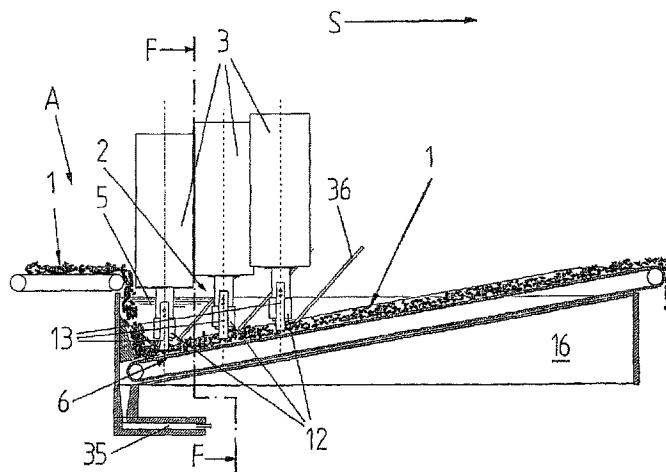




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(54) Titre : PROCEDE ET DISPOSITIF DE FRAGMENTATION ET / OU D'AFFAIBLISSEMENT D'UN MATERIAU COULANT AU MOYEN DE DECHARGES A HAUTE TENSION
(54) Title: METHOD AND DEVICE FOR FRAGMENTING AND / OR WEAKENING OF POURABLE MATERIAL BY MEANS OF HIGH-VOLTAGE DISCHARGES



(57) **Abrégé/Abstract:**

The invention relates to a method for fragmenting of pourable material (1) by means of high-voltage discharges. Thereby, a material flow of the material (1), immersed in a process liquid (5), is guided past an electrode assembly (2) by means of a conveying device (6) carrying the material flow, while by charging of the electrode assembly (2) with high-voltage pulses, high-voltage punctures through the material (1) of the material flow are produced. The electrodes (12, 13) of the electrode assembly (2) are thereby immersed in the process liquid (5) from above, and those of these electrodes (12, 13) between which the high-voltage punctures are produced face each other with an electrode spacing transversely to the material guiding-past direction (S). By means of the invention, it becomes possible to provide a continuous process for the fragmenting of large amounts of pourable material (1), in which the dwell time of the material (1) in the process zone can be set in wide ranges and virtually independently of the piece size of the materials and wherein complex conveying devices, which are electrically conductive at least in the region of the process zone, which are expensive and, in addition, are subject to severe wear, can be forgone.

ABSTRACT

The invention relates to a method for fragmenting of pourable material (1) by means of high-voltage discharges. Thereby, a material flow of the material (1), immersed in a process liquid (5), is guided past an electrode assembly (2) by means of a conveying device (6) carrying the material flow, while by charging of the electrode assembly (2) with high-voltage pulses, high-voltage punctures through the material (1) of the material flow are produced. The electrodes (12, 13) of the electrode assembly (2) are thereby immersed in the process liquid (5) from above, and those of these electrodes (12, 13) between which the high-voltage punctures are produced face each other with an electrode spacing transversely to the material guiding-past direction (S).

By means of the invention, it becomes possible to provide a continuous process for the fragmenting of large amounts of pourable material (1), in which the dwell time of the material (1) in the process zone can be set in wide ranges and virtually independently of the piece size of the materials and wherein complex conveying devices, which are electrically conductive at least in the region of the process zone, which are expensive and, in addition, are subject to severe wear, can be forgone.

**Method and device for fragmenting and / or weakening of
pourable material by means of high-voltage discharges**

TECHNICAL FIELD

5 The invention relates to a method for the
fragmenting and / or weakening of pourable material by means
of high-voltage discharges, a device for carrying out the
method, an apparatus comprising a plurality of such devices
as well as a use of the device or the apparatus according to
10 the invention.

STATE OF THE ART

 From the state of the art, it is known to crush
(fragment) the most diverse materials by means of pulsed
15 high-voltage discharges or to weaken them in such a way that
they can be crushed more easily in a subsequent mechanical
comminution process.

 For the fragmenting and / or weakening of pourable
material by means of high-voltage discharges, two different
20 process types are in principle known today.

 In the case of small material quantities or strict
requirements concerning the purity and / or the target grain
size of the processed material, the fragmenting and / or
weakening of the material takes place in a batch operation in
25 a closed process vessel in which high-voltage punctures
through the material are produced.

 In the case of large material quantities, the
fragmenting and / or weakening of the material is carried out
in a continuous process by guiding a material flow of the to-
30 be-crushed material past one or more electrodes and with
these high-voltage punctures through the material are
produced. Thereby, the material transport past the electrodes
takes place either by means of

35

gravitational force conveying or by means of a conveying device which at the same time serves as a counter-electrode to one or more high-voltage electrodes. In the former case, there is the problem that the material flow or the dwell time of the material in the process zone can only be set to a very limited extent and is strongly dependent on the piece size of the materials. In the latter case, the key disadvantage is that very complex conveying devices, which are at least electrically conductive in the region of the process zone, are required, which are expensive and are also subject to severe wear.

DISCLOSURE OF THE INVENTION

It is therefore an object to provide continuous methods and devices for fragmenting and / or weakening of large quantities of pourable material by means of high-voltage discharges which do not have the aforementioned disadvantages of the state of the art or at least in part avoid these.

A first aspect of the invention relates to a method for fragmenting and / or weakening of pourable material, in particular of slag from waste incineration, by means of high-voltage discharges.

Thereby, a material flow from the to-be-fragmented or weakened material, immersed in a process liquid, is guided past an electrode assembly with one or more high-voltage electrodes and to these high-voltage electrodes assigned counter-electrodes by means of a conveying device carrying the material flow, while high-voltage punctures between the high-voltage electrodes and the assigned counter-electrodes are produced through the material of the material flow by charging of the

5 electrode assembly with high-voltage pulses by means of
one or more high-voltage generators.

The high-voltage electrodes and counter-
electrodes assigned to these are thereby immersed in the
process liquid from above, and those of these electrodes
10 between which the high-voltage punctures are produced
face each other with an electrode spacing transversely to
the material guiding past direction.

In this way, it becomes possible to provide a
continuous process for the fragmenting and / or weakening
15 of large quantities of pourable material, in which the
dwell time of the material in the process zone can be
adjusted over wide ranges and practically independently
from the piece size of the materials and at the same time
complex conveying devices, which are at least
20 electrically conductive in the region of the process
zone, which are expensive and are also subject to severe
wear can be forgone.

In a preferred embodiment of the process, the
high-voltage electrodes and the counter-electrodes
25 between which the high-voltage punctures are produced are
in contact with the material flow.

In a further preferred embodiment of the
process, they are even immersed in the material flow.

Depending on the material and the piece size
30 of the to-be-fragmented material and / or the type or
quality of the process liquid, respectively, the one or
the other embodiment may be more preferred.

According to a further advantageous
embodiment of the method, the material flow is formed
35 from material pieces which do not exceed a specific
maximum piece size, and preferably have a maximum piece
size in the range between 40 mm and 80 mm.

In this case, it is preferred that the
electrode spacing is in each case larger than this
40 maximum piece size. This results in the advantage that
the material pieces can, with the electrodes being

5 immersed in the material flow, pass between these, as a
result of which a particularly intensive charging of the
material pieces with the high-voltage punctures becomes
possible. In addition, it is thereby possible in a
relatively simple way to charge the material flow with
10 high-voltage punctures essentially over its entire width,
which is also preferred.

Furthermore, it is thereby preferred that the
distance of the electrodes to the bottom side of the
material flow, i.e., to the upper side of the conveying
15 device carrying the material flow, is larger than this
maximum piece size. This results in the advantage that
the material pieces cannot be clamped between the upper
side of the conveying device and the electrodes when the
electrodes are in contact with the material flow or are
20 immersed in the material flow, as a result of which the
operational reliability and lifetime of the device are
considerably improved.

In yet another preferred embodiment of the
method, the material of the material flow or a part
25 thereof is divided into coarse material with a piece size
larger than a desired target size and into fine material
with a piece size smaller than or equal to the desired
target size downstream of the electrode assembly.

Thereby, it is further preferred that the
30 coarse material is fed again into the material flow
upstream of the electrode assembly in order to be again
guided past the electrode assembly and to be fragmented
or weakened, respectively, or that the coarse material is
subjected to a further fragmenting or weakening process,
35 in particular a further method according to this first
aspect of the invention, in order to be further
fragmented or weakened, respectively.

In yet another preferred embodiment of the
method, a conveying device is used, which at least in the
40 region in which it guides the material flow past the
electrode assembly, is formed as viewed in the cross-

5 section trough-shaped, in particular V-shaped. This
results in the advantage that the pourable material can
be guided from the lateral zones into the center and
thereby a substantially complete charging of the material
flow over its entire width with high-voltage punctures is
10 simplified.

Advantageously, the material flow is guided
past the electrode assembly by means of a flexible,
electrically nonconductive conveyor belt, the boundary
zones of which are arched upwards in the region in which
15 it guides the material flow past the electrode assembly.
Such conveyor belts are robust, low-maintenance and
commercially available in various designs and sizes. The
inclinations of the boundary zones of the conveyor belt
are preferably adjusted to optimize the respective
20 process. At its ends, the conveyor belt is preferably
planar such that the smallest possible expansion of the
boundary zones is required.

In this case, it is further preferred that
the material flow is transported upwards with the
25 conveyor belt downstream from the region in which it is
guided with the conveyor belt past the electrode assembly
and is fragmented or weakened there by means of high-
voltage punctures, preferably in such a way that it is
discharged out of the process liquid by the conveyor
30 belt. In this way, complex additional devices for
removing the processed material from the process liquid
can be dispensed with.

This can be achieved in a particularly simple
and cost-effective manner by using a straight conveyor
35 belt which rises in the material guiding past direction
of the material flow past the electrode assembly, in
particular with an ascent angle of between 10 and 35
degrees.

In a further preferred embodiment of the
40 method, the material flow transported upwards with the
conveyor belt is fed from the delivery end of the

5 conveyor belt, preferably via a device for sieving of
material pieces fragmented to a specific target size, to
a below arranged feeding end of another conveyor belt
with which it is fed into a further fragmenting and / or
weakening process, in particular according to this first
10 aspect of the invention. Correspondingly, the described
process is then part of a multi-stage fragmenting and /
or weakening method.

In the method according to the invention,
preferably, an electrode assembly is used, which
15 comprises a plurality of electrode pairs or electrode
groups, wherein to each electrode pair or each electrode
group, respectively, is assigned an own high-voltage
generator, with which exclusively this pair or group,
respectively, is charged with high-voltage pulses,
20 advantageously independently of the other electrode pairs
or electrode groups. In this way, a particularly
intensive charging of the material flow guided past the
electrode assembly is possible.

Here, an electrode pair is understood as a
25 combination of a high-voltage electrode, which is charged
with high-voltage pulses by the high-voltage generator,
and a single counter-electrode assigned to this high-
voltage electrode, between which electrodes the high-
voltage punctures take place.

30 An electrode group is understood here as a
combination of a high-voltage electrode, which is charged
with high-voltage pulses by the high-voltage generator,
and a plurality of counter-electrodes assigned to this
high-voltage electrode, between which electrodes the
35 high-voltage punctures take place, wherein normally the
actual high-voltage puncture takes place between the
high-voltage electrode and that of the counter-electrodes
between which the most favorable puncture conditions are
currently present.

40 In yet another preferred embodiment of the
method, the material flow is formed from material pieces

5 or comprises material pieces which form a composite of
metallic and non-metallic materials, which is e.g., the
case with slag pieces from waste incineration. In the
fragmenting or weakening, respectively, of such materials
with the inventive method, the advantages of the
10 invention are particularly apparent and it is a further
advantage that the requirements for the quality of the
process liquid, mostly water, are very low, as a result
of which the costs for the process liquid treatment are
extremely low.

15 Correspondingly, in such processes, it is
advantageous to carry out the method with a process
liquid having a conductivity of more than 500 $\mu\text{S}/\text{cm}$.

Thereby, the processed material emerging from
the process is preferably divided into metallic material
20 and non-metallic material, namely advantageously into
ferromagnetic metals, non-ferromagnetic metals, and non-
metallic material. In this way, a recycling or selective
disposal, respectively, of the components of the
processed material is simplified.

25 For producing the high-voltage punctures
through the material flow, the electrode assembly is
preferably charged with high-voltage pulses in the range
between 100 kV and 300 kV, in particular in the range
between 150 kV and 200 kV, wherein preferably the power
30 per pulse is between 100 Joule and 1000 Joule, in
particular between 300 Joule and 750 Joule. The high-
voltage pulse frequencies are preferably in the range
between 0.5 Hz and 40 Hz, in particular in the range
between 5 Hz and 20 Hz, and the material flow is during
35 the guiding past the electrode assembly preferably
charged with 0.1 to 2.0, in particular 0.5 to 1.0 high-
voltage punctures per millimeter of its extent in the
guiding-past direction.

A second aspect of the invention relates to a
40 device for carrying out the method according to the first
aspect of the invention.

5 The device comprises an electrode assembly
with one or more high-voltage electrodes and counter-
electrodes assigned to these. Its high-voltage electrodes
are chargeable with high-voltage pulses by one or more
high-voltage generators.

10 Furthermore, the device comprises a conveying
device, preferably in the form of a conveyor belt or a
conveyor chain, which is at least partially arranged in a
basin filled or fillable with a process liquid, in
particular water, and with which in the intended
15 operation a material flow of a pourable to-be-fragmented
and / or weakened material, immersed in a process liquid,
can be guided past the electrode assembly, while high-
voltage punctures through the material flow are produced
by charging of the electrodes of the electrode assembly
20 with high-voltage pulses.

 In this case, the device is structured in
such a way that, in the intended operation, the
electrodes of the electrode assembly are immersed in the
process liquid from above, and those of these electrodes
25 between which the high-voltage punctures are produced
face each other with an electrode spacing transversely to
the material guiding past direction.

 With the device according to the invention it
is possible in a simple manner to carry out the method
30 according to the first aspect of the invention with the
advantages already presented.

 In a preferred embodiment, the device is
structured in such a way that in the intended operation,
the high-voltage electrodes and the counter-electrodes
35 between which the high-voltage punctures are produced are
in contact with the material flow or are even immersed in
this.

 Depending on the material and the piece size
of the to-be-fragmented material and / or on the type or
40 quality, respectively, of the process liquid, the one or
the other embodiment may be more preferred.

5 In a further preferred embodiment of the
device, the distance between the electrodes between which
high-voltage punctures are produced is larger than 40 mm
each, more preferably larger than 80 mm each. This
results in the advantage that correspondingly large
10 pieces of material can, with electrodes being immersed in
the material flow, pass between these, as a result of
which a particularly intensive charging of the material
pieces with the high-voltage punctures becomes possible.
This also makes it possible to design the device in a
15 simple manner in such a way that the material flow can be
charged with high-voltage punctures essentially over its
entire width, which is also preferred.

 In yet another preferred embodiment, the
device comprises, downstream of the electrode assembly,
20 devices, in particular sieving devices, with which the
processed material of the material flow or a part thereof
can be divided into coarse material with a piece size
larger than a desired target size and into fine material
with a piece size smaller than or equal to the desired
25 target size.

 In yet another preferred embodiment of the
device, the electrode assembly comprises several
electrode pairs or electrode groups. In this case, a
respective high-voltage generator is assigned to each
30 electrode pair or electrode group, respectively, with
which, in the intended operation, exclusively this
electrode pair or this electrode group, respectively, can
be charged with high-voltage pulses. In this way, a
particularly intensive charging of the material flow
35 guided past the electrode assembly becomes possible.

 Here, an electrode pair is understood as a
combination of a high-voltage electrode, which in the
intended operation is charged with high-voltage pulses by
the assigned high-voltage generator, and a single
40 counter-electrode assigned to this high-voltage

5 electrode, between which electrodes the high-voltage
punctures take place in the intended operation.

An electrode group is understood here as a
combination of a high-voltage electrode, which in the
intended operation is charged with high-voltage pulses by
10 the assigned high-voltage generator, and a plurality of
counter-electrodes assigned to this high-voltage
electrode, between which electrodes in the intended
operation the high-voltage punctures take place, wherein
normally the actual high-voltage puncture takes place
15 between the high-voltage electrode and that of the
counter-electrodes between which the most favorable
puncture conditions are currently present.

In yet another preferred embodiment of the
device, the conveying device, at least in the region in
20 which it guides the material flow past the electrode
assembly, is formed as viewed in the cross-section
trough-shaped, preferably V-shaped. This results in the
advantage that the pourable material can be guided from
the lateral zones into the center and thereby a
25 substantially complete charging of the material flow with
high-voltage punctures over its entire width is
simplified.

Advantageously, the conveying device thereby
comprises a flexible, electrically nonconductive conveyor
30 belt, with which the material flow is guided past the
electrode assembly in the intended operation, the
boundary zones of which are arched upwards in the region
in which it guides the material flow past the electrode
assembly. Such conveyor belts are robust, low-maintenance
35 and commercially available in the widest variety of
designs and sizes. The inclinations of the boundary zones
of the conveyor belt are preferably adjustable for
optimizing the respective process. At its ends, the
conveyor belt is preferably planar such that the smallest
40 possible expansion of the boundary zones results.

5 The conveying device of the device preferably
comprises a conveyor belt which is structured in such a
way that in the intended operation, the material flow is,
downstream of the region in which it is guided past the
electrode assembly with the conveyor belt and fragmented
10 or weakened there by means of high-voltage punctures,
transported upwards with the conveyor belt, preferably in
such a way that it is discharged out of the process
liquid by the conveyor belt. In this way, complex
additional devices for removing the processed material
15 from the process liquid can be dispensed with.

This can be achieved in a particularly simple
and cost-effective manner by using a straight conveyor
belt which rises in the material guiding past direction
of the material flow, in particular with an ascent angle
20 of between 10 and 35 degrees.

A third aspect of the invention relates to a
multi-stage apparatus for fragmenting and / or weakening
of pourable material, comprising several devices
according to the second aspect of the invention connected
25 in series in the material conveying direction.

The apparatus is designed in such a way that,
in the intended operation, a material flow which is
transported upwards with the conveyor belt of a first one
of the devices, from the delivery end of this conveyor
30 belt, preferably via a device for sieving of material
pieces fragmented to a specific target size, is fed to
the below arranged feeding end of a conveyor belt of a
second device, following after the first device in the
material conveying direction, with which it is guided
35 past the electrode assembly of this second one of the
devices and is further fragmented and / or weakened
thereby.

With such multi-stage apparatuses, large
amounts of material can be processed.

40 A fourth aspect of the invention relates to
the use of the device according to the second aspect of

the invention or the apparatus according to the third aspect of the invention for the fragmenting and / or weakening of material pieces which form a composite of non-metallic and metallic materials, preferably of slag pieces from waste incineration.

In such uses, the advantages of the invention are particularly apparent.

BRIEF DESCRIPTION OF THE DRAWINGS

Further embodiments, advantages and applications of the invention result from the now following description with reference to the figures. Thereby show:

Fig. 1 a plan view on a first device according to the invention in a first operating mode;

Fig. 2 a vertical section through the first device along the line A-A in Fig. 1;

Fig. 3 a vertical section through the first device along the line B-B in Fig. 1;

Fig. 4 a plan view on the first device in a second operating mode;

Fig. 5 a side view of one of the electrodes of the electrode assembly of the device from Fig. 1;

Fig. 6 a side view of a first variant of the high-voltage electrode from Fig. 5;

Fig. 7 a side view of a second variant of the high-voltage electrode from Fig. 5.

Fig. 8 a longitudinal section along the line D-D in Fig. 10 through a second device according to the invention;

Fig. 9 a plan view from above on the device from Fig. 8;

Fig. 10 a cross-section through the device along the line C-C in Fig. 8;

5 Fig. 11 a longitudinal section along the line E-E in Fig. 13 through a third device according to the invention;

 Fig. 12 a plan view from above on the device from Fig. 11;

10 Fig. 13 a cross-section through the device along the line F-F in Fig. 11;

 Fig. 14 a longitudinal section along the line G-G in Fig. 16a through an apparatus according to the invention;

15 Fig. 15 a plan view from above on the apparatus from Fig. 14;

 the figures 16a and 16b cross-sections through the apparatus along the line H-H in Fig. 14;

 the figures 17 to 19 longitudinal sections as
20 Fig. 14 through different variants of individual devices of the apparatus of Fig. 14.

MODES FOR CARRYING OUT THE INVENTION

25 The figures 1 to 3 show a first device according to the invention for the fragmenting of pourable material 1 by means of high-voltage punctures, once in a plan view from above (Fig. 1), once in a vertical section along the line A-A in Fig. 1 (Fig. 2)
30 and once in a partially vertical section along the line B-B in Fig. 1 (Fig. 3).

 As can be seen, the device comprises a carousel-like device 9, 10, 11 formed by an annular base plate 10, a cylindrical outer wall 9 fixedly connected to
35 the base plate 10 and projecting vertically upwards from the base plate 10, and a cylindrical inner wall 11 not being connected to the base plate 10 and projecting vertically upwards from the base plate 10. The base plate 10 is planar and continuously closed and is supported by
40 means of a roller-collar 24 on an annular supporting element 25 of a fixed supporting structure, and is in the

5 intended operation rotated around a vertical rotation
axis Z going through the center of the annular shape of
the base plate 10 in the direction of rotation R by a
drive motor 26, by means of which the to-be-fragmented
material 1 on the base plate 10 forms an annular or
10 annular-segmented material flow 4 around the rotation
axis Z in the direction of rotation R.

The carousel-like device 9, 10, 11 is
arranged in a circular basin 27 filled with water 5
(process liquid), the bottom of which is penetrated by
15 the annular supporting element 25. The carousel-like
device 9, 10, 11 is completely immersed in the water 5 in
the basin 27, except for the upper delimiting edges of
the outer wall 9 and of the inner wall 11. In the region
within the annular supporting element 25, the bottom of
20 the basin 27 is formed by a circular, downwardly
extending funnel 19, the lower end of which ends over a
conveying belt 20, which conveys slopingly upwards up to
a level above the water level of the basin 27 (not
completely shown here for reasons of space) and is
25 arranged in a housing 30 which is connected to the lower
funnel end and forms a watertight container together with
the basin 27. The basin 27 is surrounded by an annular
protective wall 31, through which the housing of the
conveyor belt 30 and the conveyor belt 20 penetrate.

30 As can further be seen, the device comprises,
arranged above the carousel-like device 9, 10, 11, an
electrode assembly 2 with a plurality of high-voltage
Electrodes 12 arranged in a matrix-shape, which extends
approximately over a range of 270° of the annular shape
35 of the carousel-like device 9, 10, 11. In the
illustrated situation, each one of the high-voltage
electrodes 12 thereby extends from above down to just
above the surface of the annular-segmented material flow
4 guided in the carousel-like device 9, 10, 11, wherein
40 it immerses into the water 5, and comprises an own high-
voltage generator 3 arranged directly above it, with

which it is charged with high-voltage pulses during operation. For the sake of clarity, in the figures, only one of the high-voltage electrodes is provided with the reference numeral 12, each, and only one of the high-voltage generators is provided with the reference numeral 10 3, each.

As can be seen from Fig. 5, which shows one of the high-voltage electrodes 12 of the electrode assembly 2 of this device in the side view, each of the high-voltage electrodes 12 comprises a respective 15 counter-electrode 13 lying on earth potential. The high-voltage electrodes 12 and the counter-electrodes 13 assigned to these each face each other with a spacing transversely to the material guiding past direction and are thereby each arranged in such a way that, in the illustrated intended operation, high-voltage punctures between the high-voltage electrode 12 and the counter-electrode 13 assigned to it through the material 1 of the material flow 4 are produced by means of the charging of the respective high-voltage electrode 12 with high-voltage pulses. The high-voltage electrode 12 together with the single counter-electrode 13 assigned to it, thus forms an electrode pair 12, 13.

The figures 6 and 7 show side views of two variants of the high-voltage electrode from Fig. 5.

Fig. 6 shows a high-voltage electrode 12 which differs from the one shown in Fig. 5 essentially in that it comprises two identical mirror-inverted facing counter-electrodes 13 and inclined towards the high-voltage electrode 12 at their free ends. The high-voltage electrode 12 together with the two counter-electrodes 13 thus forms an electrode group 12, 13. A further difference is that this high-voltage electrode 12 has a straight electrode tip.

Fig. 7 shows a high-voltage electrode 12 which differs from the one shown in Fig. 6 essentially in that here the two mirror-inverted facing counter-

5 electrodes 13 shown in Fig. 6 are connected to a single,
U-shaped counter-electrode 13 below the high-voltage
electrode 12.

Depending on the process or the to-be-processed material, respectively, it is also foreseen
10 that the electrodes 12 and the counter-electrodes 13 are
immersed in the material flow.

As can further be seen, the device comprises
a supply conveyor belt 15 arranged in a closed housing
32, with which to-be-fragmented material 1, in the
15 present case fractures of noble metal ore rock 1, is
provided to the base plate 10 of the carrousel-like
device 9, 10, 11 upstream of the electrode assembly 2.

The height of the material filling 1 guided
below the electrode assembly 2 as annular-segmented
20 material flow 4 is limited before the inlet into the
region formed between the carrousel-like device 9, 10, 11
and the electrode assembly 2 (process zone) by a passage-
limiting plate 33.

Downstream of the electrode assembly 2, there
25 is a fixed first guiding plate 17, which extends from the
outer wall 9 of the carousel-like device 9, 10, 11
through a first gap 23 in its inner wall 11 into a region
7 in the center of the carrousel-like device 9, 10, 11
and, in the illustrated intended operation, essentially
30 completely guides material flow 4 emerging from the
process zone into the central region 7 via the first gap
23 in the inner wall 11.

The bottom of the central region 7 is
designed as a planar sieve bottom 8 with a sieve opening
35 size which is dimensioned such that material 1a
fragmented to the target size passes through the sieve
openings and falls into the below arranged funnel 19,
while material 1b which is larger than the target size,
remains on the sieve bottom 8. The completely processed
40 or fragmented to target size material 1a, respectively,

5 is guided by the funnel 19 onto the conveyor belt 20,
with which it is transported out of the device.

The incompletely processed or not yet
fragmented to target size material 1b, respectively, is
pushed over the sieve bottom 8 by the succeeding material
10 1 and is, by a fixed second guiding plate 21 adjoining
the first guiding plate 17, via a second gap 28 in the
inner wall 11 fed from the central region 7 back into the
annular-segmented material flow 4, with which it is again
guided past a part of the high-voltage electrodes 12 of
15 the electrode assembly 2 and thereby charged with high-
voltage punctures.

As can be seen from Fig. 3, which shows a
vertical section through a part of the first device in
the region of the process zone along the line B-B in Fig.
20 1, the base plate 10 of the carrousel-like device 9, 10,
11 comprises a top side covered with a wear-inhibiting
layer 29 of rubber, on which the to-be-processed material
1 rests.

Fig. 4 shows a plan view on the device in a
25 different operating mode. As can be seen, here, the
second guiding plate 21 is arranged in a position in
which it closes the second gap 28 in the inner wall 11
from the side of the central region 7 and opens up a
discharge duct 34 into which the incompletely processed
30 or not yet fragmented to target size material 1b,
respectively, which is pushed over the sieve bottom 8 by
the succeeding material 1, falls into and is then guided
away from the device by (not shown) devices.

The figures 8 to 10 show a second device
35 according to the invention for fragmenting of pourable
material 1 by means of high-voltage discharges, once in a
longitudinal section along the line D-D in Fig. 10 (Fig.
8), once in a plan view from above (Fig. 9), and once in
a cross-section along the line C-C in Fig. 8 (Fig. 10).

40 As can be seen, the device comprises an
electrode assembly 2 with a matrix of high-voltage

5 electrodes 12, which, as viewed in material flow direction S, are arranged in four successively arranged rows, each with four high-voltage electrodes 7 (only one of the electrodes is provided with the reference numeral 12 in the figures for the sake of clarity).

10 In the illustrated intended operation, the electrodes 12 are each charged with high-voltage pulses by a high-voltage generator 3 arranged directly above them.

Below the electrode assembly 2, a conveyor
15 belt 6 is arranged in a basin 16 flooded with water 5 (process liquid), with which a material flow of a to-be-fragmented, pourable material, in the present case fragments of ore rock, is guided past the electrodes 12 of the electrode assembly 2 from the feed side A of the
20 device in the material flow direction S, while high-voltage punctures through the material 1 are produced as a result of a charging of the electrode assembly 2 with high-voltage pulses. Thereby, the material 1 of the material flow is immersed in the water 5 located in the
25 basin 16, as well as the electrodes 12 arranged thereabove.

The height of the material flow is adjusted before the inlet into the region between the conveyor belt 6 and the electrode assembly 2 (process zone) by
30 means of a passage limiting plate 18.

As can be seen from Fig. 10, the conveyor belt 6, as viewed in the flow direction S, extends over the entire width of the basin 16 such that the moved material flow encompasses the entire width of the basin
35 16.

As can be seen in particular from the figures 8 and 10, the central zone of the material flow is charged with high-voltage punctures during passing through of the process zone, which results in an
40 increasing fragmenting of the material 1 in this region, while the boundary zones of the material flow remain

practically unaffected by high-voltage punctures, such that the material 1 guided therein retains its original piece size.

Downstream of the electrode assembly 2, the material flow emerging from the process zone is discharged from the conveyor belt 6 into three collecting funnels 14, 14a, 14b separated by separation walls 22 and extending side by side next to each other over the entire width of the conveyor belt 6 at the end of the basin 16. Thereby, the separation walls 22 are arranged in such a way that the fragmented material 1 from the central zone of the material flow is discharged into the central collecting funnel 14, while the non-fragmented material 1 from the boundary zones of the material flow is discharged into the outer collection funnels 14a, 14b.

The fragmented material 1, which is discharged into the central collection funnel 14, is conveyed out of the basin 16 by means of a (not shown) conveying device and fed to another use. The non-fragmented material 1, which is discharged into the outer collecting funnels 14a, 14b, is conveyed out of the basin 16 by means of (not shown) conveying devices and fed back into the material flow on the feed side A of the device.

As can be seen from Fig. 6, which shows one of the electrodes 12 of the electrode assembly 2 of the device in the side view, each of the high-voltage electrodes 12 comprises two identical mirror-inverted facing counter-electrode each inclined towards the high-voltage electrode 12 at their free ends, which lie on ground potential and are attached to the supporting structure of the high-voltage electrode 12. The high-voltage electrode 12 together with the two counter-electrodes 13 forms an electrode group 12, 13. Thereby, the high-voltage electrodes 12 and the respective two counter-electrodes 13 assigned to these, face each other with an electrode spacing

5 transversely to the material guiding past direction and
are immersed in the material flow.

The figures 11 to 13 show a third device
according to the invention for fragmenting of pourable
material 1 by means of high-voltage discharges, once in a
10 longitudinal section along the line E-E in Fig. 13 (Fig.
11), once in a plan view from above (Fig. 12) and once in
a cross-section along the line F-F in Fig. 11 (Fig. 13).

As can be seen, the device comprises an
electrode assembly 2 with three high-voltage electrodes
15 12, which are arranged one behind the other in material
flow direction S.

Also here, the high-voltage electrodes 12 and
the assigned counter-electrodes 13 are structured as
shown in Fig. 6, face each other with an electrode
20 spacing transversely to the material guiding past
direction and are immersed in the material flow.

As can further be seen from Fig. 12, in which
the positions of the respective high-voltage electrodes
12 and counter-electrodes 13 are shown dashed, these
25 electrode groups 12, 13 each have a lateral offset with
respect to each other in the material flow direction S.

In the illustrated intended operation, the
high-voltage electrodes 12 are each charged with high-
voltage pulses by a high-voltage generator 3 arranged
30 directly above them.

Below the electrode assembly 2, there is,
arranged in a basin 16 flooded with water 5 (process
liquid), a straight conveyor belt 6 rising in a material
flow direction S with an angle of 10 degrees made of a
35 flexible, electrically non-conductive strip material
(fabric-reinforced rubber), by means of which a material
flow of the to-be-fragmented pourable material 1, in the
present case slag pieces from waste incineration with a
maximum piece size of 80 mm, is guided past the
40 electrodes 12, 13 of the electrode assembly 2 from the
feed side A of the device in the material flow direction

5 S, while high-voltage punctures through the material 1 as
a result of a charging of the high-voltage electrodes 12
of the electrode assembly 2 with high-voltage pulses are
produced. Thereby, the material 1 of the material flow is
immersed in the water 5 located in the basin 16 in the
10 region of the electrode assembly 2, as are the electrodes
12, 13 arranged thereabove, which are also immersed in
the material flow.

At the same time, process water is discharged
from the basin 16 via a discharge line 35 arranged at the
15 bottom of the basin 16 and supplied to a (not shown)
water treatment plant, from which treated process water
is conveyed back into the basin 16 via supply lines 36,
which each inject the water into the material flow in the
region of the electrodes 12, 13.

20 As can be seen from the FIGS. 12 and 13, the
boundary zones of the conveyor belt 6 are arched upwards
in the region in which it guides the material flow past
the electrode assembly 2, such that the conveyor belt 6
is formed in this region as viewed in the cross-section
25 trough-shaped or V-shaped, respectively, in such a way
that the pourable material 1 of the material flow is
guided from the lateral zones into the center.

By means of this, the material flow is
charged with high-voltage punctures essentially over its
30 entire width, which leads to a fragmenting of the entire
material flow.

The inclination angle of the boundary zones
of the conveyor belt is adjustable in order to be able to
optimally adapt the device to the to-be-processed
35 material or its piece size, respectively. The conveyor
belt 6 is planar in the region of its ends.

Downstream from the electrode assembly 2, the
material flow emerging from the process zone is
discharged out of the basin 16 upwards by the conveyor
40 belt 6 and afterwards fed to a further (not shown)
utilization or processing step, respectively.

5 The figures 14, 15, 16a and 16b show an
apparatus according to the invention for fragmenting of
pourable material 1 by means of high-voltage discharges,
once in a longitudinal section along the line G-G in Fig.
16a (Fig. 14), once in a plan view from above (Fig. 15)
10 and twice in a cross-section along the line H-H in Fig.
14 (figures 16a and 16b).

As can be seen, this apparatus consists of
three devices according to the figures 11 to 13 connected
in series (three steps), with the difference that each of
15 the devices instead of the three electrode groups 13, 12,
13 arranged one behind the other in the material flow
direction S and offset with respect each other and with
its own high-voltage generator 3 each, has only one
centrally positioned electrode group 13, 12, 13, each,
20 with respectively assigned high-voltage generator 3. In
addition, the ascent angle of the conveyor belt 6 is with
15 degrees here considerably steeper than in the
previously described third device according to the
invention according to the figures 11 to 13. All other
25 details are carried out identically and are therefore not
explained here again.

The figures 16a and 16b show cross-sections
through the apparatus along the line H-H in Fig. 14
(although without basin and high-voltage generator) at
30 different settings of the inclination angles α of the
boundary zones of the illustrated conveyor belt 6, namely
once at inclination angles α of 23 degrees (Fig. 16a) and
once at inclination angles α of 33 degrees (Fig. 16b).

The figures 17 to 19 show longitudinal
35 sections as Fig. 14 through different variants of a
device of the apparatus according to the figures 14, 15,
16a, and 16b.

The first device variant according to Fig. 17
differs from the device shown in Fig. 14 in that the to-
40 be-processed material is fed to the feeding end A of the
device via an inclined sieving surface 37 arranged

5 outside of the basin 16, by means of which fine material
with a specific piece size, e.g., depending on the
arrangement location of the device within the apparatus
of smaller than 2 mm, smaller than 5 mm, or smaller than
8 mm, is sieved even before the entry into this device.

10 The second device variant according to Fig.
18 differs from the device shown in Fig. 14 in that the
to-be-processed material at the feeding end A of the
device is fed onto the conveyor belt 6 of the device via
an inclined sieving surface 38 arranged within the basin
15 16, by means of which fine material with a specific piece
size, e.g., depending on the arrangement location of the
device within the apparatus of smaller than 2 mm, smaller
than 5 mm, or smaller than 8 mm, is sieved within the
basin 16 of this device but before the entry into the
20 process zone.

The third device variant according to Fig. 19
consists of a device according to Fig. 18, at the
discharge end of which the processed material is
discharged onto an inclined sieving surface 41 through
25 which the material fragmented to a desired piece size
falls onto a below arranged further transporting conveyor
belt 39. The insufficiently fragmented material travels
over the sieving surface 38 and at its end falls onto a
conveyor belt 40 with which it is conveyed back to the
30 feeding end of the device and is fed back again into the
to-be-processed material flow 1.

The devices according to the figures 17 to 19
each individually also form a device according to the
invention.

35 While there are described preferred
embodiments of the invention in the present application,
it is to be clearly pointed out that the invention is not
limited thereto and can also be carried out in another
manner within the scope of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for fragmenting and/or weakening of pourable material by means of high-voltage discharges, comprising the steps:

a) providing an electrode assembly which is assigned to one or more high-voltage generators, by means of which it is chargeable with high-voltage pulses;

b) guiding a material flow of pourable material past the electrode assembly by means of a conveying device carrying the material flow, wherein the material flow is immersed in a process liquid; and

c) producing high-voltage punctures through the material flow during the guiding thereof past the electrode assembly by charging of the electrode assembly with high-voltage pulses;

wherein the electrodes of the electrode assembly are submerged from above in the process liquid, and those electrodes between which the high-voltage punctures are produced face each other with an electrode spacing transversely to the material guiding past direction.

2. A method according to claim 1, wherein the electrodes of the electrode assembly are in contact with the material flow.

3. A method according to claim 2, wherein the electrodes of the electrode assembly are immersed in the material flow.

4. A method according to any one of claims 1 to 3, wherein the material flow is formed by material pieces which do

not exceed a specific maximum piece size, and wherein the electrode spacing is larger than this maximum piece size each.

5. A method according to claim 4, wherein the specific maximum piece size is in the range between 40 mm and 80 mm.

6. A method according to any one of claims 1 to 5, wherein the high-voltage punctures are produced in such a way that the material flow is charged with high-voltage punctures essentially over its entire width.

7. A method according to any one of claims 1 to 6, wherein the material of the material flow or a part thereof is divided into coarse material with a piece size larger than a desired target size and into fine material with a piece size smaller than or equal to the desired target size downstream of the electrode assembly.

8. A method according to claim 7, wherein the coarse material is fed again into the material flow upstream of the electrode assembly.

9. A method according to claim 7, wherein the coarse material is subjected to a further fragmenting or weakening method.

10. A method according to any one of claims 1 to 9, wherein the material flow is formed by material pieces or comprises material pieces which do not exceed a specific maximum piece size, and wherein the distance of the electrodes to the

bottom side of the material flow is larger than this maximum piece size.

11. A method according to claim 10, wherein the specific maximum piece size is in the range between 40 mm and 80 mm.

12. A method according to any one of claims 1 to 11, wherein the conveying device, at least in the region in which it guides the material flow past the electrode assembly, is formed as viewed in the cross-section trough-shaped.

13. A method according to claim 12, wherein the conveying device, at least in the region in which it guides the material flow past the electrode assembly, is formed as viewed in the cross section V-shaped.

14. A method according to claim 12 or 13, wherein the conveying device, at least in the region in which it guides the material flow past the electrode assembly, is formed in such a way that the pourable material is guided from the lateral zones into the center.

15. A method according to any one of claims 1 to 14, wherein the material flow is guided past the electrode assembly by means of a flexible, electrically nonconductive conveyor belt, wherein its boundary zones are arched upwards in the region in which it guides the material flow past the electrode assembly.

16. A method according to claim 15, wherein the conveyor belt is planar in the region of its ends.

17. A method according to claim 15 or 16, wherein the inclinations of the boundary zones of the conveyor belt are adjusted.

18. A method according to any one of claims 1 to 17, wherein the material flow, downstream from the region in which it is guided past the electrode assembly with the conveying device or the conveyor belt, respectively, is transported upwards with the conveying device or the conveyor belt, respectively.

19. A method according to claim 18, wherein the material flow is guided out of the process liquid with the conveying device or with the conveyor belt, respectively.

20. A method according to claim 18 or 19, wherein a straight conveyor belt is used, with an ascent angle in the material guiding past direction of between 10 and 35 degrees.

21. A method according to any one of claims 18 to 20, wherein the material flow transported upwards with the conveyor belt, from the delivery end of the conveyor belt, is fed to a below arranged feeding end of another conveyor belt, with which it is supplied to a further fragmenting and/or weakening method.

22. A method according to claim 21, wherein the material flow is transported upwards via a device for sieving of material pieces fragmented to a specific target size.

23. A method according to any one of claims 1 to 22, wherein the electrode assembly comprises a plurality of electrode pairs or electrode groups, wherein a respective high-voltage generator is assigned to each electrode pair or each electrode group, respectively, with which exclusively this pair or this group, respectively, is charged with high-voltage pulses.

24. A method according to claim 23, wherein each electrode pair or electrode group is charged independently of the other electrode pairs or electrode groups.

25. A method according to any one of claims 1 to 24, wherein the material flow is formed by material pieces or comprises material pieces which form a composite of metallic and non-metallic materials.

26. A method according to claim 25, wherein the material pieces are slag pieces from waste incineration.

27. A method according to claim 25 or 26, wherein the process liquid has a conductivity of more than 500 pS/cm.

28. A method according to any one of claims 25 to 27, wherein the processed material resulting from the method is divided into metallic material and non-metallic material.

29. A method according to claim 28, wherein the processed material resulting from the method is divided into ferromagnetic metals, non-ferromagnetic metals, and non-metallic material.

30. A method according to any one of claims 1 to 29, wherein the electrode assembly for producing the high-voltage punctures through the material flow is charged with high-voltage pulses in the range between 100 kV and 300 kV.

31. A method according to claim 30, wherein the high-voltage pulses are in the range between 150 kV and 200 kV.

32. A method according to any one of claims 1 to 31, wherein the electrode assembly for producing the high-voltage punctures through the material flow is charged with high-voltage pulses with a power per pulse of between 100 Joule and 1000 Joule.

33. A method according to claim 32, wherein the high-voltage pulses have a power per pulse of between 300 Joule and 750 Joule.

34. A method according to any one of claims 1 to 33, wherein the electrode assembly for producing the high-voltage punctures through the material flow is charged with high-voltage pulse frequencies in the range between 0.5 Hz and 40 Hz.

35. A method according to claim 34, wherein the high-voltage pulse frequencies are in the range between 5 Hz and 20 Hz.

36. A method according to any one of claims 1 to 35, wherein the material flow during guiding past the electrode assembly is charged with 0.1 to 2.0 high-voltage punctures per millimeter of its extent in the guiding-past direction.

37. A method according to claim 36, wherein the material flow during guiding past the electrode assembly is charged with 0.5 to 1.0 high-voltage punctures per millimeter of its extent in the guiding-past direction.

38. A device for carrying out the method according to any one of claims 1 to 37, comprising:

a) an electrode assembly which is assigned to one or more high-voltage generators, by means of which it is chargeable with high-voltage pulses;

b) a conveying device, at least in part arranged in a basin which is filled or fillable with a process liquid with which in the intended operation a material flow of a pourable, to be fragmented and/or to be weakened material, immersed in a process liquid, can be guided past the electrode assembly while high-voltage punctures through the material flow are produced by means of charging of the electrode assembly with high-voltage pulses,

wherein the device is structured in such a way that in the intended operation the electrodes of the electrode assembly are immersed in the process liquid from above, and those electrodes

between which the high-voltage punctures are produced face each other with an electrode spacing transversely to the material guiding past direction.

39. A device according to claim 38, wherein the conveying device is in form of a conveyor belt or a conveyor chain.

40. A device according to claim 38 or 39, wherein the device is structured in such a way that in the intended operation the electrodes of the electrode assembly are in contact with the material flow.

41. A device according to claim 38 or 39, wherein the device is structured in such a way that in the intended operation the electrodes of the electrode assembly are immersed in the material flow.

42. A device according to claim 41, wherein the electrodes are immersed in the material flow with a distance to the bottom side of the material flow of more than 40 mm.

43. A device according to claim 42, wherein the electrodes are immersed in the material flow with a distance to the bottom side of the material flow of more than 80 mm.

44. A device according to any one of claims 38 to 43, wherein the electrode spacing is greater than 40 mm.

45. A device according to claim 44, wherein the electrode spacing is greater than 80 mm each.

46. A device according to any one of claims 38 to 45, wherein the device is structured in such a way that in the intended operation the material flow is chargeable with high-voltage punctures essentially over its entire width.

47. A device according to any one of claims 38 to 46, wherein the device, downstream from the electrode assembly, comprises devices with which the material of the material flow or a part thereof can be divided into coarse material with a piece size larger than a desired target size and into fine material with a piece size smaller than or equal to the desired target size.

48. A device according to any one of claims 38 to 47, wherein the electrode assembly comprises a plurality of electrode pairs or electrode groups, and wherein a respective high-voltage generator is assigned to each electrode pair or each electrode group, respectively, with which, in the intended operation, exclusively this pair or this group, respectively, can be charged with high-voltage pulses.

49. A device according to any one of claims 38 to 48, wherein the conveying device, at least in the region in which it guides the material flow past the electrode assembly, is formed as viewed in the cross-section trough-shaped.

50. A device according to claim 49, wherein the conveying device, at least in the region in which it guides the material

flow past the electrode assembly, is formed as viewed in the cross-section V-shaped.

51. A device according to claim 49 or 50, wherein the conveying device, at least in the region in which it guides the material flow past the electrode assembly, is formed in such a way that the pourable material is guided from the lateral zones into the center.

52. A device according to any one of claims 49 to 51, wherein the conveying device comprises a flexible, electrically nonconductive conveyor belt, with which, in the intended operation, the material flow is guided past the electrode assembly, wherein its boundary zones are arched upwards in the region in which it guides the material flow past the electrode assembly.

53. A device according to claim 52, wherein the conveyor belt is planar in the region of its ends.

54. A device according to claim 52 or 53, wherein the inclinations of the boundary zones of the conveyor belt are adjustable.

55. A device according to any one of claims 38 to 54, wherein the conveying device comprises a conveyor belt which is structured in such a way that, in the intended operation of the device, the material flow is, downstream of the region in which it is guided past the electrode assembly with the conveyor belt, transported upwards with the conveyor belt.

56. A device according to claim 55, wherein the material flow is guided out of the process liquid with the conveyor belt.

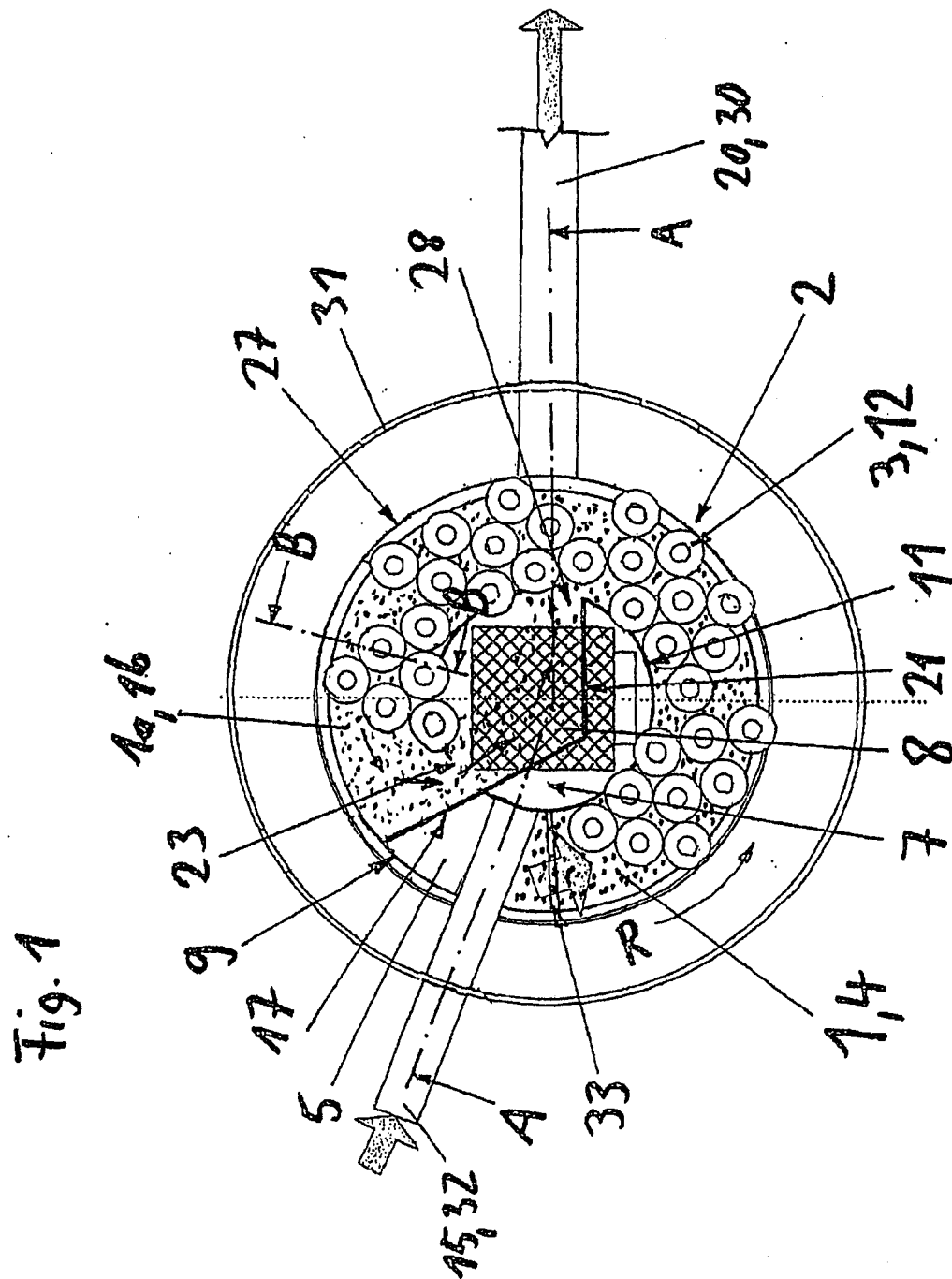
57. A device according to claim 55 or 56, wherein the conveyor belt is a straight conveyor belt, with an ascent angle in material guiding past direction of between 15 and 35 degrees.

58. An apparatus comprising a plurality of devices according to any one of claims 38 to 57 arranged one behind the other in the material guiding direction, wherein, in the intended operation of the apparatus, the material flow transported upwards with the conveyor belt of a first one of the devices, from the delivery end of this conveyor belt, is supplied to the below arranged feeding end of a conveyor belt of a second device, following after the first device in the material guiding direction, with which it is guided past the electrode assembly of this second device and is further fragmented and/or weakened thereby.

59. An apparatus according to claim 58, wherein the material flow is transported upwards via a device for sieving of material pieces fragmented to a specific target size.

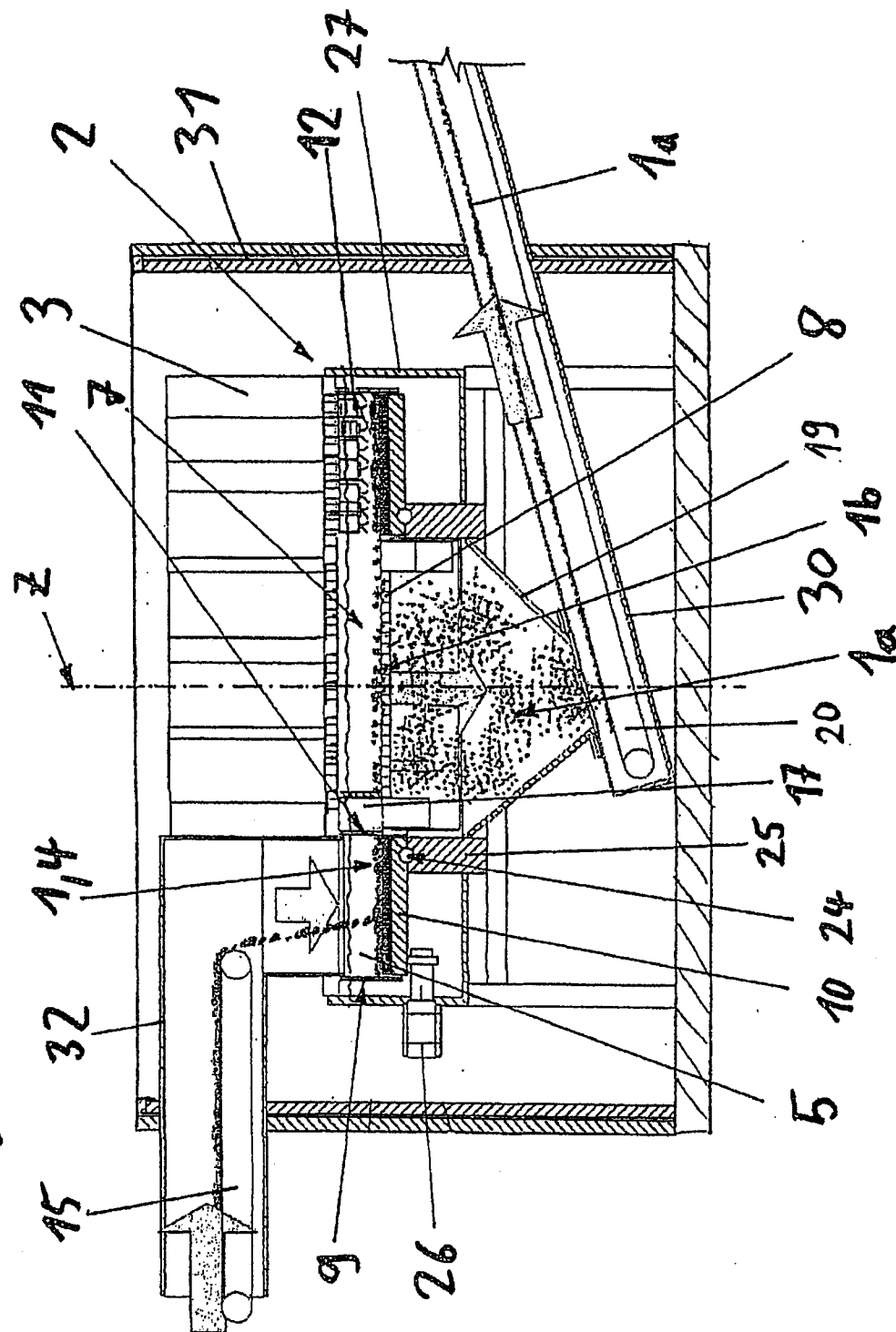
60. Use of the device according to any one of claims 38 to 57 or of the apparatus according to claim 58 or 59 for the fragmenting and/or weakening of pieces of material which form a composite of non-metallic and metallic materials.

61. Use according to claim 60, wherein the pieces of material are slag pieces from waste incineration.



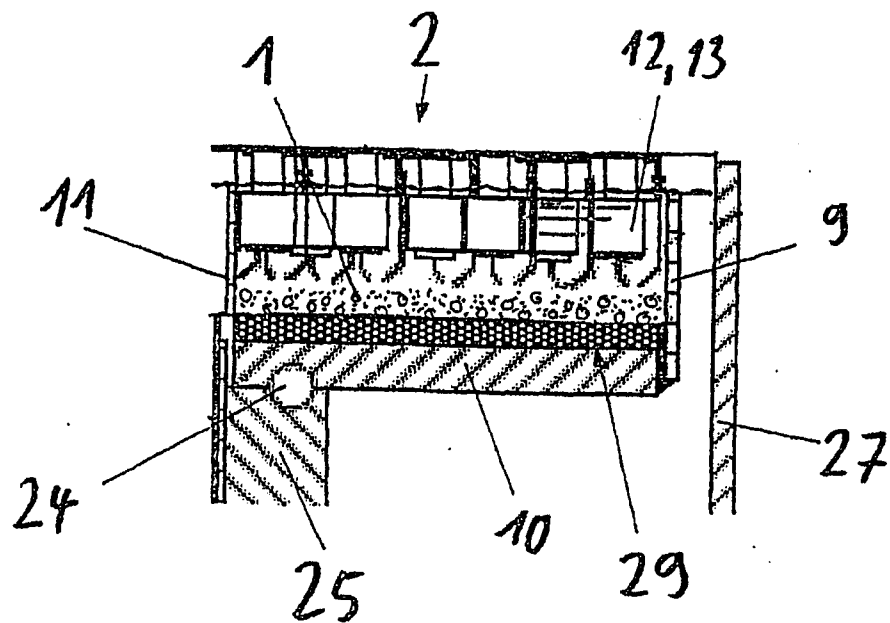
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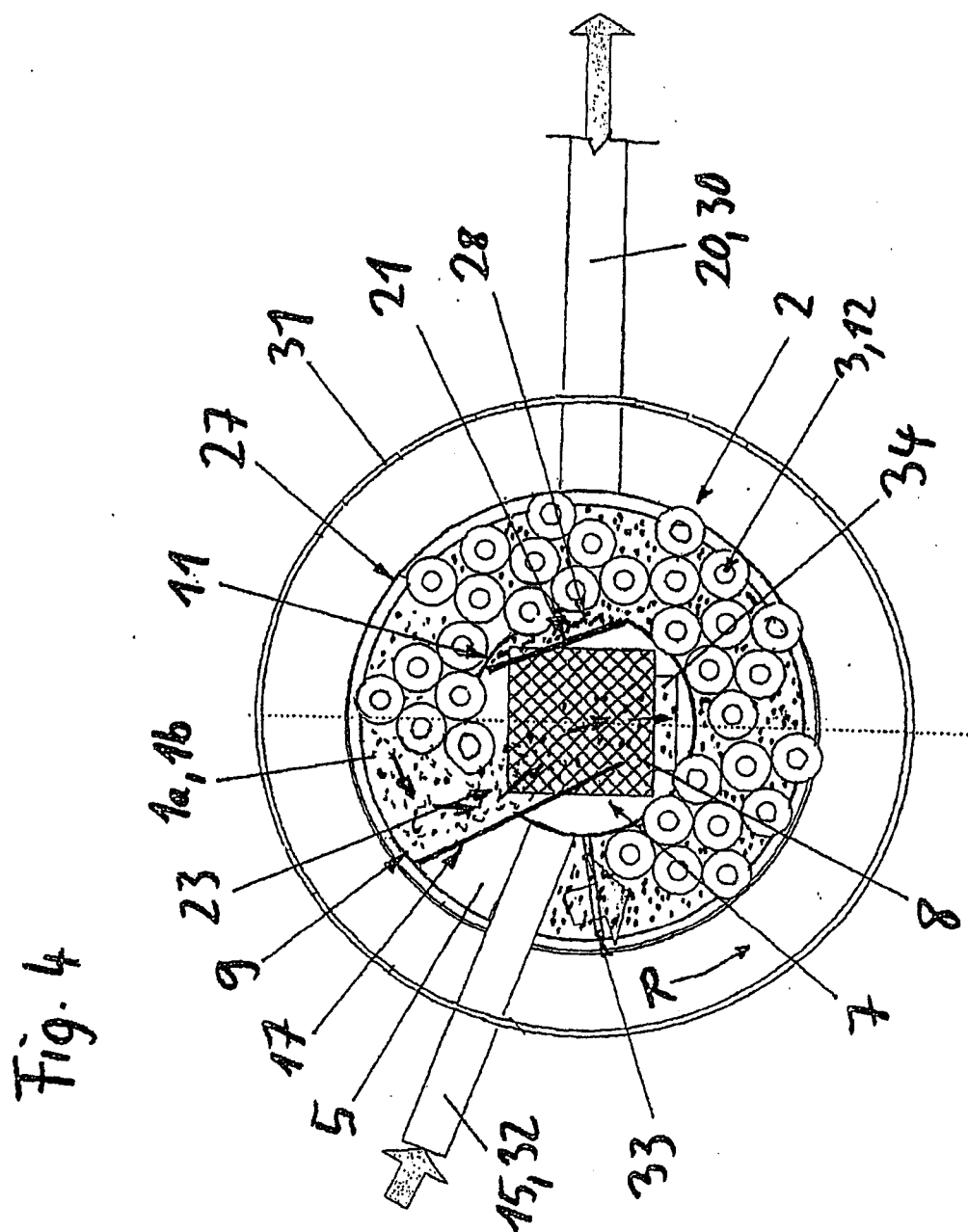
Fig.2



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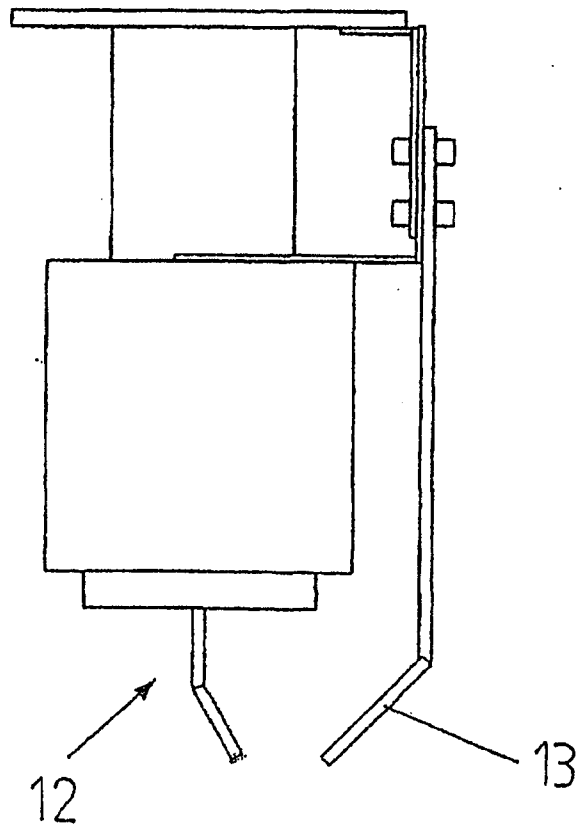
Fig. 3





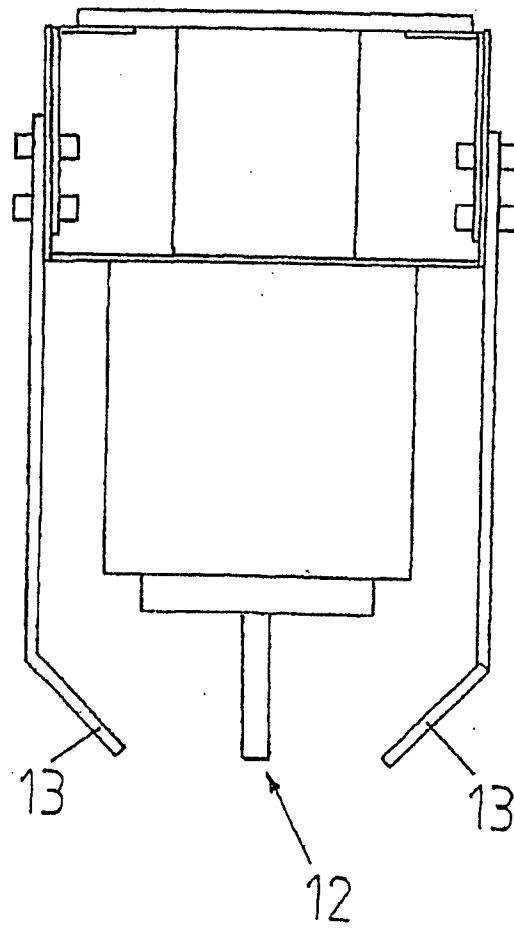
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Fig.5



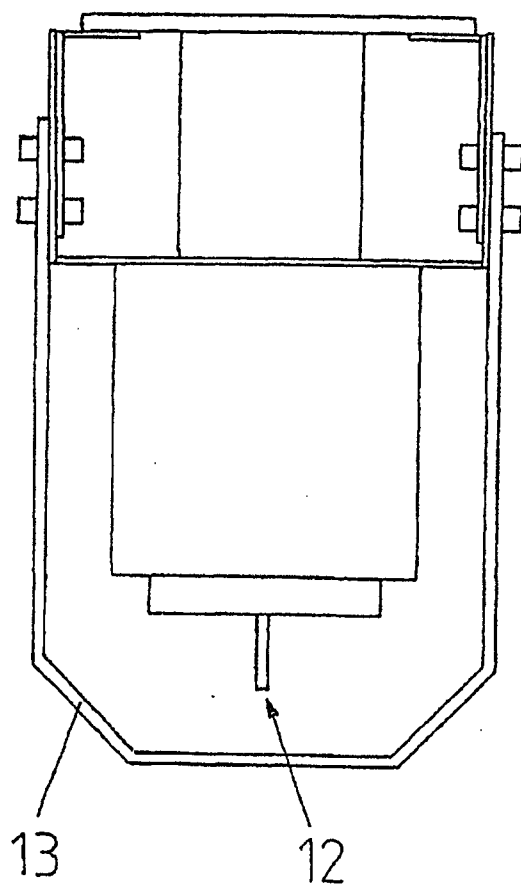
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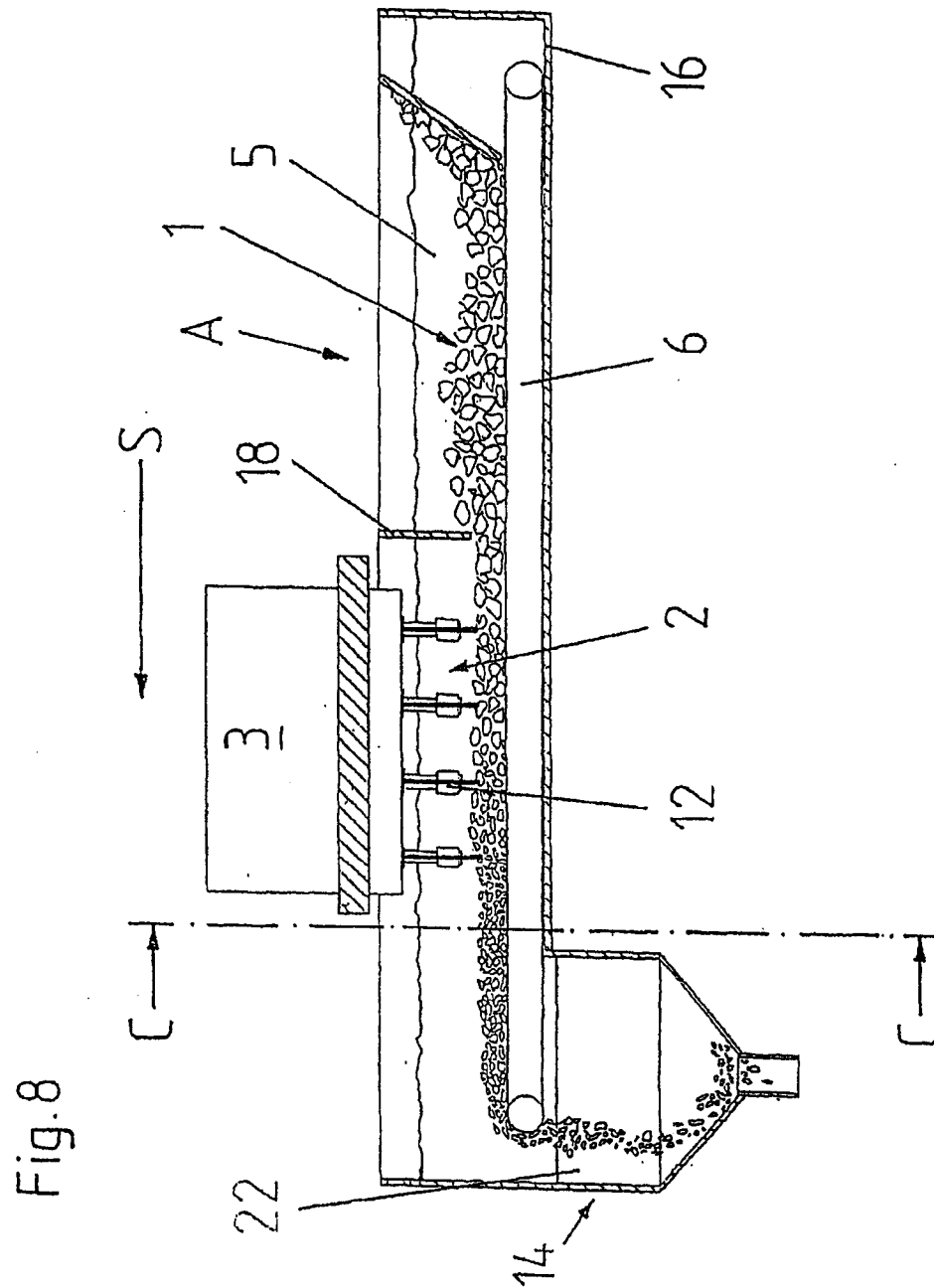
Fig.6



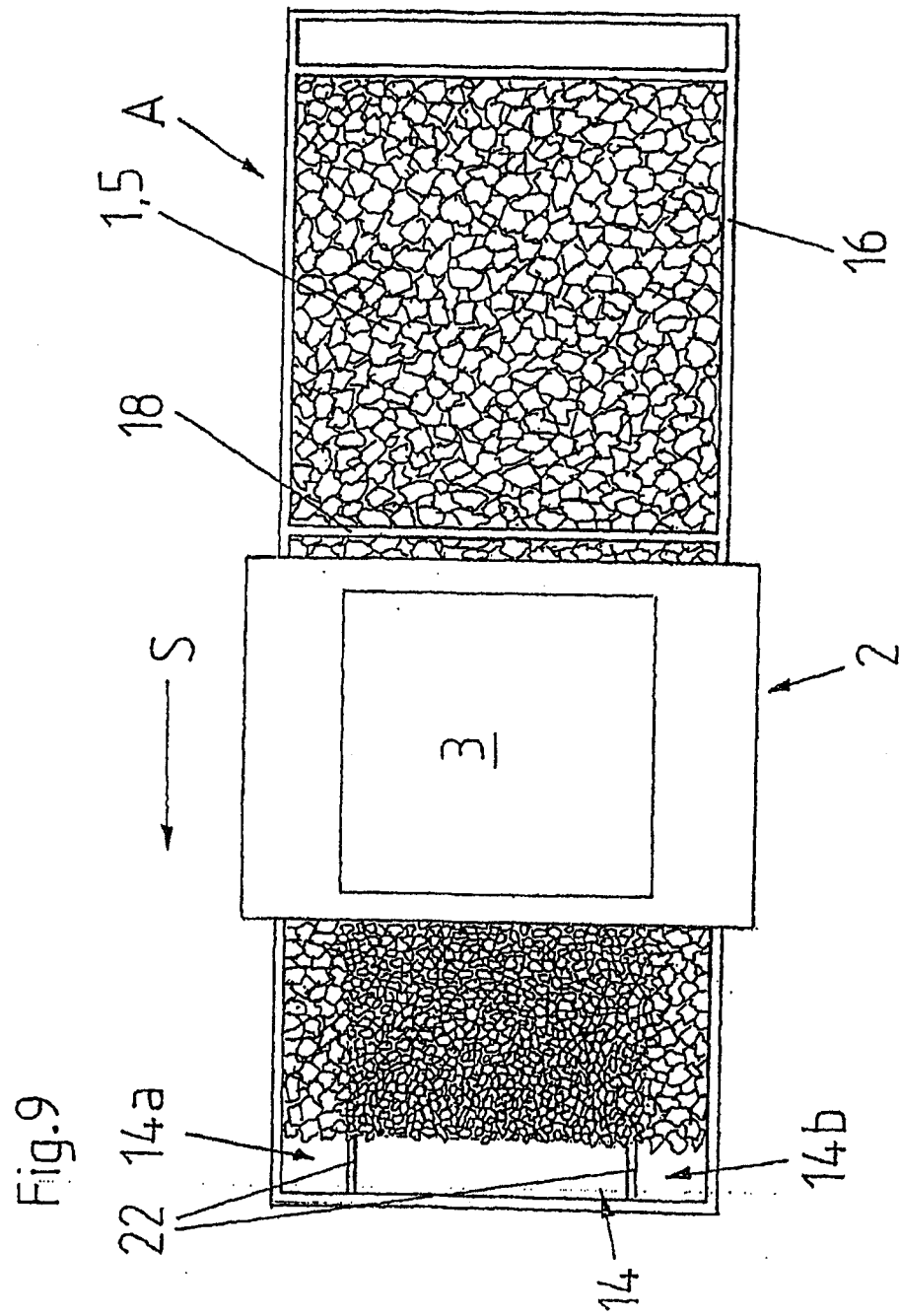
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Fig.7



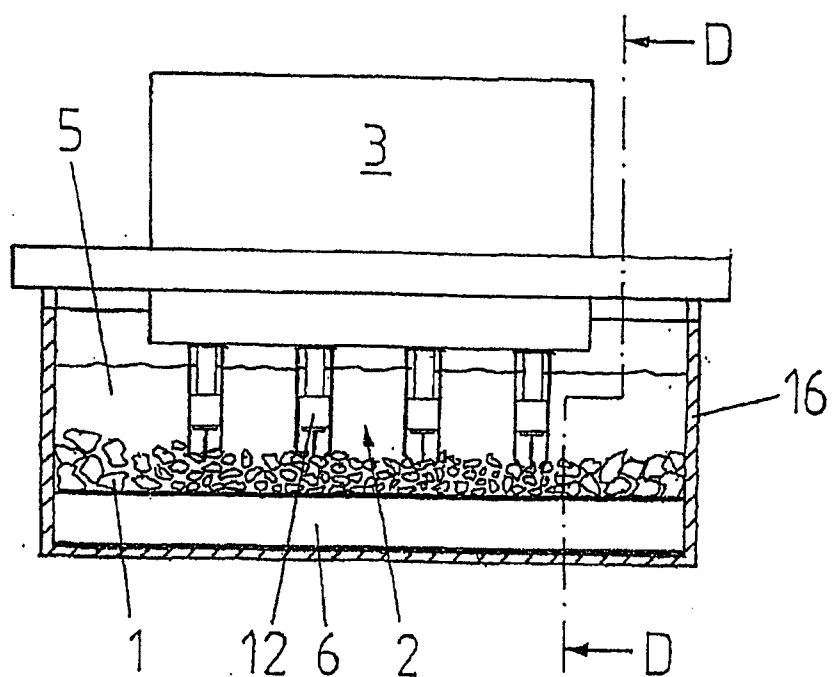


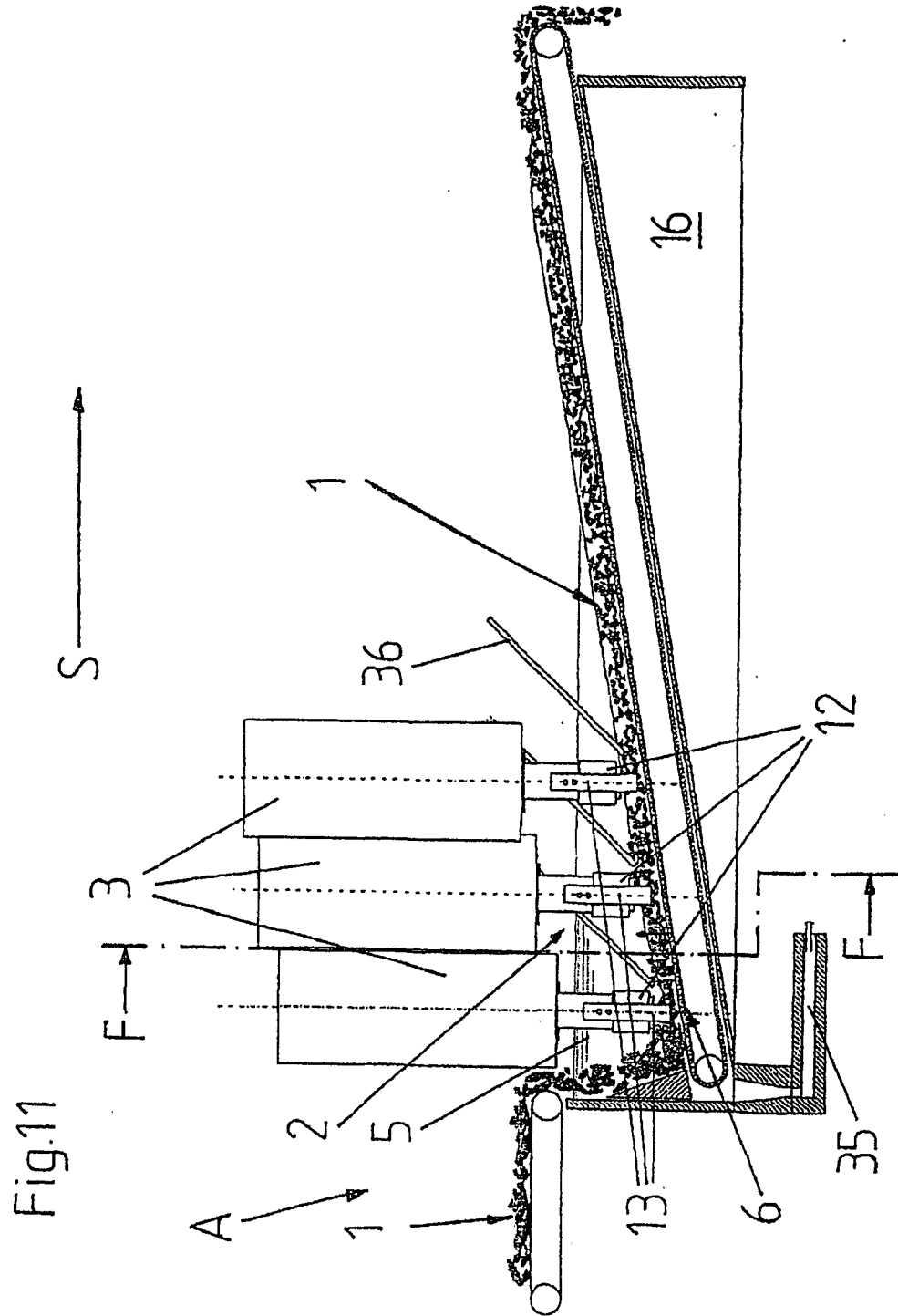
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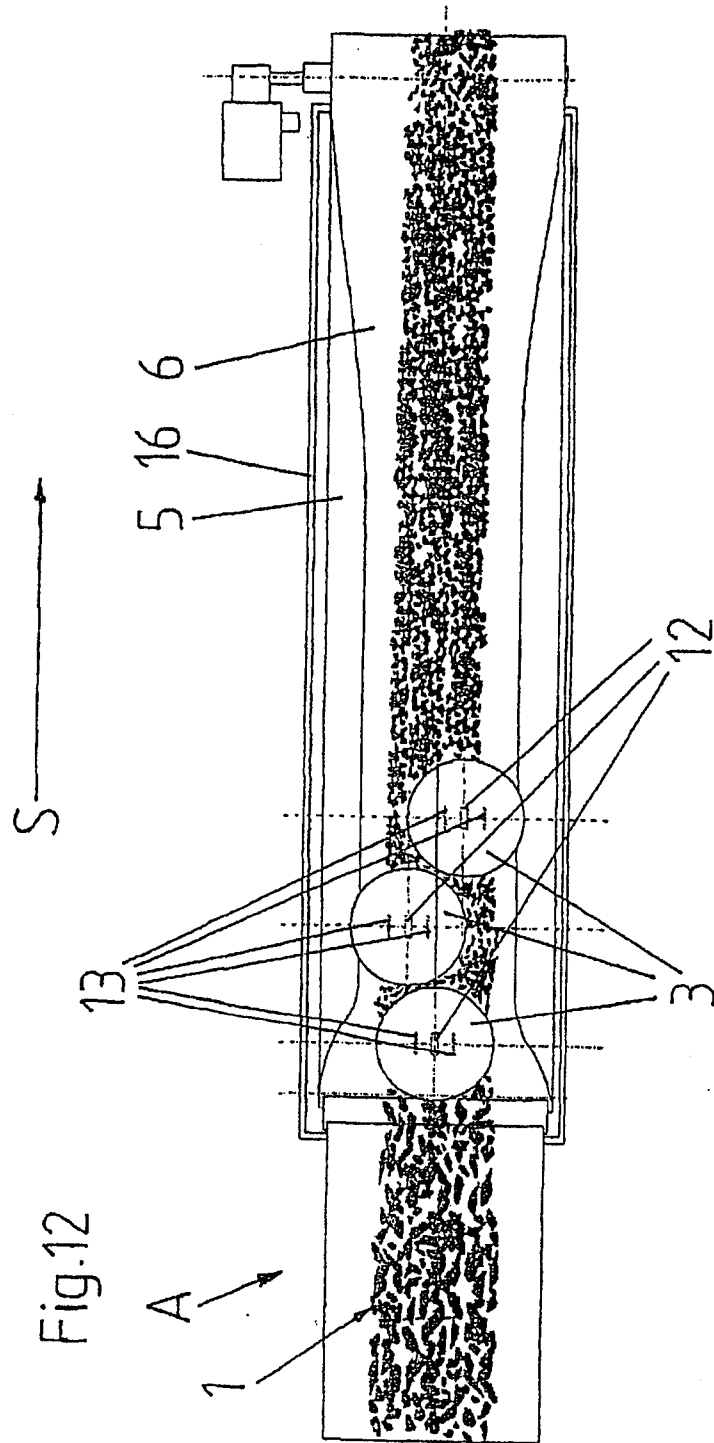
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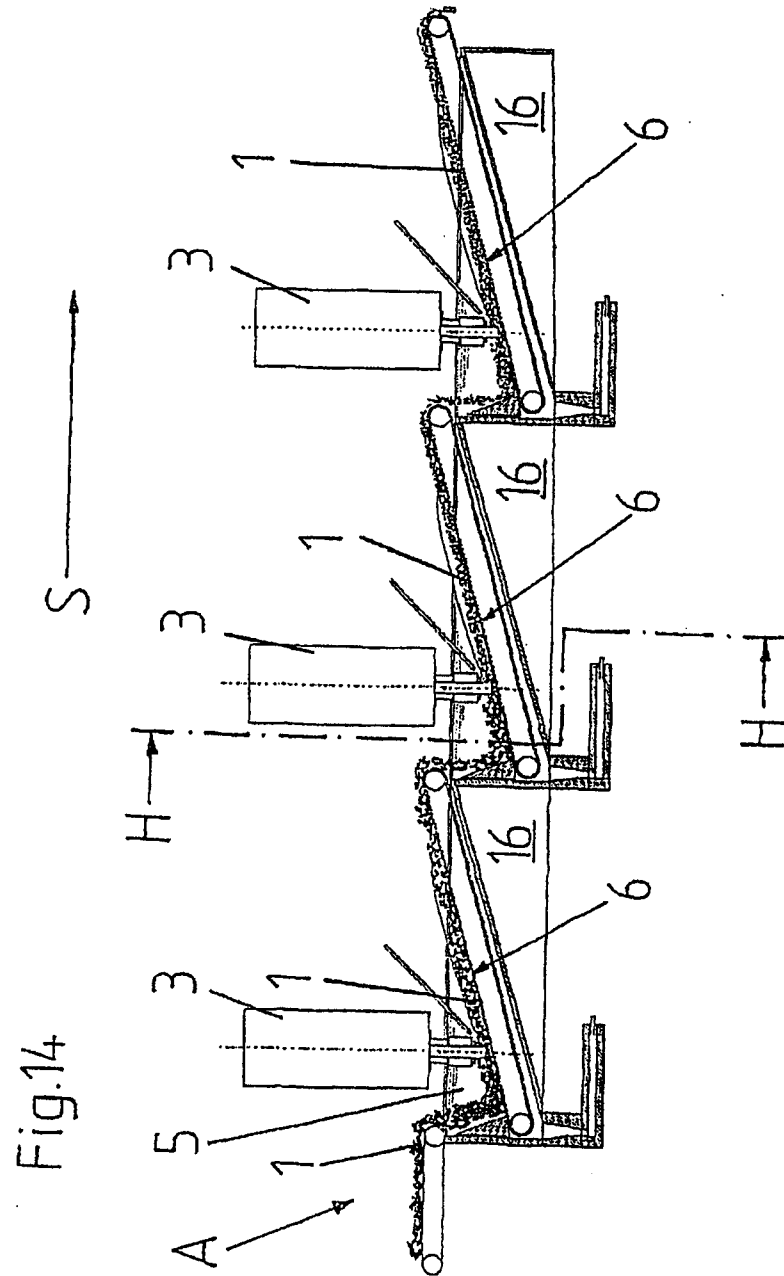
Fig.10

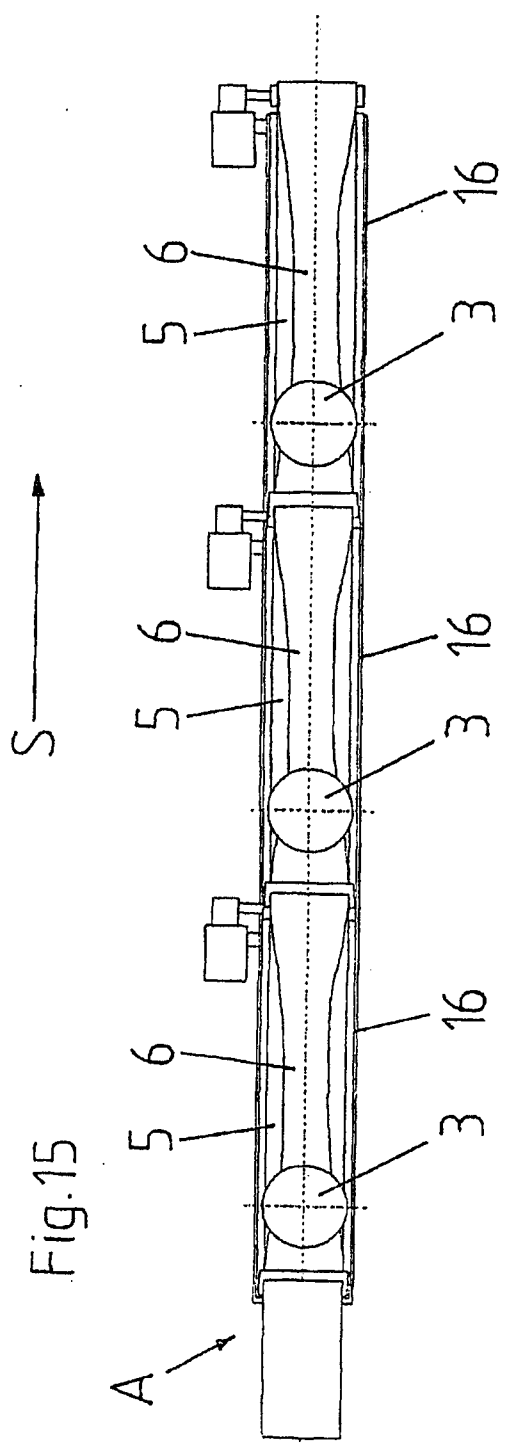




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Fig.16a

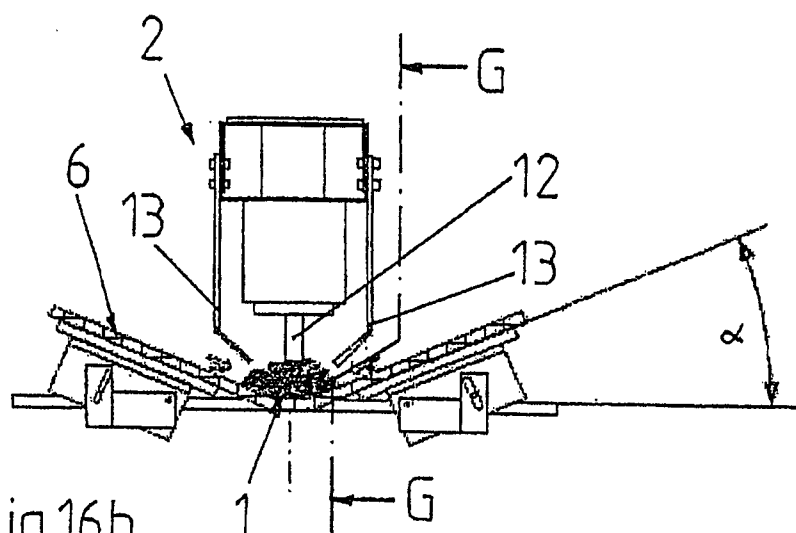
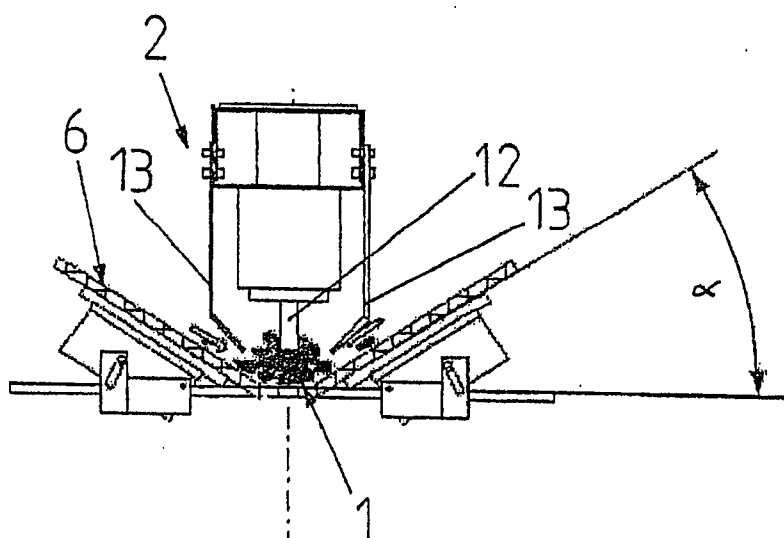
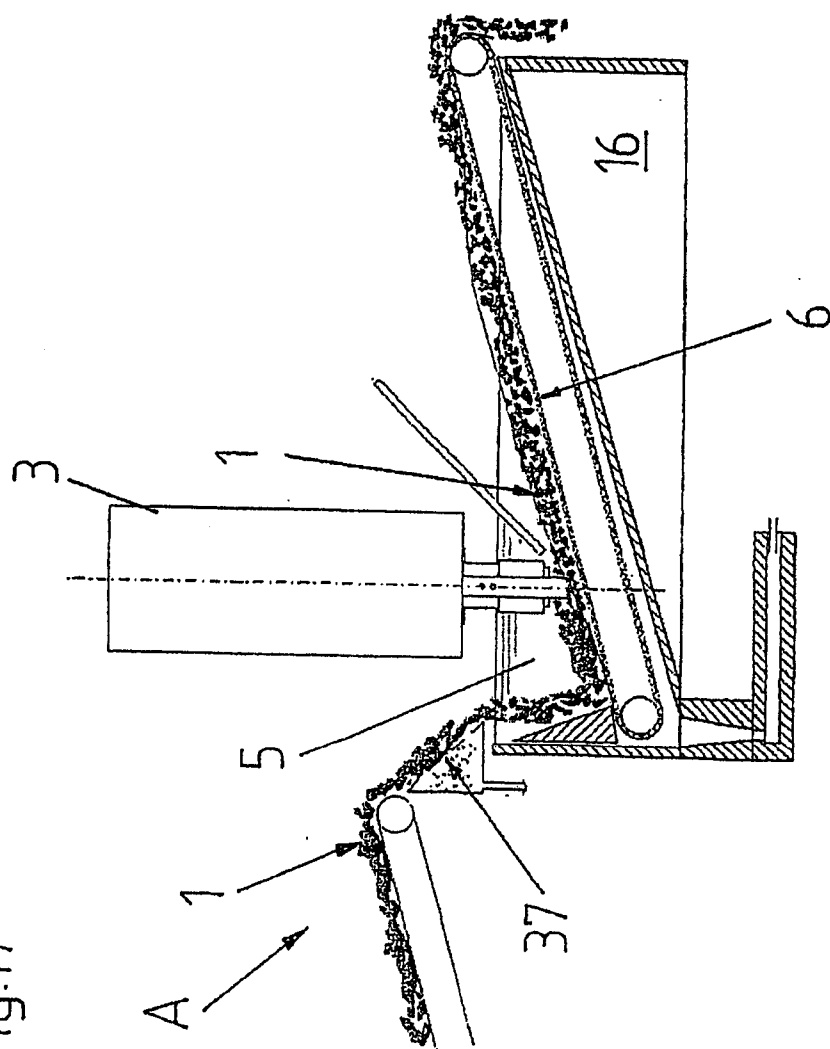


Fig.16b



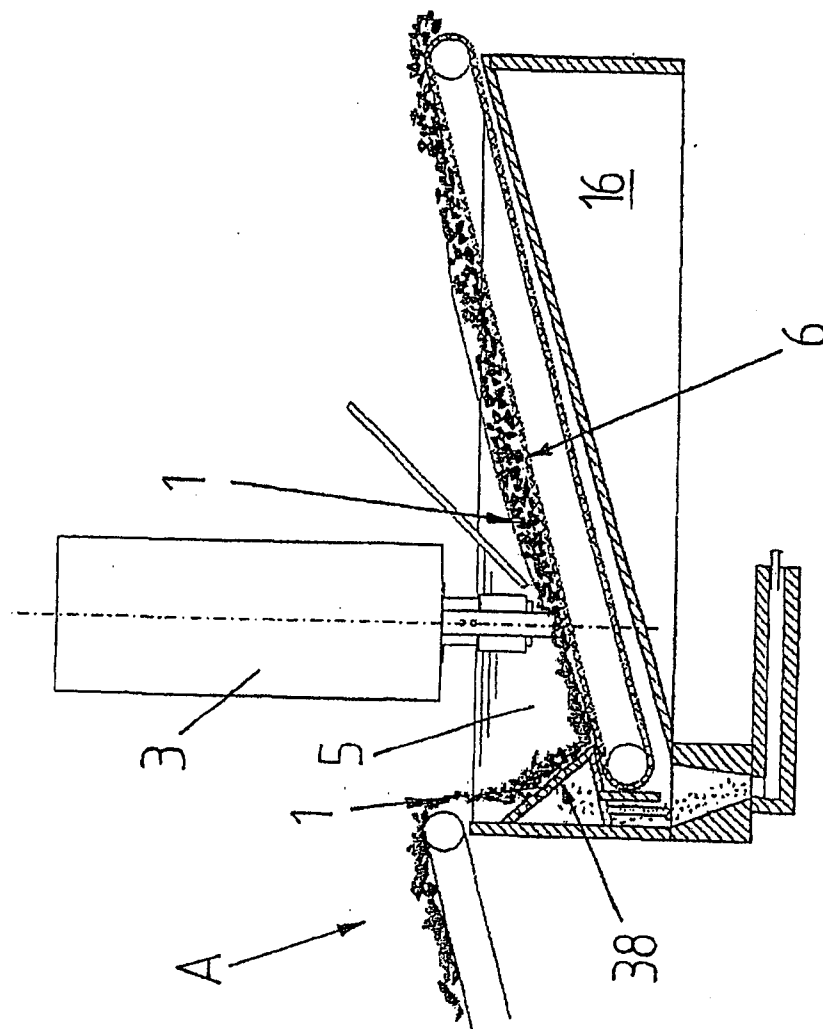
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Fig.17



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Fig.18



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Fig.19

