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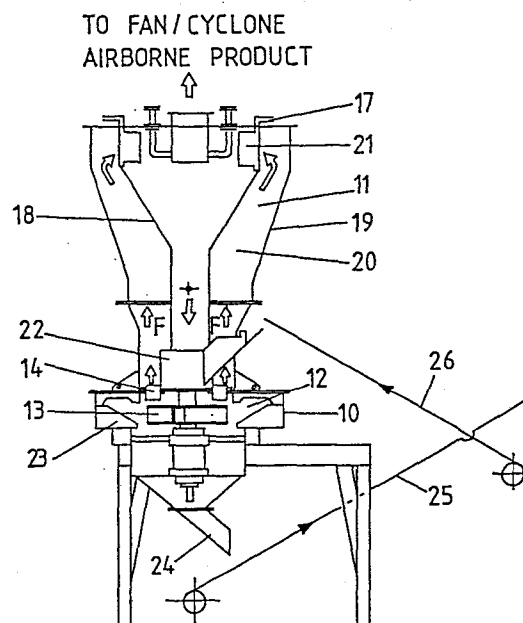
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54 **Apparatus for and method of obtaining a comminuted product from a solid feed material.**

57 An apparatus for obtaining a comminuted "fines" product from a solid feed material, a large proportion of the particles of which are greater than 1 cm, comprises a housing having a lower region forming a crusher (10) and an upper region forming a classifier (11). There is an inlet for the solid feed material leading to a hopper (22) from whence feed material passes to a rotor (13) which causes the material to be flung centrifugally outwards in the crushing chamber (23) where it is comminuted. As a result of movement of the rotor, there is a predominantly upward air flow (F) from the crushing chamber (23) to the classifier (11). This air flow entrains a high proportion of "fines" which can be classified, in the classifier (11) using vanes (21), and collected.

The apparatus is capable of producing an output product having a very high proportion of "fines" from even very abrasive feed material with particles of a size up to 5 cm.



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APPARATUS FOR AND METHOD OF OBTAINING A COMMINUTED
PRODUCT FROM A SOLID FEED MATERIAL

5 This invention relates to an apparatus for and
a method of obtaining a comminuted product from a
solid feed material.

10 There is known a wide variety of apparatus for
reducing the size of solid materials and examples
of such apparatus are described, for example, at
pages 8-16 to 8-44 of the 5th edition of "Chemical
Engineers' Handbook" edited by R.H. Perry and C.H.
Chilton and published by McGraw-Hill Book Company
in 1973. Further information is to be found, for
example, in the book "Crushing and Grinding - The
Size Reduction of Solid Materials" by G.C. Lowrinson
15 and published by Butterworths in 1974.

20 It is generally accepted that in order to obtain
from a feed material larger than 1cm in size a product
smaller than 150 μ m it is necessary to use a succession
of pieces of equipment including: one or more crushers
followed by a grinding mill for successively reducing
particle size; and a separator or classifier wherein
final classification of the particles is undertaken.

25 British Patent Specifications Nos. 645,673, 522,339
and 386,698 disclose examples of methods and apparatus
for fine grinding where a feed material with a
generally small particle size, usually considerably
less than 1cm, is ground down to produce a fines

output. The apparatus of these three specifications grinds the material by causing it to come into contact with components of the apparatus, for example beaters, grinding rings or grinding bodies. The construction
5 of these grinding apparatus is such that they cannot grind large particles (for example, greater than about 1cm) nor can they operate economically with highly abrasive materials due to the wear and tear which would result from contact with the grinding components.

10 British Patent Specifications Nos. 1,579,295 and 1,531,254 disclose examples of crushing apparatus which use two counter-rotating components to crush material by contact of the material with these components. Problems often arise where counter-rotating
15 components are used due to gyroscopic effects. In addition, the components are subject to a considerable amount of erosion and need continual attention and maintenance. One way of attempting to reduce such erosion is disclosed in United States
20 Patent Specifications Nos. 3,180,852 and 3,162,382 where centrifugal pulverisers are provided for reducing the wear on moving parts by incorporating angle members to trap matter centrifugally flung from a rotor whereby a protective surface is built
25 up. However, the problems involved in using two counter-rotating parts are not overcome.

We have now found surprisingly that by modifying the construction of one type of crusher it is possible to obtain directly, and at a reduced cost,
30 from a feed material substantially all of which is coarser than 1cm good yields of a product finer than 150 μ m.

According to one aspect of the present invention there is provided a method of obtaining a comminuted
35 product at least a major proportion of which is smaller than 150 μ m from a solid feed material at least a major proportion of which is larger than

1cm, which method comprises centrifugally flinging the feed material towards an impact surface which is composed partially or wholly of such material whereby the feed material is comminuted; and entrain-
5 ing in a predominantly upward airflow a portion of the comminuted material comprising particles of less than a given size, to classify the particles to produce the product.

In accordance with another aspect of the present
10 invention there is provided an apparatus suitable for carrying out the method according to the one aspect of the present invention, which apparatus comprises a housing having a lower region forming a crusher, an upper region forming a classifier,
15 an inlet for a solid feed material, and an outlet for a product, wherein the crusher comprises: means which, in use, cause the feed material to be flung towards an impact surface in said lower region of the housing, said means and the
20 disposition of the lower region of the housing being such that some of the feed material is retained, by gravity and friction forces, in said lower region of the housing so that the impact surface is composed partially or wholly of the material so retained,
25 whereby the material is comminuted; and means for causing during use of the apparatus a predominantly upward airflow from the lower region to the upper region of the housing which airflow entrains a portion of the comminuted material and conveys
30 it to the upper region of the housing for classifying said portion of the comminuted material according to particle size to produce said product.

In accordance with a further aspect of the present invention there is provided equipment comprising:
35 an apparatus in accordance with said other aspect of the present invention; first conveyor means for conveying the feed material to the inlet; and

second conveyor means for returning oversize particles from a further output of the apparatus to said first conveyor means for recomminuting said oversize particles.

5 In one embodiment of the present invention, the crusher comprises a rotor which is adapted to rotate about a vertical or substantially vertical axis and which, in use, causes the feed material to be flung centrifugally towards the impact surface.

10 The given size will vary according to the desired requirements for the characteristics of the product and is dependent on the velocity of material leaving the rotor, the velocity of the air-flow and the type and density of the feed material.

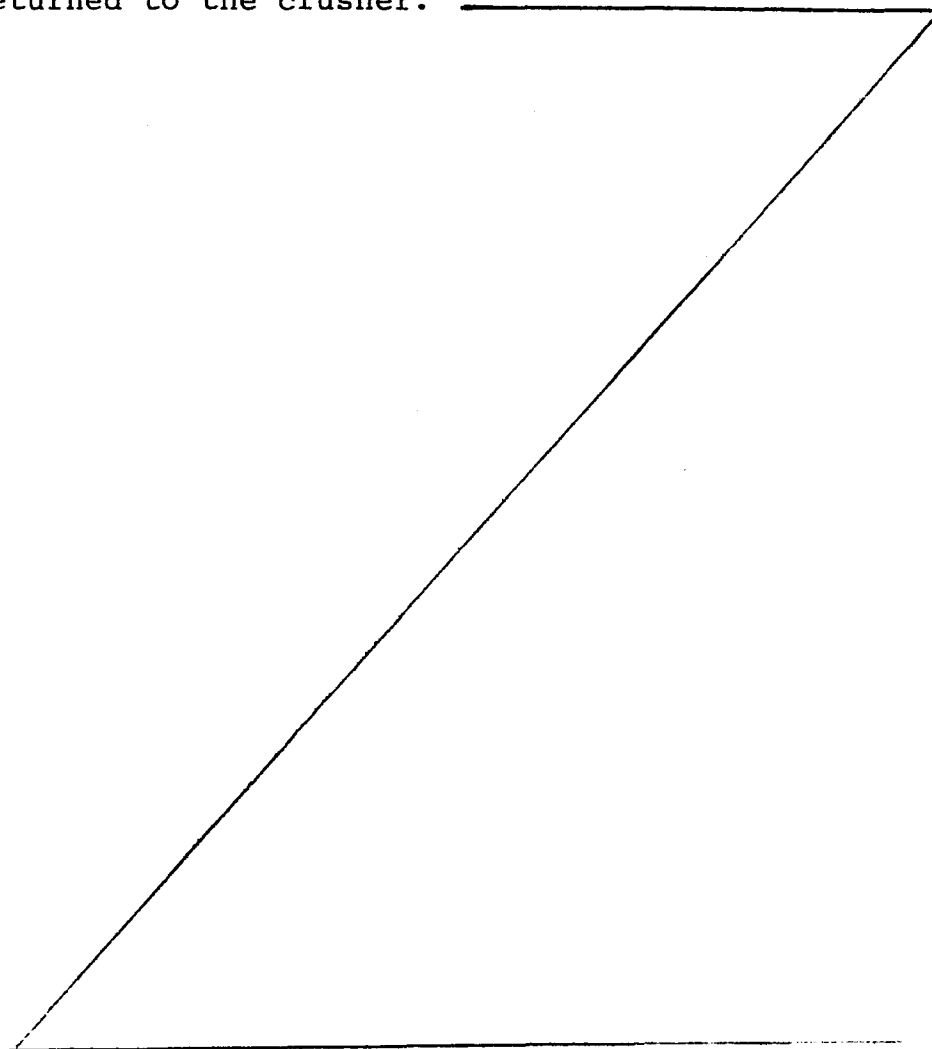
 The apparatus of the invention can be constructed
15 by modifying a crusher of the kind which utilise stonebeds or crushing beds derived from the same material as that which is to be comminuted, either by impact or attrition or interparticle comminution. A crusher of this type is described in British Patent
20 Specification No. 1439639, the matter contained therein being herein incorporated by reference.

 The crusher of British Patent Specification No. 1439639, and the method of crushing described therein give rise to a certain amount of a "fine
25 product" which heretofore has merely been a byproduct of the crushing process. In this context the term "fine product" is used to describe particles having a size of less than 150 μ m.

 We have now found that if the crusher of British
30 Patent Specification No. 1439639 is modified so as to provide an apparatus in accordance with the present invention, a "fine product" output comparable to that achieved by conventional grinding mills of roller and ring or roller and table design, can
35 be attained by the apparatus, with savings in capital costs and running costs, especially in the case of abrasive fines.

Preferably, in the apparatus according to the one aspect of the present invention, the lower region of the housing is provided with a lid portion having one or more aperture through which said predominantly upward airflow can pass for conveying said portion of comminuted material to the upper region of the housing.

In the described embodiment, the classifier comprises a double cone separator having an outer cone for receiving said predominantly upward airflow and an inner cone through which comminuted material comprising particles greater than a given size can be returned to the crusher.



For a better understanding of the present invention, and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

5 Figure 1 shows on a larger scale part of an apparatus in accordance with one embodiment of the present invention;

Figure 2 shows a diagrammatic section through the apparatus of which part is shown in Figure 1;

10 Figure 3 illustrates diagrammatically equipment using an apparatus in accordance with another embodiment of the present invention;

Figure 4 shows a section through an apparatus as shown in Figure 3;

15 Figure 5 is a plan view of the apparatus of Figure 4;

Figure 6 is a view looking in the direction of arrow VI in Figure 4;

20 Figure 7 is a view looking in the direction of arrow VII in Figure 4; and

Figure 8 is a section taken along line VIII-VIII in Figure 4 with the feed chute having been removed.

25 Figure 1 shows a portion of a crusher such as that described in British Patent Specification No. 1439639 which has been modified to provide an apparatus in accordance with the present invention and which is generally designated by reference numeral 10. Large amounts of a "fine product" are internally circulating, within the confines of a housing 12
30 of the crusher, on an air current caused by the fan effect of the rotor 13. Furthermore, due to internal air vanes 14 within the housing 12, the airflow is caused to circulate in an upwards direction, i.e. vertically upwards from the horizontal plane
35 of the rotor 13. One important modification is

the construction of a lid 1 of the housing 12 as a removable portion, rather than as an integral part of the housing.

5 Arrow A indicates the direction of the predominant air flow within the housing; arrow F_1 indicates the incoming feed; and reference numeral 16 indicates a dust flap.

10 Thus, as shown in Figure 2, a "double cone separator", generally designated by reference numeral 11, is attached over the portion of the crusher shown in Figure 1, thereby making it possible to extract the "fine" airborne material into this double cone separator.

15 The double cone separator is constructed as follows:

Two cones 18, 19 of differing dimensions are constructed, the smaller cone 18 being fixed inside the larger cone 19 with a space 20 between the two cones.

20 Around the periphery of the top of the inner cone 18 are vanes 21 which can be mechanically adjusted from the outside of the encapsulating outer cone 19. In addition, a duct 17 is led from the inner cone 18 to the outside upper end of the larger,
25 outer cone 19. This duct 17 is attached to a suction fan which in turn is in series with a cyclone. The lower end of the smaller, inner cone 18 is led back into a feed hopper 22 of the crusher where it is sealed to the feed hopper structure.

30 It is possible to induce greater volumes of a "fine product" into the separator 11 by connecting the exit or discharge part of the separator to a multi blade fan which is in effect sucking the material up into the double cone. Differing points of split
35 can be attained by operating the fan which draws the fine material from the crusher 10, passing it

into the large enclosing cone 19 where it takes up a cyclonic motion, and then either moving the control vanes 21 radially or tangentially.

5 The "fine" fraction of material exits via a fan duct and ultimately discharges the required fines into a cyclone for future reclamation, while the coarse material falls down the inner cone 18 and is discharged back into the crusher 10 via a sealed joint into the crusher feed system.

10 The arrows F indicate the "fine" material which is to be classified, and the arrow O represents the tailings which are returned to the crushing chamber 23 of the crusher 10.

15 The particles in the comminuted material which are not entrained in the upwards airflow fall through a discharge chute 24 and may be returned to the feed hopper of the crusher 10 by means of conveyor belts 25, 26.

20 As an alternative to the external fan it is possible to attach fan blades to the rotor 13, adjusting the power of the motor or feed to compensate for the additional drag which would result.

25 This could be achieved by attaching a fan plate to the top of the rotor, and would reduce the required capacity of the external fan.

30 Figure 3 shows an alternative arrangement for using a crusher in accordance with another embodiment of the present invention (and shown in Figure 4). In the arrangement of Figure 3, a feed hopper 30 is arranged to supply a feed material fed into the hopper 30 to a table feeder 32. A first feed conveyor 34 is arranged to transport material from the table feeder 32 to an inlet of the crusher, generally designated by reference 10' in Figure 3. As described
35 earlier, coarse material is discharged at an outlet of the crusher 10' to be returned by means of a second conveyor 36 to the first conveyor 34 for

recycling to the inlet of the crusher 10'. A screen 38 may be used for screening material discharged from the crusher 10' on conveyor 36 before it is returned to conveyor 34. The fines output from the crusher 10' is fed via ducting 40 to a cyclone 42 which has an output to a bagging plant for reclamation of the "fines". An extraction fan and motor 44 is disposed in ducting 46 leading from the cyclone 42 for the extraction of air from the cyclone. It has been found in use of the apparatus that the air outputted from duct 46 contains a high portion of extremely fine material so for the purposes of reclaiming this material and so that it is not dispersed into the atmosphere, ducting 46 leads to one or more bag filter for collection of the extremely fine material.

The arrangement of Figure 3 with the feed hopper 30 and conveyors 34, 36 has the advantage that the feed material inputted to the crusher 10' may be controlled. The screen 38 is installed to take out coarse material only as required. This enables material of a more or less constant bulk density to be inputted to the apparatus to avoid problems which may arise due to an insufficient amount of large particles being present, such as reduced crushing efficiency and stalling of the motor.

The crusher 10' shown in Figure 3 will now be described in more detail with reference to Figures 4 to 8, primed reference numerals designating the same parts as reference numerals in Figures 1 and 2. The standard details of the crusher are shown in British Patent Specification No. 1439639 and are not described in detail herein. The crusher shown in Figure 4 has an input duct 48 into which feed material is fed from conveyor 34 in the direction of arrow F2'. The feed material enters the crusher and is flung outwards by rotor 13' to be crushed

against a bed of material built up against the walls of the housing 12' in a crushing chamber 23'.

5 The apparatus shown in Figure 4 differs from that shown in Figure 1 in that the removable portion or lid 1' of the housing 12' is provided, as shown in Figure 5, with twelve circumferentially spaced openings 50 (three only being shown in Figure 5). With twelve such openings 50, the angle ϕ is 30° . In addition, the larger cone 19', instead of being
10 constructed along the dotted line in Figure 4 (as it is in Figure 1) is constructed as a cone in its upper region with upwardly extending walls 52 in its lower region which meet the lid 1' of the housing 12' at a region which is further away from the centre line of the crusher 10' than in the apparatus of
15 Figure 1. In the embodiment shown in Figure 1, the air must flow around a corner between the rotor 13 and the housing 12 which can create a restriction in the air flow, and turbulence. In contrast, in
20 the embodiment shown in Figure 4, the air can flow directly upwardly from the crushing chamber 23' without such restriction. This disposition of the walls 52 of the larger cone 19' of the separator in combination with the openings 50 in the lid 1' remarkably increases the upward flow of air from
25 the crusher through the separator, and consequently the percentage output of "fines".

Twelve air inlets 54 (Figure 6) are disposed in the upwardly extending wall 52 of the larger
30 cone 19', which enable a further adjustment of the air flow to be made. In practice, however, it has been found that the crusher operates in an optimum manner with these air inlets fully open. The flow of air through the crusher can also be controlled
35 by adjustment of the spacing of vanes (not shown in Figure 4) in the upper region of the separator and of a thimble 56, which can move up and down

between the lines x-x and y-y: with the thimble pushed down, the product becomes coarser. In this way, the particle size in the output material can be finely controlled since it is dependent on the upward air flow which varies with the volume available in the separator.

As shown in Figure 8, an inspection door 58 is provided whereby the crushing chamber 23' can be inspected.

The following dimensions are given by way of example for the crusher shown in Figure 4:

diameter of thimble 56,	a = 88.5cm
diameter of thimble plate 57,	b = 105cm
outside diameter of upwardly extending wall 55	
of inner cone,	c = 140cm
inside diameter of upwardly extending wall 54	
of outer cone,	d = 177cm
vertical dimensions of separator,	e = 33cm
	f = 150cm
	g = 199cm
	h = 252cm
width of air inlet 54,	i = 31cm
spacing between air inlets 54,	j = 15.3cm
spacing between ports 50,	k = 10cm
width of feeder 48,	l = 56cm
width of inspection door 58,	m = 50cm

As an illustration of the capability of the crusher shown in Figure 4, the following tests have been carried out using calcined phosphate. In the test:

the speed of the conveyor belt 34 feeding the crusher was 400ft per minute (2.03 ms^{-1});

the speed of the recycling conveyor 36 was 200 ft per minute (1.02 ms^{-1});

the recycling rate of material through the closed circuit 34, 10', 36 was 32.8 tons (33.3 tonnes) per hour;

The motor being used was generating 150 horse power; and the volume of air used was 14,000 cubic

ft per minute (0.025 cubic metres per second),
although this could be reduced to about 11,000
cubic ft per minute for a similar output.

Material: Calcined Phosphate from West Africa.

5

Feed Size: All minus 30 mm.

1. Capacity: 2.5 T.P.H. (2.54 tonnes per hour) finished
product. (Classifier set fine)

10 Analysis of Product:

	TEST A	TEST B	TEST C
- 420 micron	99.8%	99.9%	99.9%
- 210 micron	97.6%	98.0%	98.1%
- 150 micron	94.9%	95.4%	96.5%
- 75 micron	81.6%	82.2%	86.0%
- 53 micron	70.4%	70.4%	75.2%

15

20

2. Capacity: 5.76 T.P.H. (5.85 tonnes per hour) finished
product (Classifier set coarse).

Analysis of Product:

25

	TEST A
- 420 micron	99.5%
- 210 micron	98.1%
- 150 micron	92.7%
- 75 micron	52.9%
- 53 micron	27.6%

30

35

In the above test, the rise in temperature of the material after one hour was 15°C, the temperature remaining stable thereafter. This rise in temperature can be an advantage, particularly where hygroscopic materials are being used. Thus, the apparatus is
5 capable of handling raw feed material which has not been previously dried. About 10% of the net output was carried forward as extremely fine material to the bag filters via ducting 46.

Typically, the feed material inputted to the crusher may have a bulk density of about 81lb per
10 cubic ft (0.35 kg per cubic centimetre).

The test results are illustrative of the extremely high percentage of "fines" in the output which can be achieved from the apparatus of the present invention. The apparatus accordingly has applications
15 for use with a wide variety of materials, and is particularly useful with very abrasive materials which cannot be used economically in existing fine grinding mills.

Other advantages of the apparatus of the present invention are as follows:

- 20 a) its increased capacity, that is the quantity of material which can be comminuted per unit of energy input to the apparatus;
- b) the possibility of using the crusher for very abrasive materials (for example quartzite, basalt, granite, steel slag, copper slag, brown
25 fused alumina, and chinese bauxite) with greatly reduced maintenance costs due to wear and tear, this being a result of the crusher being designed originally for crushing highly abrasive materials;
- 30 c) the particle size of feed material can be as high as 50mm, which is much greater than the material normally accepted by existing fine grinding equipment; and
- d) since no metallic grinding plates are used,
35 as in many conventional fine grinding mills, contamination of the output product is minimal - this is particularly useful where the final product is to be used in high grade materials.

It will be appreciated that an apparatus and a method in accordance with the present invention may be used to produce a "fine product" for a variety of applications. For example, for industrial applications, the product material may comprise phosphate, potash or talc. The apparatus may further be used in the field of metalliferous mining to extract a metal, such as copper, tin, silver, gold, iron, lead or zinc, from its ore.

In addition, as mentioned hereinabove, the apparatus is capable of handling material of a higher moisture content than most existing equipment since the material is not forced through a gap of a predetermined size as occurs, for example, in roller path type grinding mills. In such mills, material with a high moisture content can become compacted and thus affect operation of the mill.

CLAIMS

1. A method of obtaining a comminuted product
at least a major proportion of which is smaller
than 150 μ m from a solid feed material at least a
5 major proportion of which is larger than 1cm, which
method comprises centrifugally flinging the feed
material towards an impact surface which is composed
partially or wholly of such material whereby the
feed material is comminuted; and entraining in a
10 predominantly upward airflow a portion of the
comminuted material comprising particles of less
than a given size, to classify the particles to
produce the product.

15

2. An apparatus for obtaining a comminuted
product from a solid feed material, which apparatus
comprises a housing having a lower region forming
20 a crusher, an upper region forming a classifier,
an inlet for a solid feed material, and an outlet
for a product, wherein the crusher comprises:

means which, in use, cause the feed material
to be flung towards an impact surface in said lower
25 region of the housing, said means and the
disposition of the lower region of the housing being
such that some of the feed material is retained,
by gravity and friction forces, in said lower region
of the housing so that the impact surface is composed
30 partially or wholly of the material so retained,
whereby the material is comminuted; and means
for causing during use of the apparatus a predom-
inantly upward airflow from the lower region to the
upper region of the housing which airflow entrains
35 a portion of the comminuted material and conveys
it to the upper region of the housing for classifying
said portion of the comminuted material according

to particle size to produce said product.

3. An apparatus as claimed in claim 2, wherein the crusher comprises a rotor which is adapted to rotate about a vertical or substantially vertical axis and which, in use, causes the feed material to be flung centrifugally towards the impact surface.

4. An apparatus as claimed in claim 2 or 3, in which the lower region of the housing is provided with a lid portion having one or more aperture through which said predominantly upward airflow can pass for conveying said portion of comminuted material to the upper region of the housing.

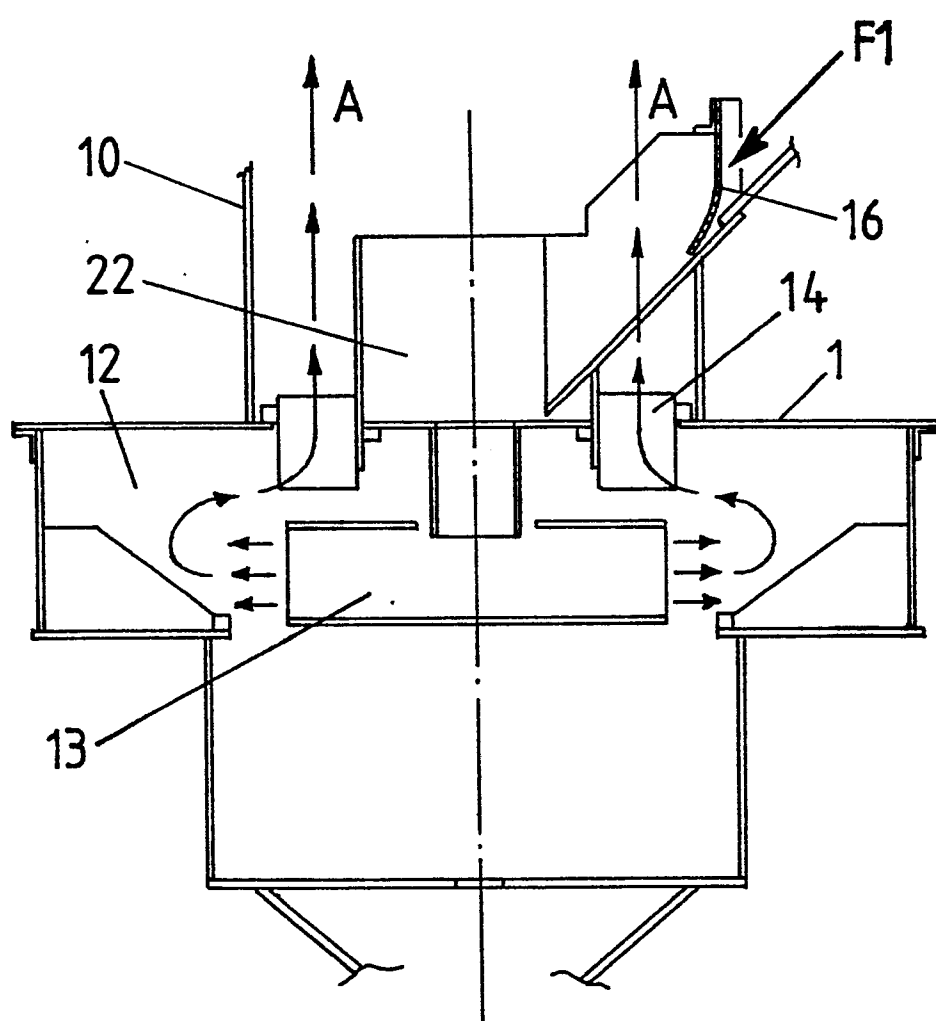
5. An apparatus as claimed in claim 2, 3 or 4, wherein said classifier comprises a double cone separator having an outer cone for receiving said predominantly upward airflow and an inner cone through which comminuted material comprising particles greater than a given size can be returned to the crusher.

6. Equipment for obtaining a comminuted product comprising: an apparatus as claimed in any of claims 2 to 5; first conveyor means for conveying the feed material to the inlet; and second conveyor means for returning oversize particles from a further output of the apparatus to said first conveyor means for recomminuting said oversize particles.

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FIG. 1.



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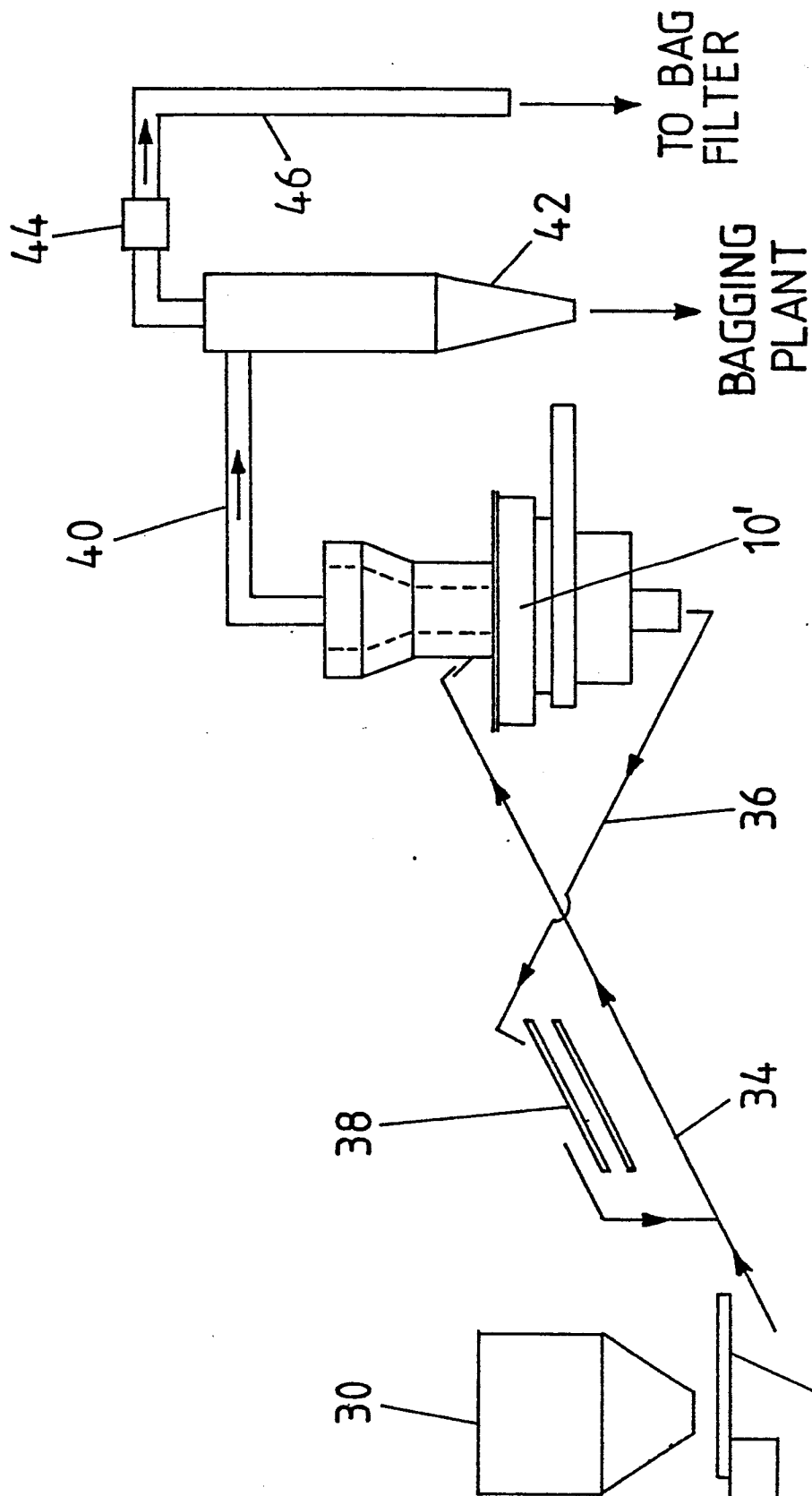


FIG. 3.

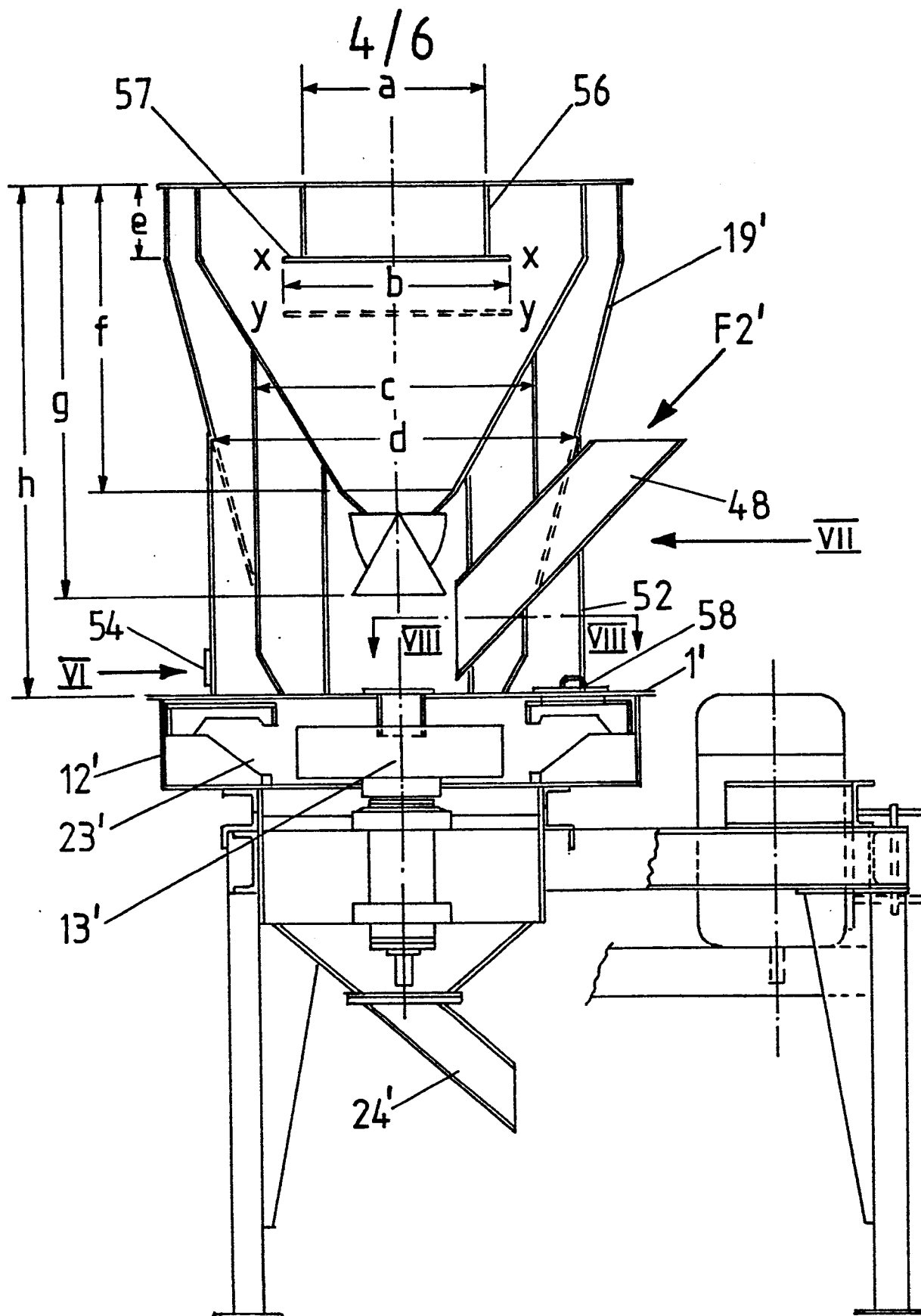
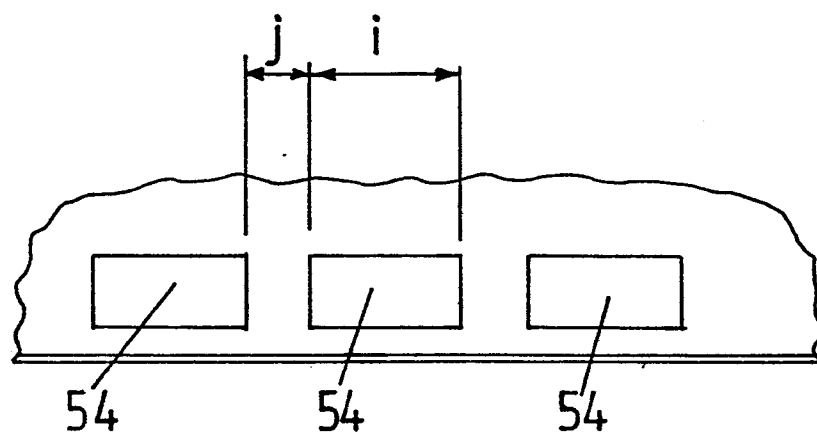
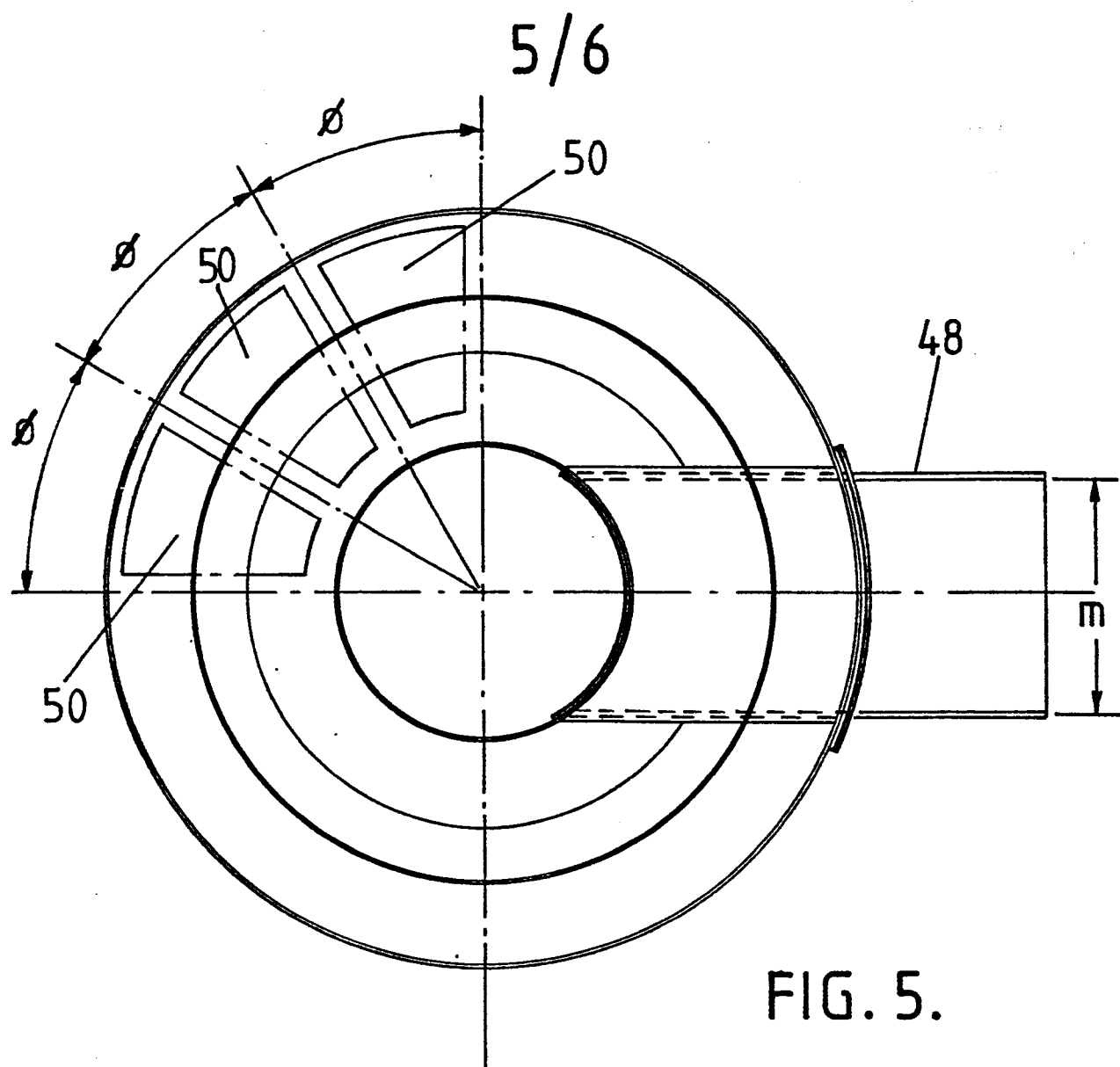


FIG. 4.



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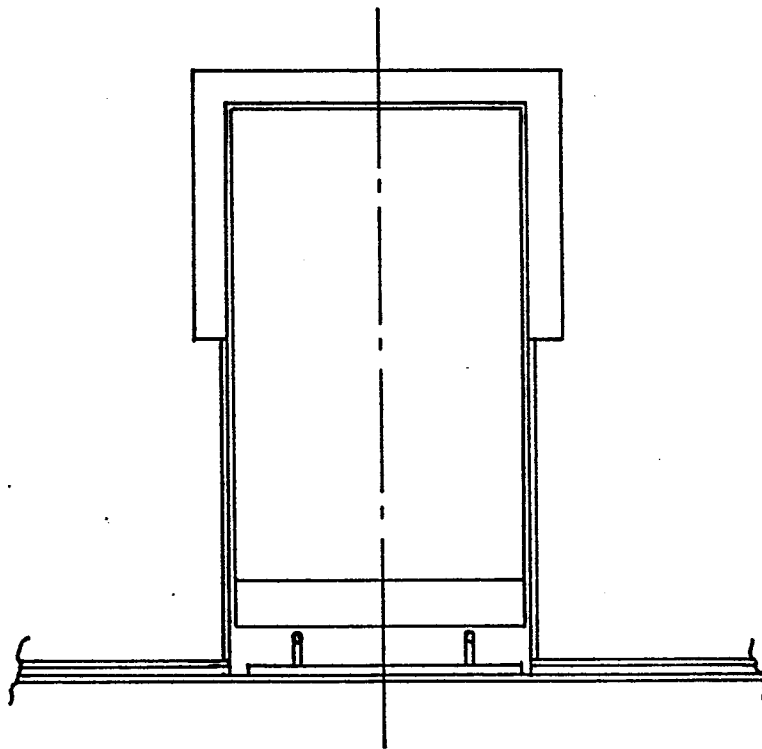


FIG. 7.

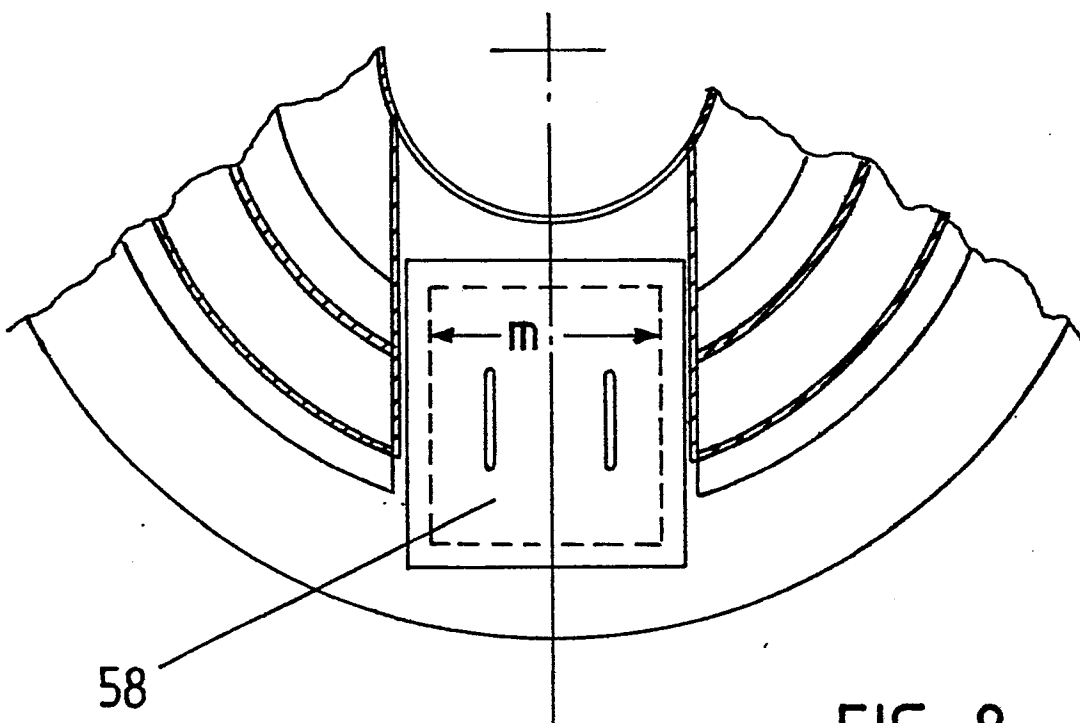


FIG. 8.