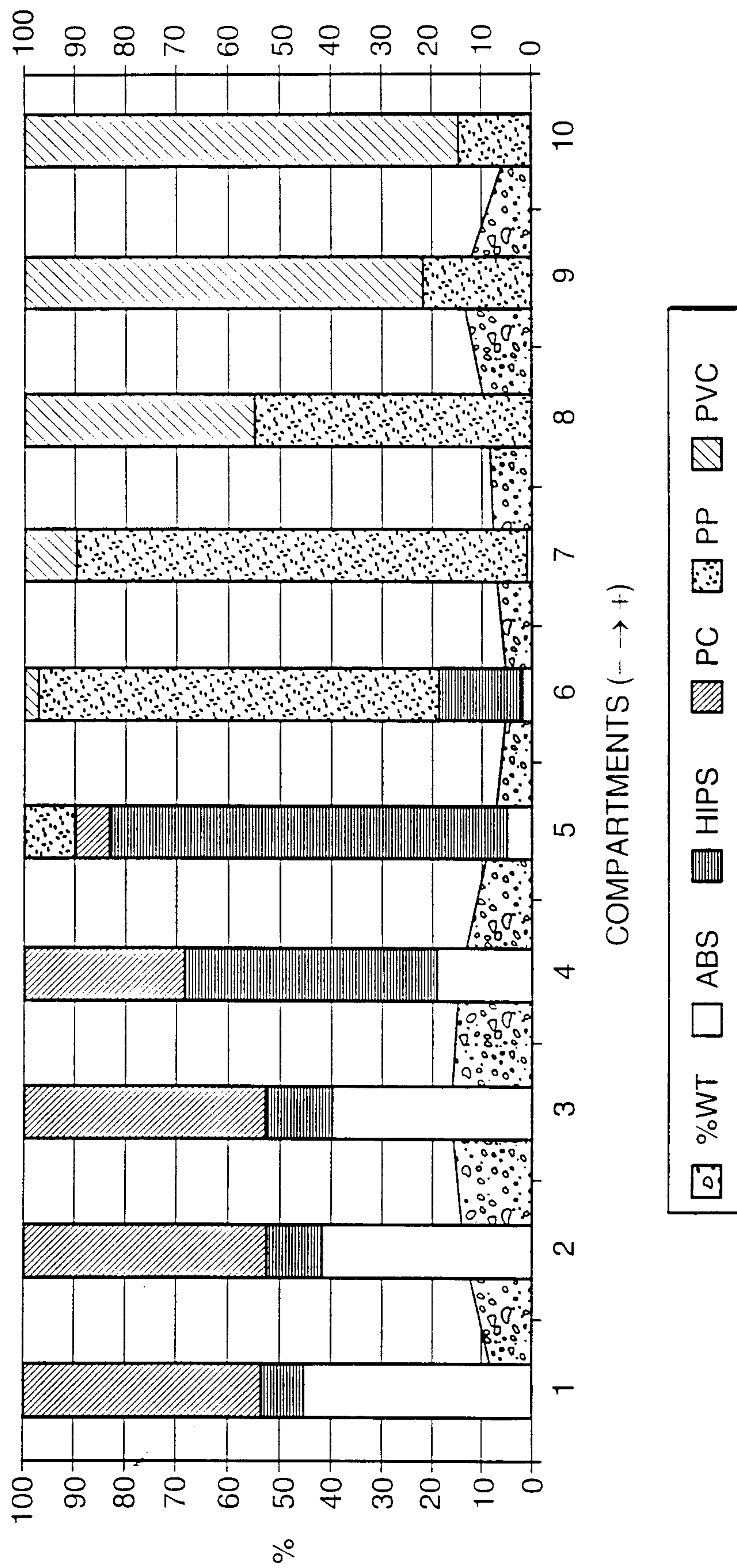


FIG. 9

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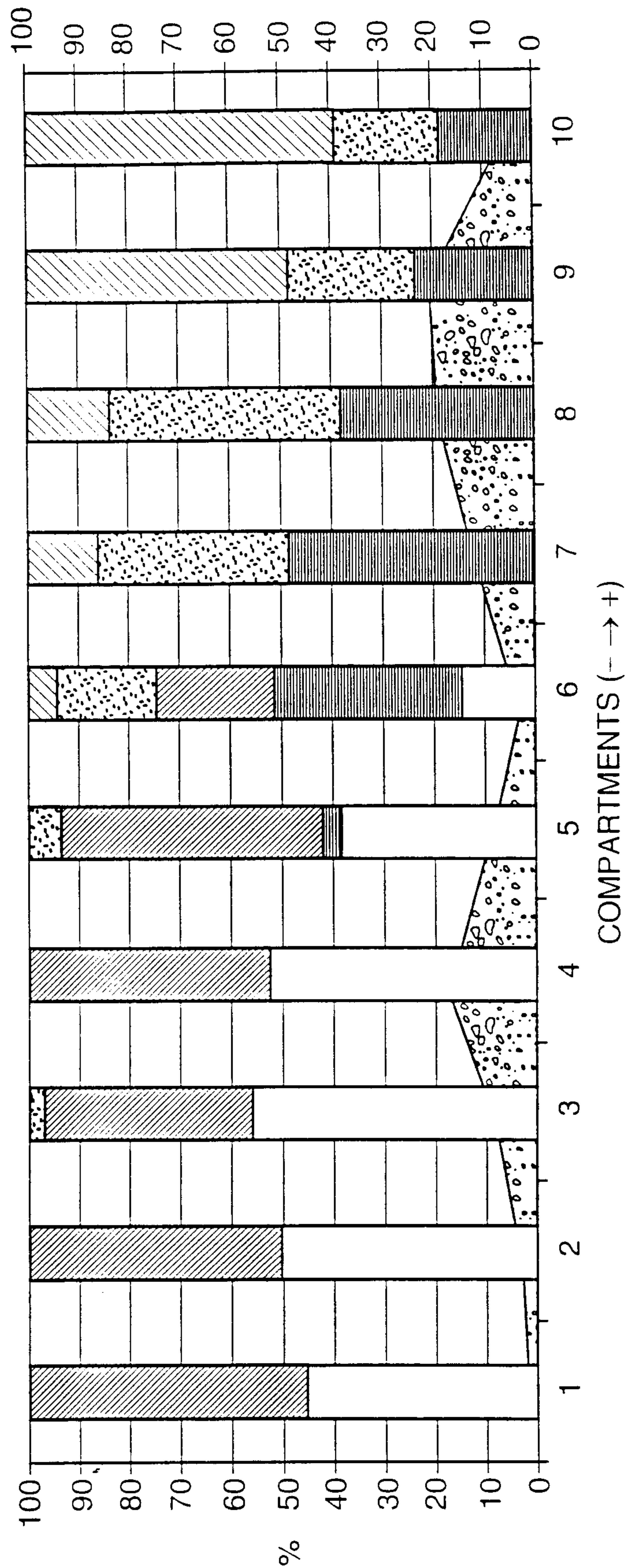


FIG. 10

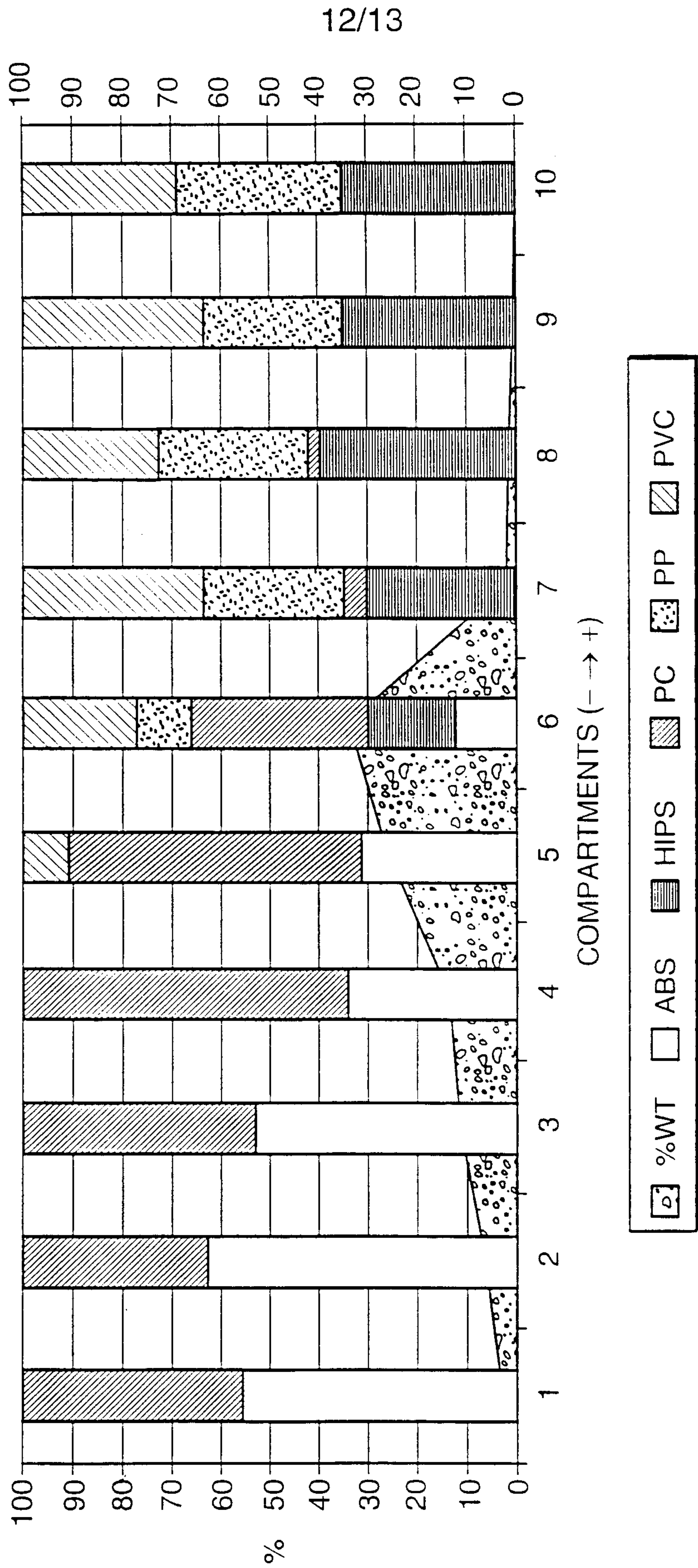


FIG. 11

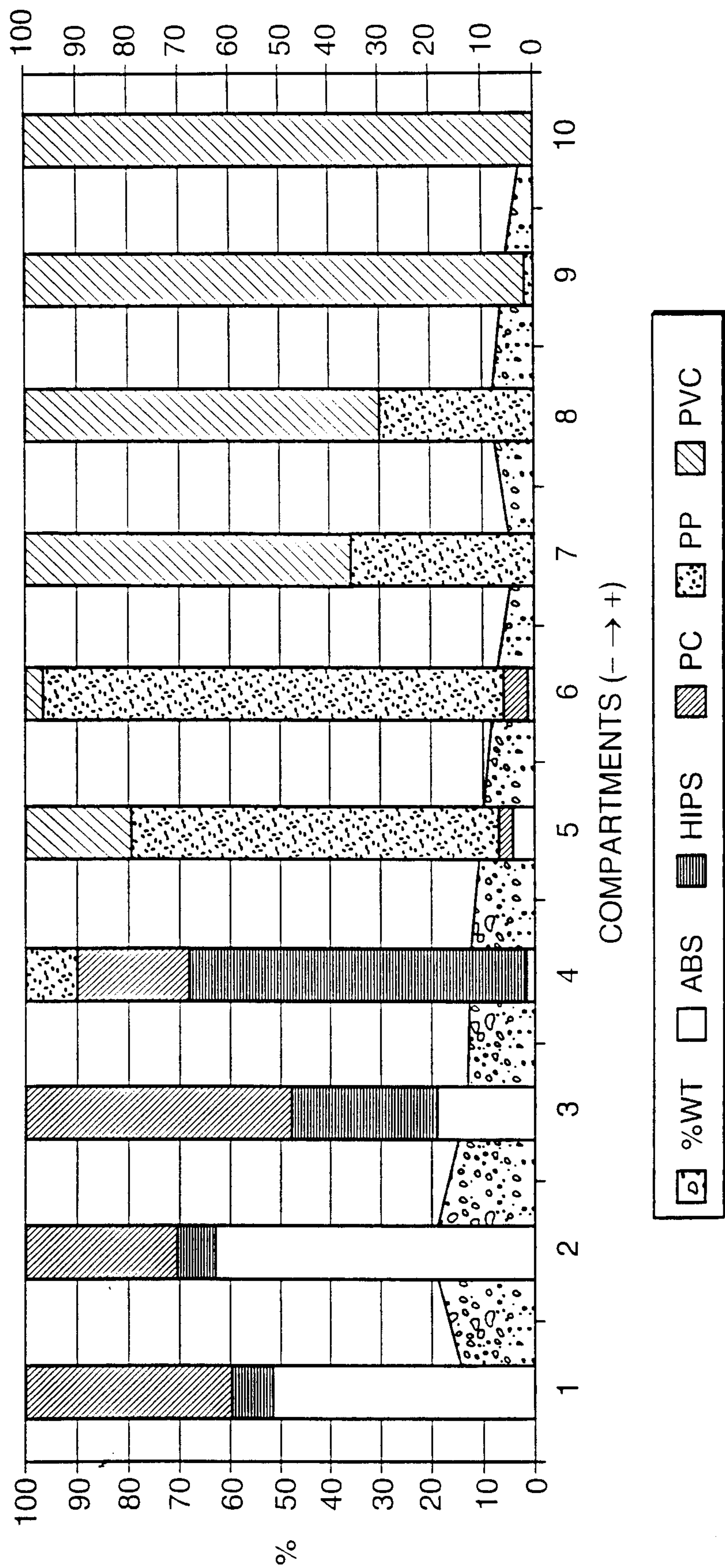


FIG. 12

