

[54] **APPARATUS FOR COOLING SOLID PARTICULATE MATERIAL**

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[52] U.S. Cl. .... 432/80, 432/118

[51] Int. Cl. .... F27b 7/02, F27b 7/14

[58] Field of Search. .... 432/80, 118, 77

[56] **References Cited**

**UNITED STATES PATENTS**

1,179,952	4/1916	Mount .....	432/118
3,441,259	4/1969	Heyer et al. ....	432/118
3,607,121	9/1971	Watson .....	432/118
3,643,933	2/1972	McDonald .....	432/80

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[57] **ABSTRACT**

Apparatus for cooling solid particulate material treated in a kiln comprising a plurality of elongated cylinders attached to the periphery of a rotary kiln. Particulate material is discharged from the kiln into the material inlet of the cooler while cooling air is introduced into the cooler countercurrent to the material flow. The particulate material is uniformly advanced from the material inlet to the outlet by means of a helical plate means which is continuous throughout its length. Annularly offset openings in the plate means deflect the cooling air from its initial flow path in order to increase the rate of heat transfer between the cooling gas and the particulate material, plate means and walls of the cooler. The plate means is easily manufactured and installed. The plate means is designed to prevent clogging by the particulate material. The interior of the cooler and the entire plate means are easily accessible for maintenance or repair by means of access doors near the material inlet and outlet. Spent gas is returned to the kiln to be used as preheated air of combustion.

6 Claims, 8 Drawing Figures

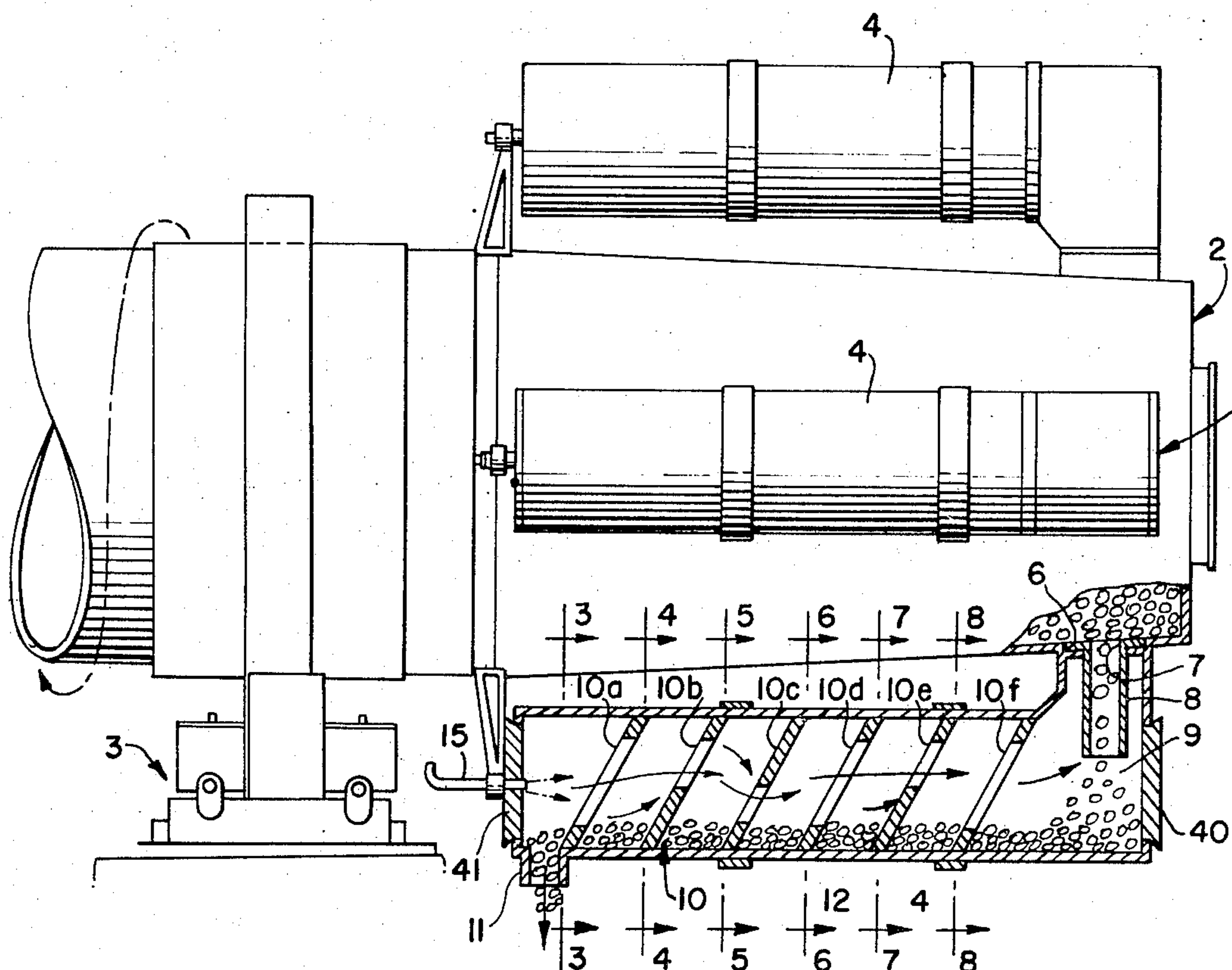


FIG. 1.

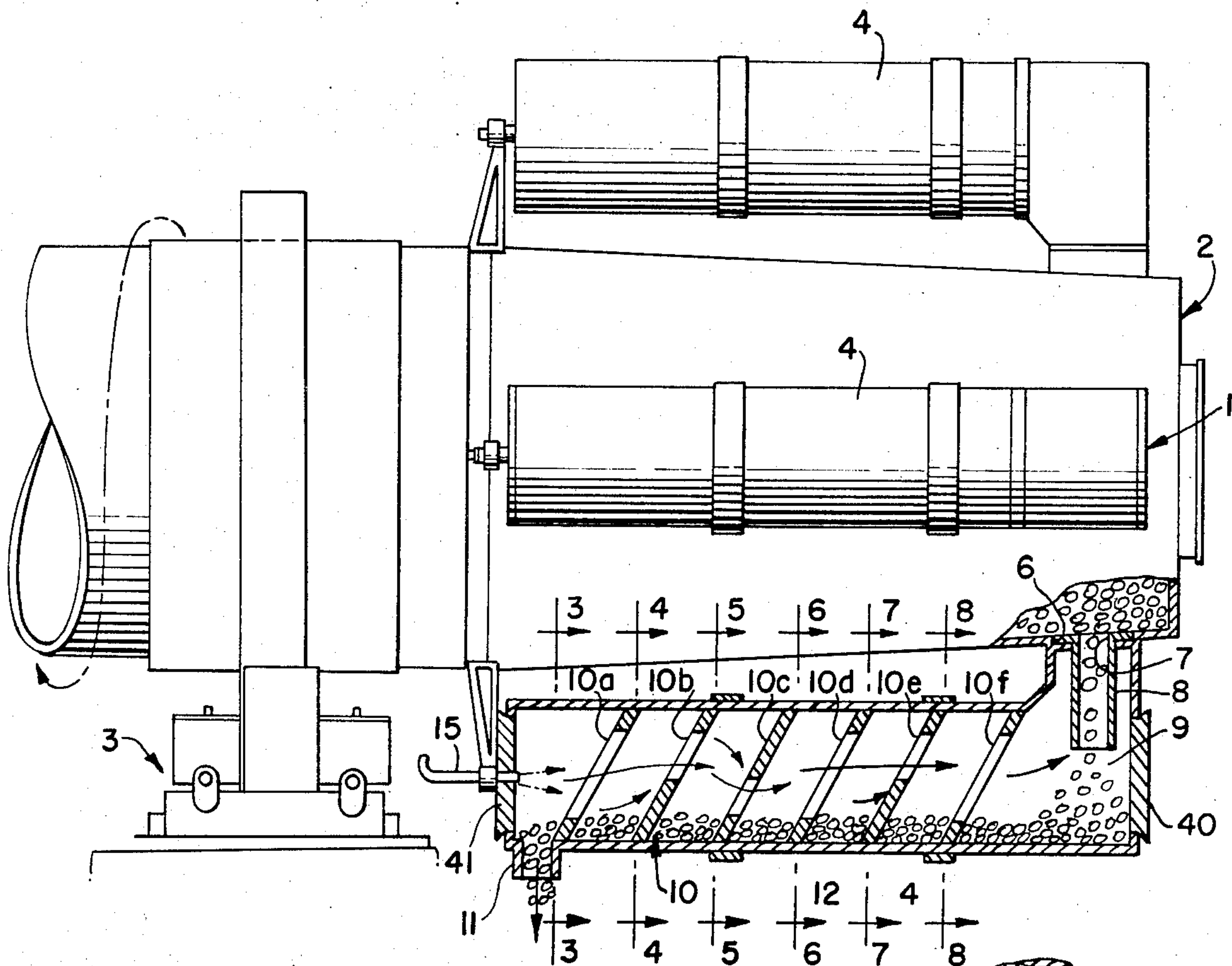


FIG. 2.

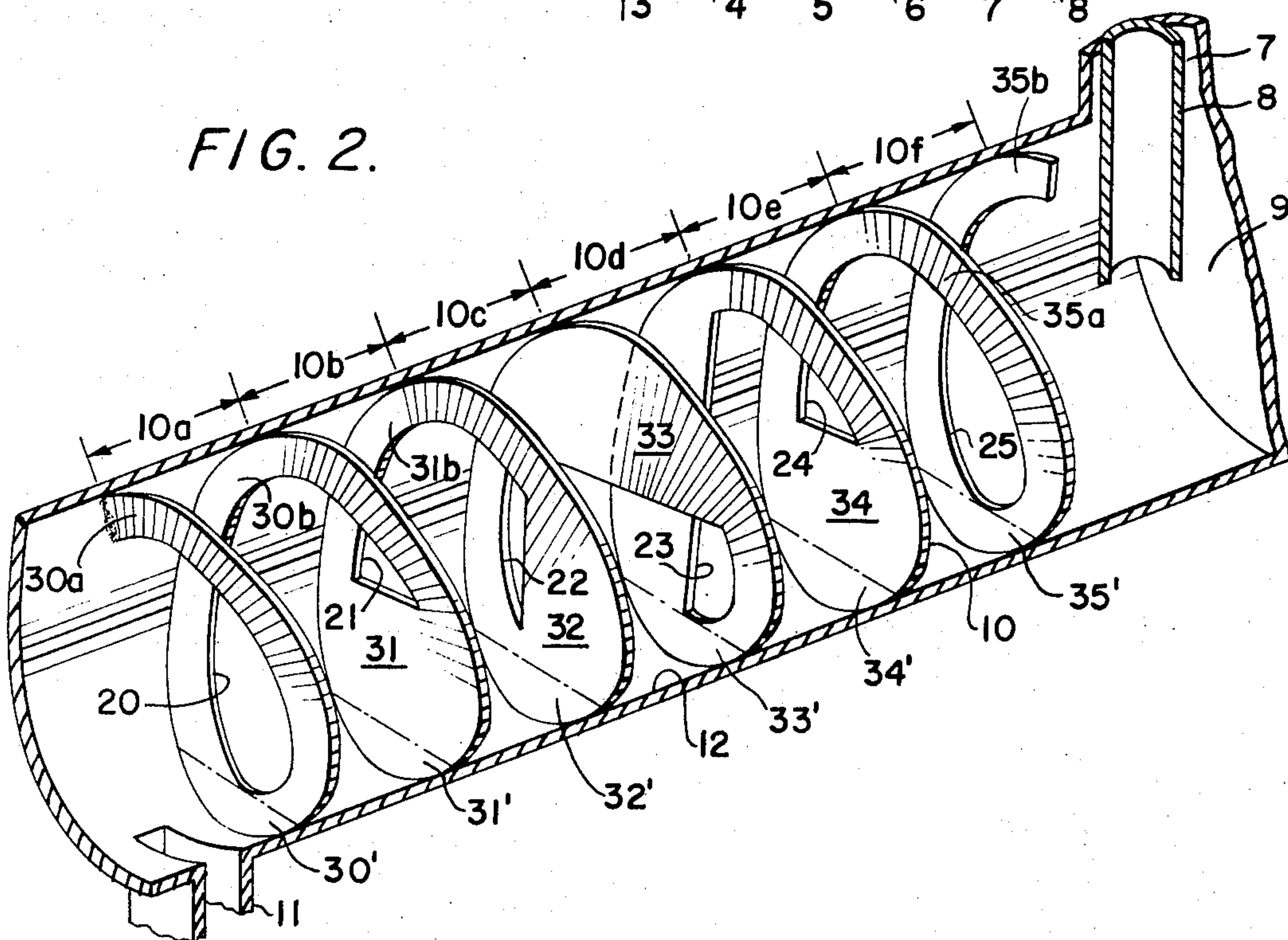




FIG. 3.

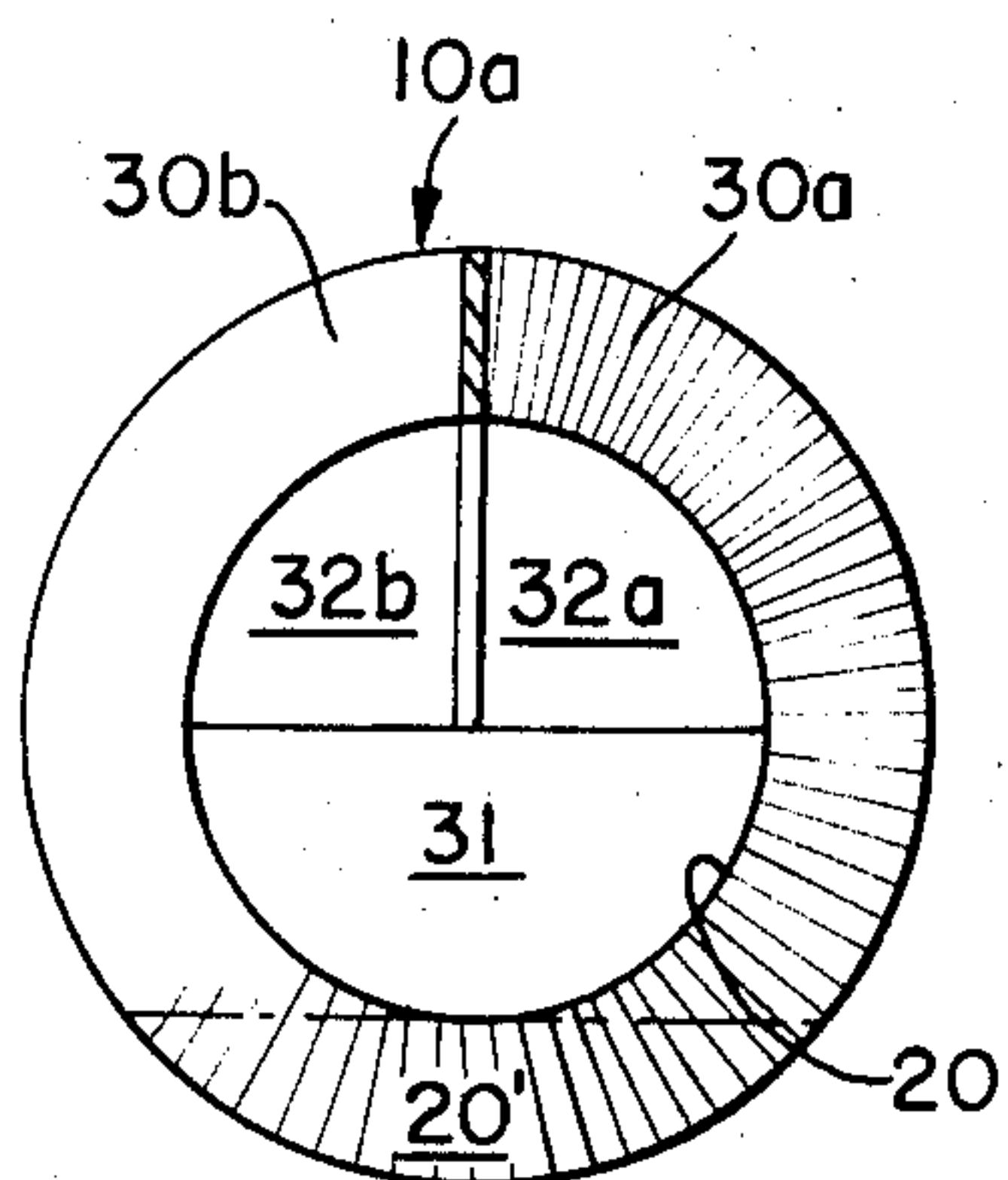


FIG. 4.

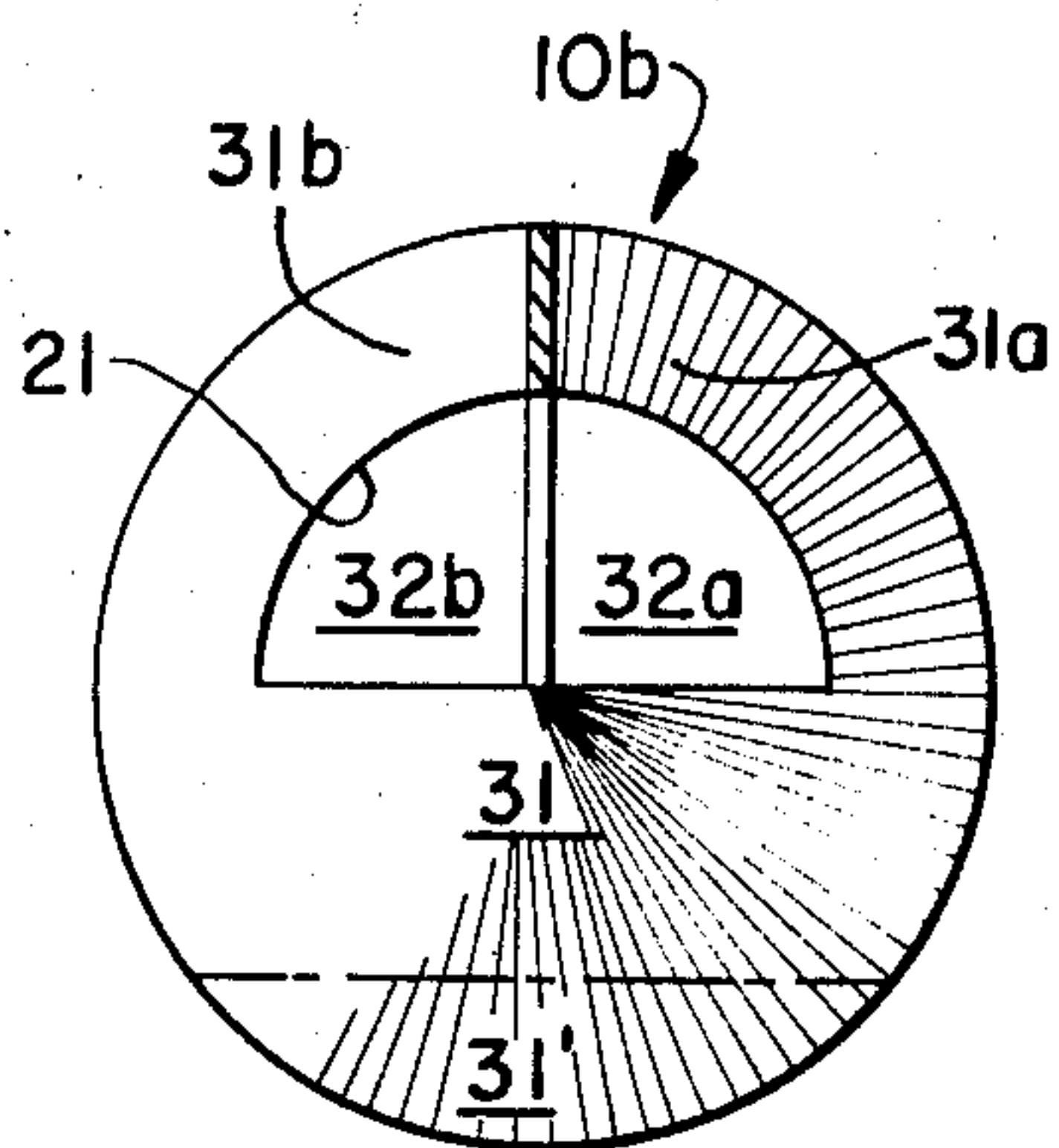


FIG. 5.

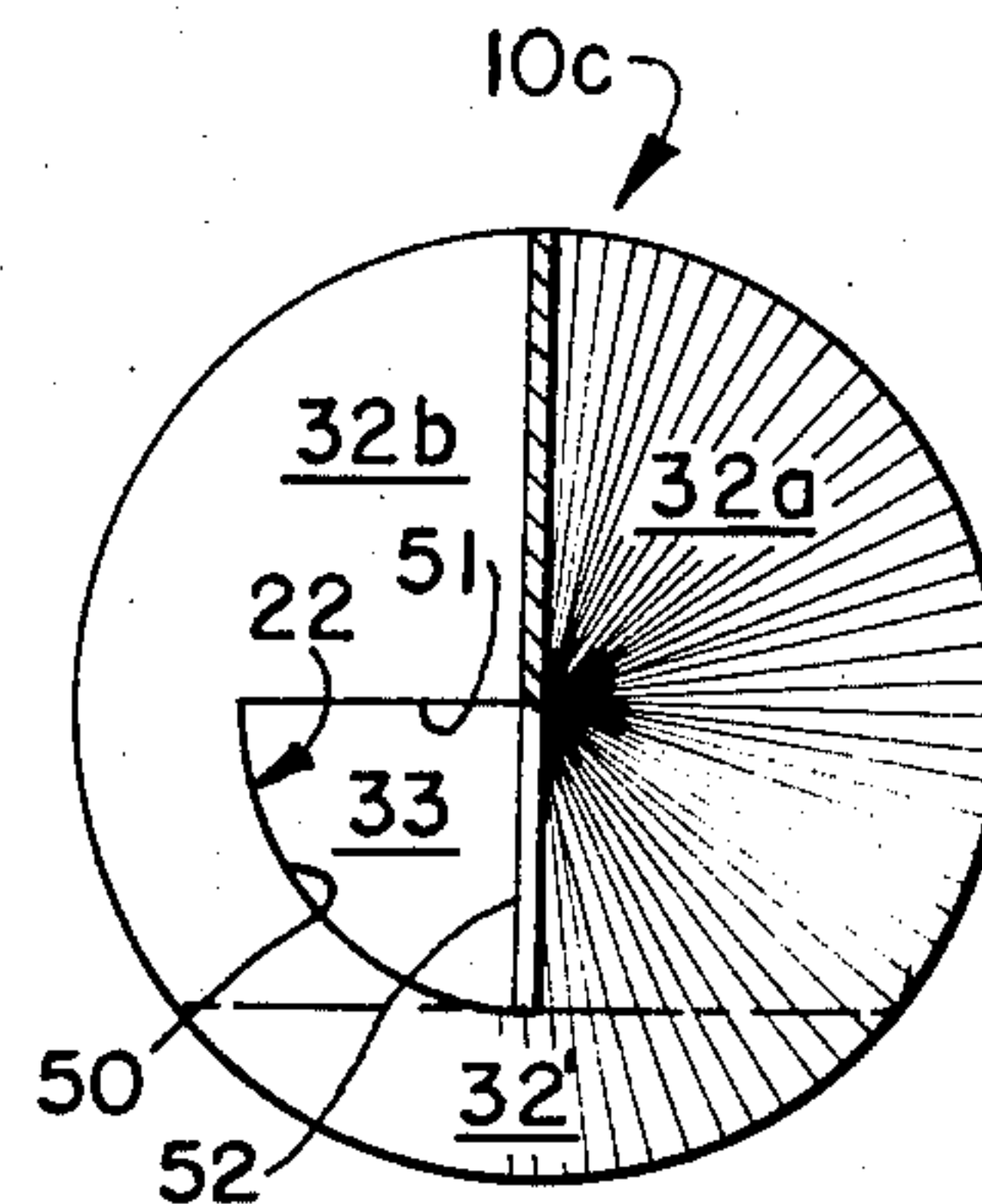


FIG. 6.

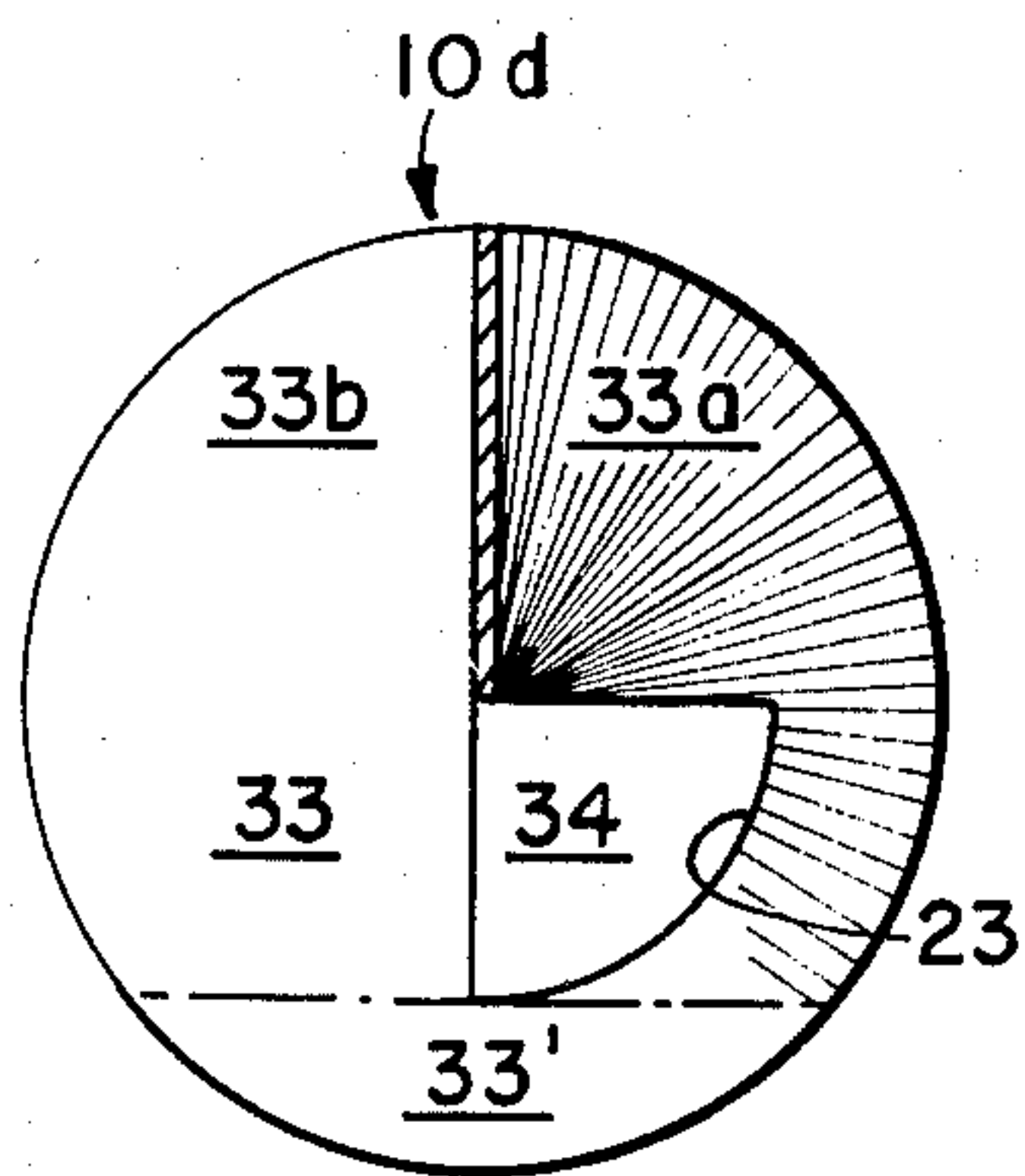


FIG. 7.

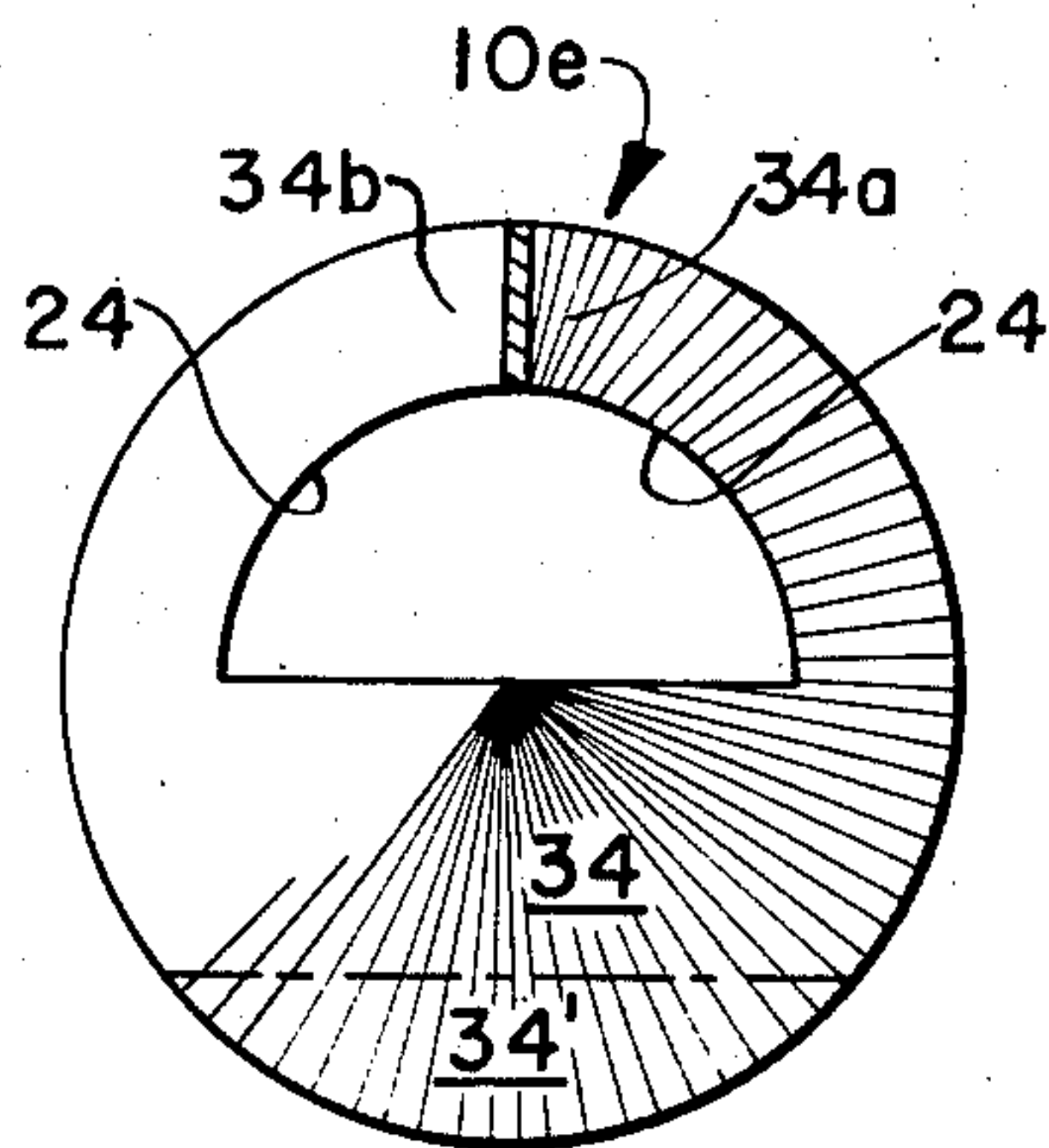
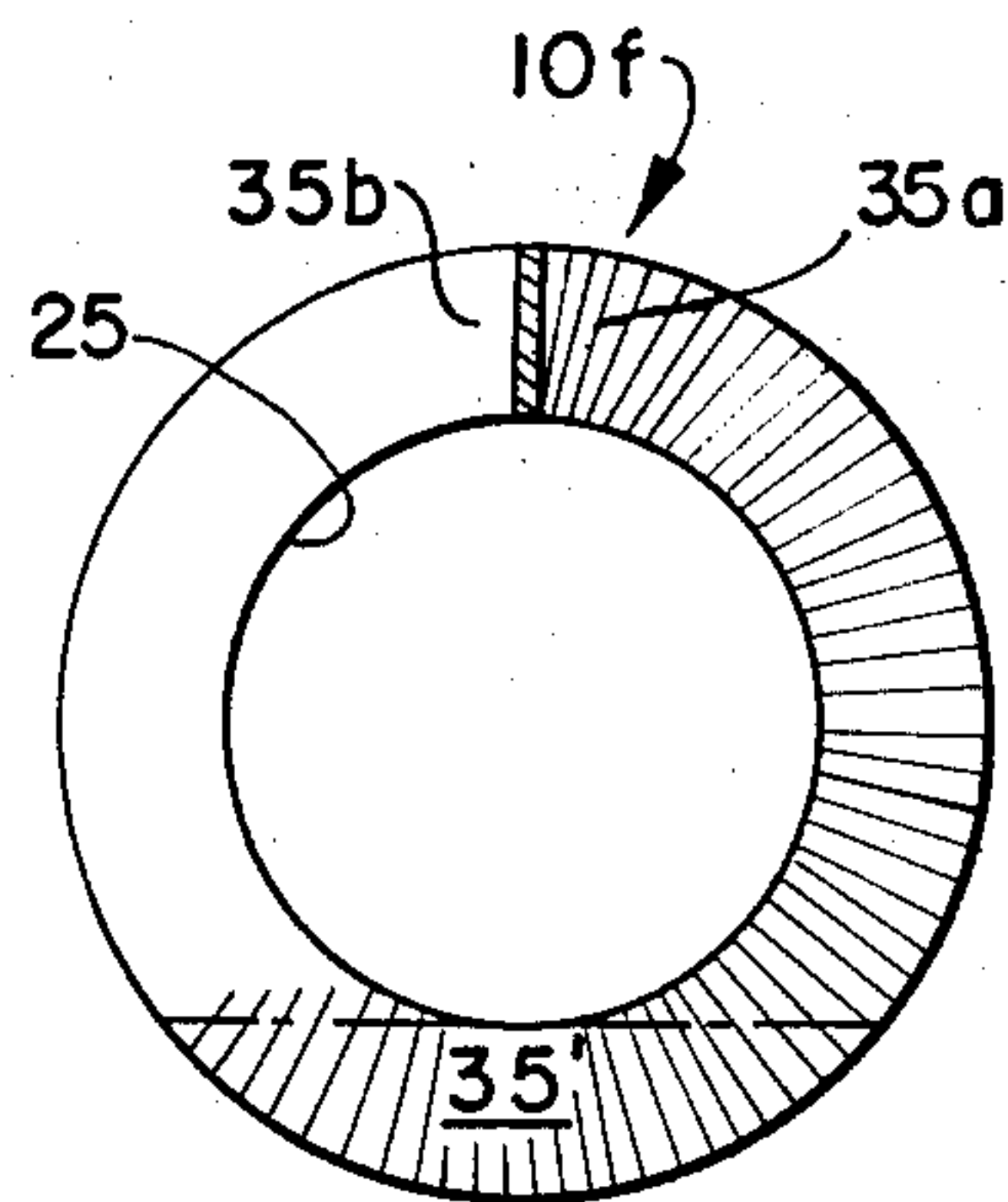


FIG. 8.





## APPARATUS FOR COOLING SOLID PARTICULATE MATERIAL

### BACKGROUND OF THE INVENTION

The present invention provides attached tube coolers for cooling material treated in a kiln including an improved means for obtaining effective heat transfer.

Coolers arranged in a planetary fashion around the periphery of a rotary kiln have been used to cool particulate material discharged from the kiln for many years. Particulate material is fed into the material inlet near one end of a cooler as large quantities of the cooling gaseous fluid, usually air, is introduced countercurrent to the material flow near the material outlet. Spent air passes from the cooler through the material inlet into the kiln to be used as preheated air of combustion.

Coolers of the prior art have tried various means to increase the rate of heat transfer between the particulate material and the gaseous fluid. U.S. Pat. No. 1,905,744 is illustrative of helical plate means attached to the inner wall of the cooler which advance material at a uniform rate. By varying the pitch of the helix, the amount of time which the particulate material is retained within the cooler can be controlled, subject to certain limitations imposed by the discharge rate of particulate material from the kiln. Cooling air is passed through the concentric openings in the various plates which comprise the helix. A disadvantage of this type of cooler is that much of the cooling air will not contact the particulate material, the plate means, or the interior walls of the cooler but will instead pass unobstructedly through the concentric openings in the plate means from the inlet to the outlet.

In an effort to overcome the disadvantage described above, complex diverting baffle plates were introduced within the openings of the helical plate means in order to deflect the cooling air from its initial path parallel to the axis of the cooler against the surfaces of the particulate material, plate means, and the inner walls of the cooler and thereby achieve an increased rate of heat transfer for a given quantity of cooling fluid. The baffle plates of the prior art were difficult to manufacture, install, and replace. The baffle plates were also subject to clogging by the particulate material which may at times be binding or adhesive. During extreme conditions, a complete blockage of the cooler plate means may necessitate shutting down of the entire kiln operation in order to effect unclogging of one or more of the coolers. An access opening must generally then be burned with a torch through the side wall of the cooler casing to permit unclogging of the plate means. shutdowns of the kiln operation and cleaning of the cooler in this manner cause extremely costly delays.

### SUMMARY

It is, therefore, the principal object of this invention to provide an attached tube cooler for a rotary kiln which improves the heat exchange between the hot material and the cooling air.

It is another object of this invention to provide an improved cooler for hot particulate material which permits greater contact between the hot material and the cooling air than can be achieved with prior cooler of the type to which the present invention relates.

It is a still further object of this invention to provide an attached tube cooler for a rotary kiln which improves material advancement through the cooler.

The objects of the present invention will be achieved by providing apparatus for cooling solid particulate material treated in a rotary kiln including a plurality of elongated cylinders adapted to be connected to the rotary kiln for rotation with said kiln about an axis; each of said cylinders having an inlet at one end for receiving hot solid particulate material discharged from said kiln, an outlet at the other end for discharging cooled solid particulate material from said cylinder; means adapted to be connected to said other end of said cylinder for supplying cooling air to said cylinder whereby the cooling air passes through the cylinder, cools the hot material, is heated by the hot material and is returned to the kiln as combustion air; and apparatus for improving heat exchange between the solid particulate material and the cooling air and controlling the movement of solid particulate material from said inlet to said outlet comprising: a substantially continuous helical plate means rigidly mounted in said cylinder for increasing the rate of heat exchange by contact between the cooling air, solid particulate material and said plate means and having a first flight near said cylinder outlet, a last flight near said cylinder inlet and a plurality of flights intermediate said first and last flights, each of said flights having at least one opening therein for the passage of cooling air therethrough; said opening in at least the first and last flight having a circular opening therethrough having its center on the longitudinal axis of the cylinder; said opening in the flights intermediate said first and last flight having an opening smaller than said circular opening and having its center offset from the center of said circular opening and being spaced angularly from the opening in the adjacent flights to thereby define a tortuous air flow path through said cylinder; each of said openings being dimensioned to permit sufficient cooling air to pass through the cylinder to cool the material.

### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in connection with the annexed drawings wherein:

FIG. 1 is a view of the cooler of the present invention shown in relationship with a rotary kiln with one section of the cooler shown in section;

FIG. 2 is an enlarged perspective view of a portion of the present invention;

FIG. 3 is a sectional view of a portion of the present invention as taken along the lines 3—3 of FIG. 1 in the direction of the arrows; and

FIGS. 4 through 8 are sectional views similar to FIG. 3 as taken along the lines 4—4 to 8—8, respectively, in FIG. 1 in the direction of the arrows.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, a cooler of the present invention generally designated at 1 has been shown in relationship to a rotary kiln which is shown generally as 2. The kiln 2 is rotatably mounted on support roller bearings and kiln riding rings, both shown generally as 3, and is driven by conventional driving means (not shown). The cooler 1 includes a plurality of elongated cylinders 4 each attached to the discharge end of kiln 2 by any conventional means such as welding (not shown). Since the cylinders 4 are fixed to the kiln 2, as the kiln is rotated about its own axis, the cooler 1 will be rotated about the longitudinal axis of the kiln.



Particulate material is discharged from kiln 2 by gravity into each cylinder 4, in turn, as each cylinder rotates below the height of the kiln discharge outlet 6. After material has entered each cylinder 4, it will contact the plate means 10 of the present invention for heat transfer. Material enters cylinder 4 through material inlet 7 which is flow connected to the kiln outlet 6. Particulate material is prevented from reentering kiln 2 when cooler 1 is raised above the axis of the kiln by any conventional means, such as conduit 8 which extends into the material inlet 7 a distance greater than the normal height of the material bed in cooler 1. As material cascades down inlet section 9, it contacts the plate means of the present invention shown generally as 10 and specifically as 10a through 10f. It should be understood that the number of plate means and the helical pitch as shown in FIGS. 1 and 2 are intended merely as schematic representations because these factors will vary for any cooler upon the rate of heat transfer sought to be achieved and the quantity of cooling fluid which is used. Furthermore, while subsequently the cooling fluid will be referred to as "air," it should be understood that any inert gas may be used as a cooling medium and should be considered within the scope of the present invention.

Particulate material will be advanced from the material inlet 7 to the material outlet 11 at a uniform rate by plate means 10 connected to the inner cooler walls 12 by any suitable means, such as welding. Air supplied by any conventional means (not shown) enters the cooler countercurrent to the particulate material through gas inlet 15 and communicates with plate means 10 wherein the air is deflected from its initial path of flow parallel to the axis of the cylinder by plate means 10 and is caused to contact the pulverulent material, the subsequent portions of plate means 10, and the inner cooler walls 12. It is well known that as the time in which the air is retained within the cooler 2 is increased, the rate of heat transfer for a given quantity of air is also increased.

Referring now to FIGS. 2, 3 and 9, plate means 10a and 10f are seen in a plane perpendicular to the axis of the cylinder as screw flights with a concentric circular opening. Plate means 10b through 10e, shown in FIGS. 4 through 7, respectively, are each seen in a plane perpendicular to the axis of the cylinder as a screw flight which has an opening therethrough which is a circular section less than a complete circle.

Plate means 10a and 10f, which are considered transitional plates, provide surfaces 30' and 35' respectively, for advancing pulverulent material while cooling air passes through circular openings 20 and 25. Plate means 10b through 10e, however, have smaller openings, and conversely, larger surfaces to deflect cooling gas tortuously from its initial flow path towards the inner cylinder walls 12 and towards the material which is being advanced through the cooler. More specifically referring to FIG. 2 and 4, plate means 10b is seen to have opening 21 for the passage of cooling air therethrough and surface 31 for deflecting the air into intimate contact with the material to obtain heat transfer. Surface 31 is seen to block and deflect the air, forcing the air through opening 21 towards surface 32 of subsequent plate means 10c. Plate means 10c may be partially viewed through opening 21 in FIG. 4. A portion of the air will initially contact surface 32a and then be

blocked and deflected tortuously towards surface 32b and through opening 22 in plate means 10c.

Referring specifically to FIG. 5, opening 22 in plate 10c is seen as a portion of a circular opening through which surface 33 of plate 10d is visible. Opening 22 may be formed by arc 50 and planar surfaces 51 and 52.

It should be apparent that in forming helical plate means 10, surface 30b of a flat circular plate 10a would be joined as by welding to surface 31a of subsequent plate 10b while surface 31b of the same plate 10b would be joined to surface 32a of subsequent plate 10c. The joining of plates in this manner will be continued until all subsequent surfaces 33 through 35 are similarly joined to provide a helical plate means which is continuous throughout its length for uniformly advancing particulate material while permitting large portions of cooling air to tortuously pass therethrough. Spent air which has passed through the last plate 10f will be discharged from the cooler and enter the kiln to be used as secondary air of combustion.

It is believed that the objects of the present invention will be effectively achieved if the radius of openings 20 through 25 are approximately one-half to three-fourths the radius of the cylinder 4. This radius will permit surfaces 30' through 35' to be higher than the level of the bed of particulate material being advanced by the conveying helix. It should be readily understood that additional portions of intermediate plate means similar to plate means 10b through 10e may be included within the scope of the invention for longer coolers or increased heat transfer and would be assembled and connected to one another and to the inner cooler wall 12 by the same means such as welding and in the same manner as illustratively described above. The flow path of the air from the gas inlet 15 to the gas discharge, if additional plates are included, will be substantially similar throughout the length of the cooler as that which has been described with reference to plate means 10b through 10e.

Referring again to FIG. 1, access door 40 has been provided near the material inlet portion 9 to permit access to the interior of the cooler for inspection, maintenance or repair. The arrangement of the plate means 10 of the present invention should enable a person to easily enter most coolers of conventional size for these purposes. A second access door 41 may also be provided near the material outlet 5 for the same purposes of inspection, maintenance or repair.

In the operation of the cooler 1, the rotation of kiln 2 causes particulate material to be discharged through kiln outlet 6 which is flow connected to cooler material inlet 7, through conduit 8, into the cooler inlet portion 9. The particulate material is uniformly advanced through cooler 1 by plate means 10 towards material discharge outlet 11. Cooling air enters cooler 1 through gas inlet 15 near material discharge outlet 11 countercurrent to the direction of flow of material and contacts plate means 10 which deflects the gaseous fluid against the material and inner cooler walls 12. Spent air which has been heated enters the kiln through the material inlet 7 to be used as preheated air of combustion.

The path of flow of the air may typically be described as passing through opening 20 in transition flight 10a whereupon a portion of the flow contacts surface 31 of flight 10b before being deflected upwardly against the upper portion of the inner cooler wall 12 and down-



wardly towards the particulate material which is advanced by surface 31'. The gaseous fluid then passes through opening 21 in plate means 10b whereupon it initially contacts surface 32a and is then deflected laterally downward, contacting particulate material between plate means 10b and 10c, and then passes through the opening 22 in plate means 10c after contacting surfaces 32b and 33a. The air is deflected downwardly and the flow path of the air repeats the pattern described above wherein opening 23 and surface 33 of plate means 10d correspond to opening 22 and surface 32 of plate means 10c, respectively. While the air is contacting the plate means as described above, the lower surfaces of plate means 10 such as 30' through 35' are uniformly advancing particulate material from the material inlet 7 towards the outlet 11 without the material becoming clogged between the plate means or without clogging the openings. It will be understood that all of the air will be totally deflected from its initial path parallel to the axis of the cylinder within a distance equivalent to twice the pitch of the conveying helix formed by the plate means 10b through 10e. In this way the heat exchange between the air and the material can effectively be achieved.

Inspection, maintenance, and repair of most conventional coolers can be achieved by means of access doors 40 or 41 which will permit a person to enter the cooler. The arrangement and openings of plate means 10 will permit an inspector or repairman to pass through the cooler without the necessity of damaging the side of the cooler or plate means. It will be readily appreciated by those skilled in the art that the various portions of plate means 10 may be easily fabricated from individual circular sections and fastened together by any suitable means such as welding.

While the invention has been described above in reference to a cooler attached to a rotary kiln, it will be understood by those skilled in the art that the apparatus of the present invention can be applied to any heat transfer process such as drying or heating wherein gaseous fluid is communicated with the particulate material, plate means, and inner cylinder walls in an apparatus rotatably mounted and adapted to a source of power for rotating the cylinder. It is for this reason that it is desired that the invention be limited solely to that which is claimed below.

I claim:

1. Apparatus for cooling solid particulate material treated in a rotary kiln including a plurality of elongated cylinders adapted to be connected to the rotary kiln for rotation with said kiln about an axis; each of said cylinders having an inlet at one end for receiving hot solid particulate material discharged from said kiln, an outlet at the other end for discharging cooled solid

particulate material from said cylinder; means adapted to be connected to said other end of said cylinder for supplying cooling air to said cylinder whereby the cooling air passes through the cylinder, cools the hot material, is heated by the hot material, and is returned to the kiln as combustion air; and apparatus for improving heat exchange between the solid particulate material and the cooling air and controlling the movement of solid particulate material from said inlet to said outlet comprising:

a substantially continuous helical plate means rigidly mounted in said cylinder for increasing the rate of heat exchange by contact between the cooling air, solid particulate material and said plate means and having a first flight near said cylinder outlet, a last flight near said cylinder inlet and a plurality of flights intermediate said first and last flights, each of said flights having at least one opening therein for the passage of cooling air therethrough; said opening in at least the first and last flight having a circular opening therethrough having its center on the longitudinal axis of the cylinder; said opening in the flights intermediate said first and last flight having an opening smaller than said cylinder opening and having its center offset from the center of said cylinder opening, being spaced angularly from the opening in the adjacent flights to thereby define a tortuous air flow through said cylinder;

each of said openings being dimensioned to permit sufficient cooling air to pass through the cylinder to cool the material.

2. The apparatus of claim 1 wherein said openings in the intermediate flights are angularly spaced apart to cause all of the gaseous fluid to be deflected from a path parallel to the axis of said cylinder within the distance equivalent to twice the pitch of said helical plate.

3. The apparatus of claim 2 wherein the openings in said intermediate flights include, in a plane perpendicular to the axis of said plate means, a substantially semi-circular shape through which cooling air first passes and substantially a quarter circular section through which cooling air subsequently passes.

4. The apparatus of claim 3 wherein each of said openings have a planar surface which is 90° from the planar surface of the opening in the adjacent flight.

5. The apparatus of claim 4 wherein said continuous helical plate means has an opening which is continuous for the passage of cooling air therethrough.

6. The apparatus of claim 5 wherein the radius of said opening is between approximately one-half to three-fourths the radius of said cylinder.

\* \* \* \* \*

**UNITED STATES PATENT OFFICE**  
**CERTIFICATE OF CORRECTION**

Patent No. 3,809,528 Dated May 7, 1974

Inventor(s) Douglass J. Kramm

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 24, "cylinder" should read --circular--.

Column 6, line 26, "cylinder" should read --circular--.

Signed and sealed this 1st day of October 1974.

(SEAL)  
Attest:

McCOY M. GIBSON JR.  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents