United States Patent [19] [11] 3,905,757
von Dreusche, Jr. [45] Sept. 16, 1975

[54] APPARATUS AND METHOD FOR DISTRIBUTING MATERIAL BEING PROCESSED OVER A FURNACE HEARTH FLOOR

[75] Inventor: **Charles F. von Dreusche, Jr.**, Ramsey, N.J.

[73] Assignee: **Nichols Engineering & Research Corporation**, Belle Mead, N.J.

[22] Filed: **July 18, 1974**

[21] Appl. No.: **489,462**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 362,335, May 21, 1973, Pat. No. 3,834,859.

[52] **U.S. Cl.** **432/18;** 432/22; 432/131; 432/139; 432/142

[51] **Int. Cl.** **F27b 1/02**

[58] **Field of Search** 432/18, 22, 139, 142, 151, 432/131

[56] **References Cited**

UNITED STATES PATENTS

850,041	4/1907	McNeal	432/151
1,251,692	1/1918	Pomeroy	432/151
1,811,920	6/1931	Dickson	432/18
3,834,859	9/1974	von Dreusche, Jr.	432/18

FOREIGN PATENTS OR APPLICATIONS

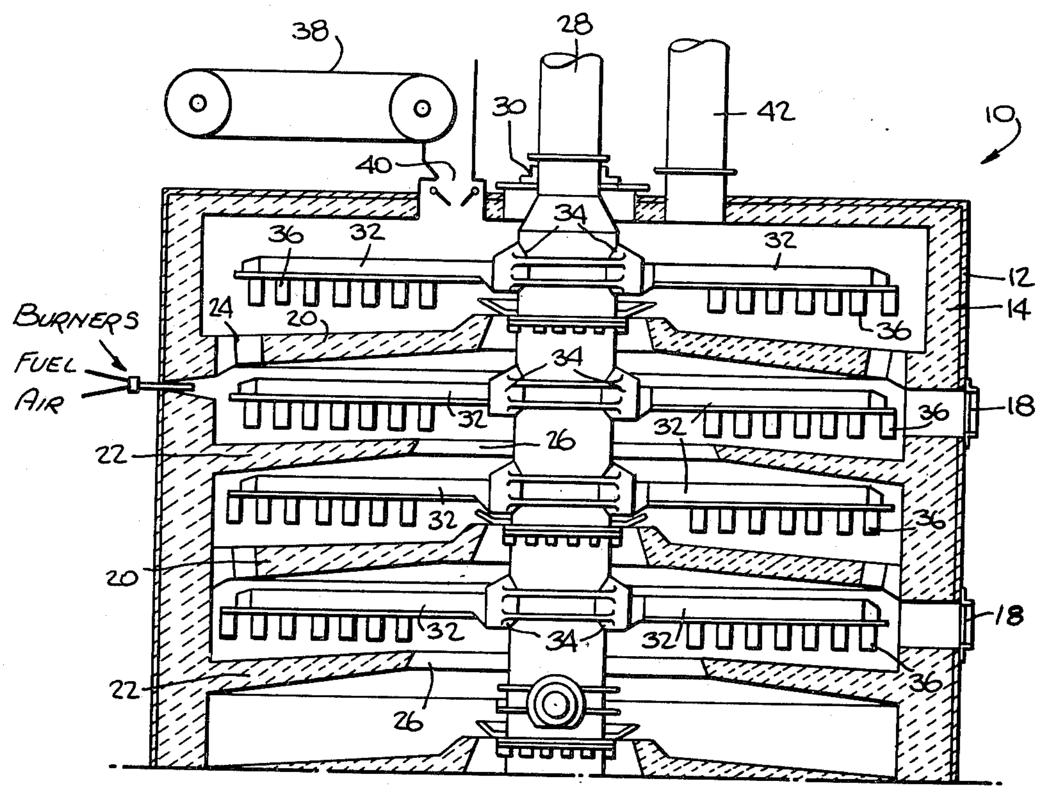
372,965	1932	United Kingdom	432/142

Primary Examiner—John J. Camby
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper, & Scinto

[57] **ABSTRACT**

Method and apparatus for distributing solid material over the hearth of a single hearth furnace or over an upper hearth in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a member for providing a radial flow component of the material being processed on an upper hearth, an independent member for providing the circumferential flow component of the material being processed on the same hearth with respect to the member for controlling the radial flow component, so that when the center shaft is rotated the material being processed is distributed across the entire hearth area, thereby preventing the formation of stagnant zones.

31 Claims, 14 Drawing Figures



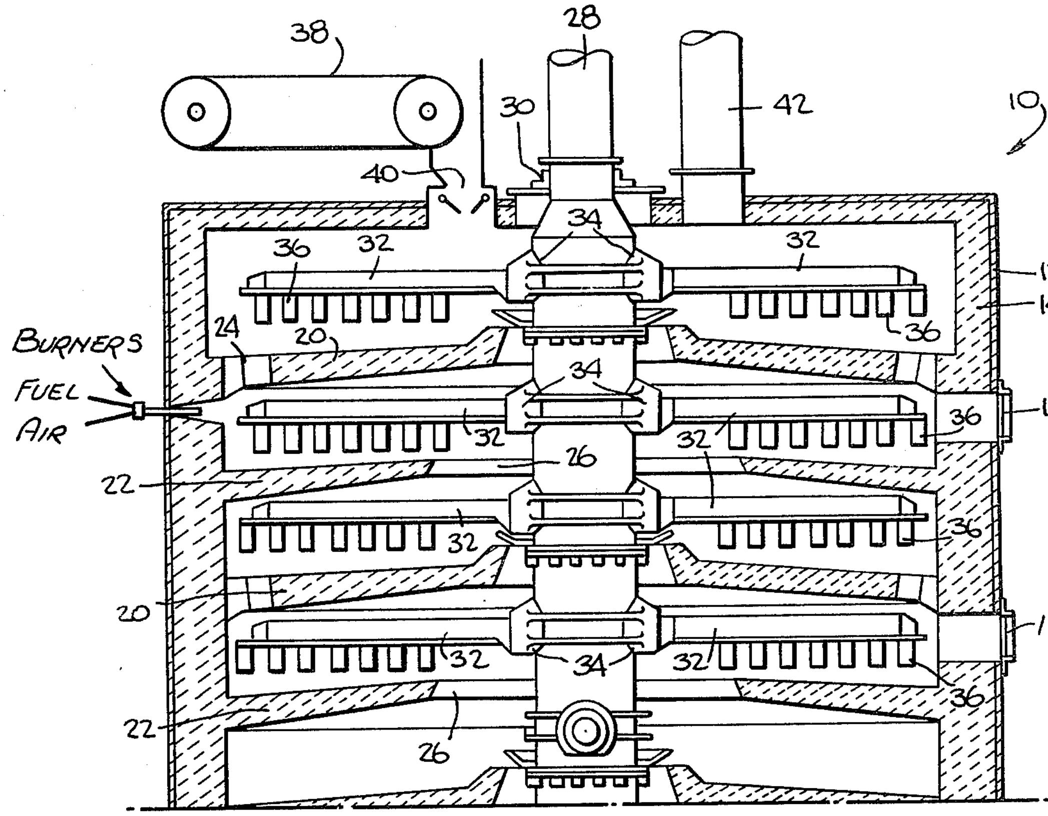


Fig. 1.

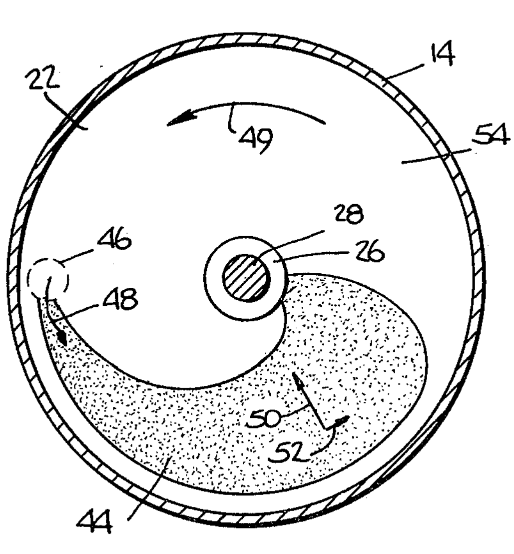


Fig. 2.

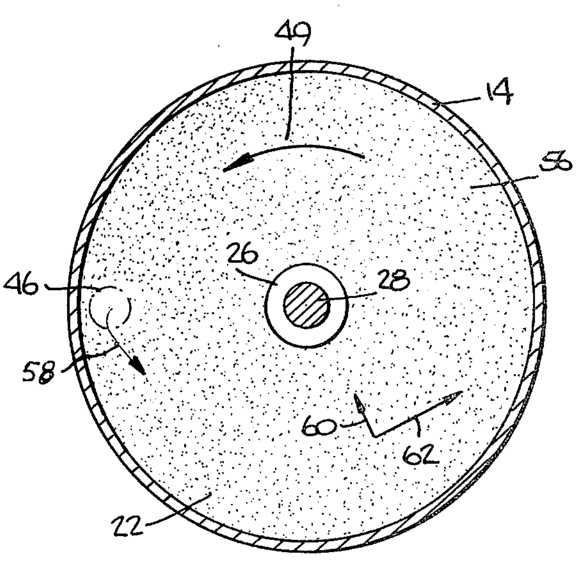


Fig. 3.

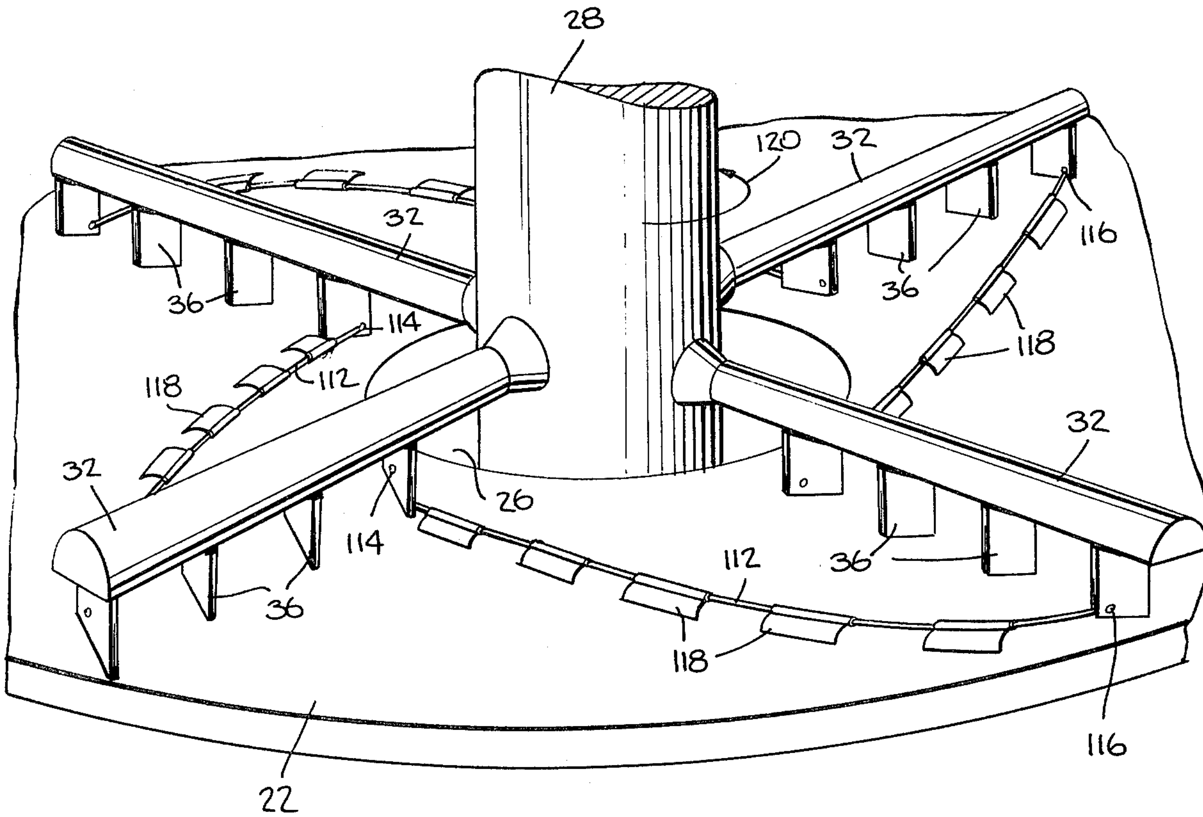


Fig. 12.

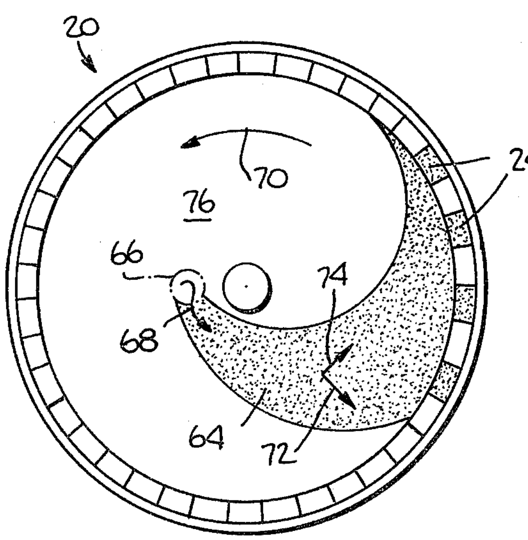


Fig. 4.

PRIOR ART

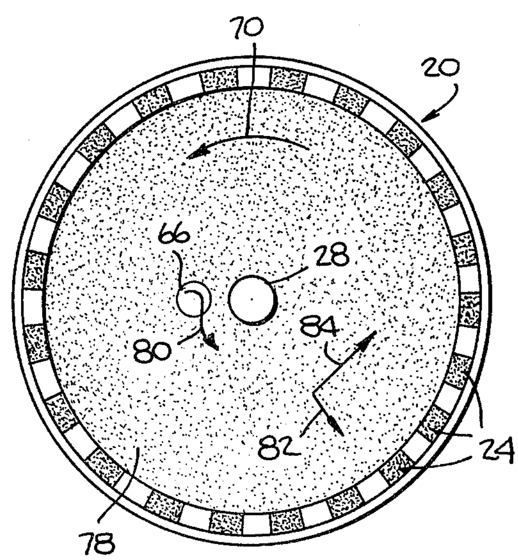


Fig. 5.

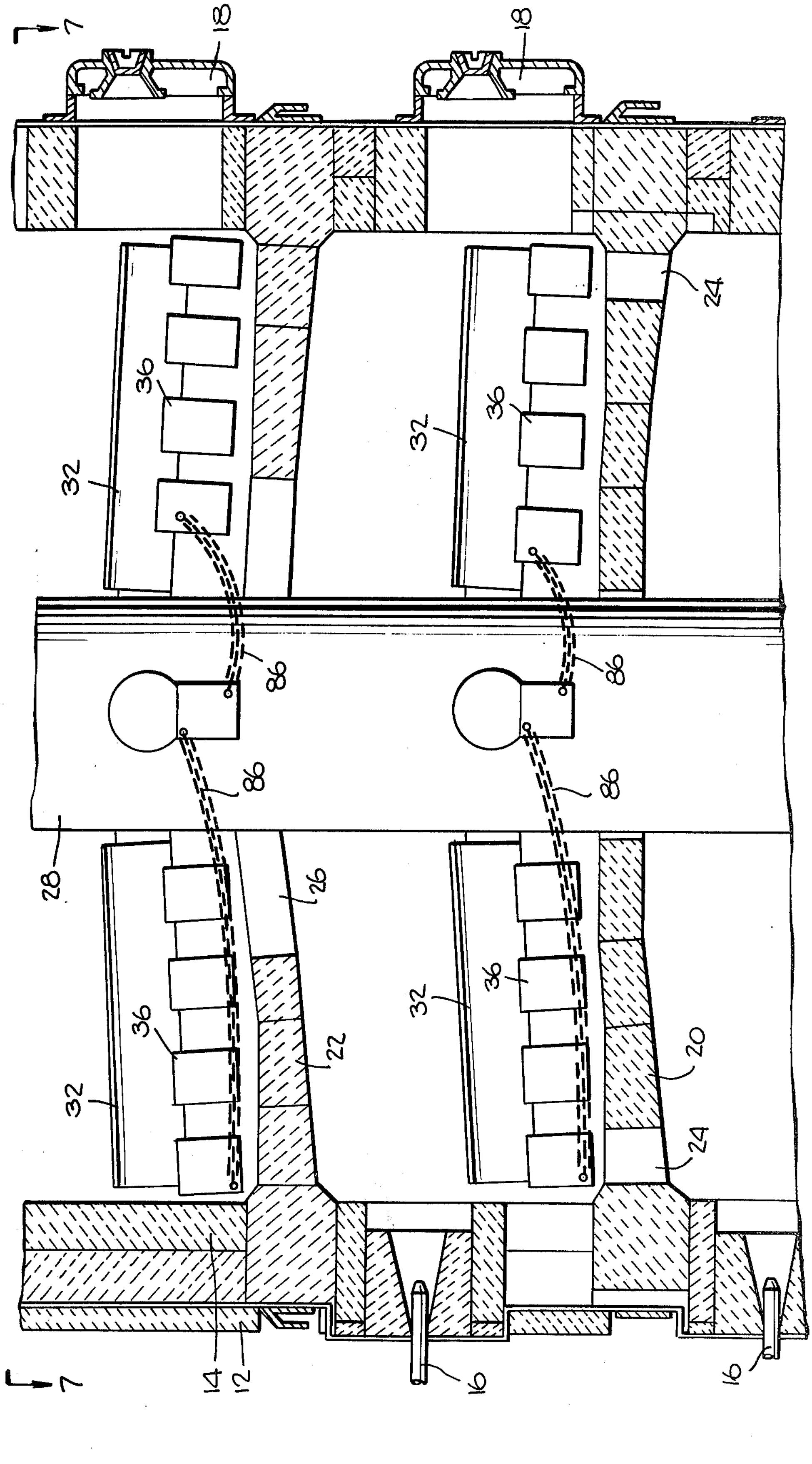

7
18
18
24
36
32
32
36
86
86
86
86
28
26
22
36
32
32
36
20
24
7
14
12
16
16

Fig. 6.

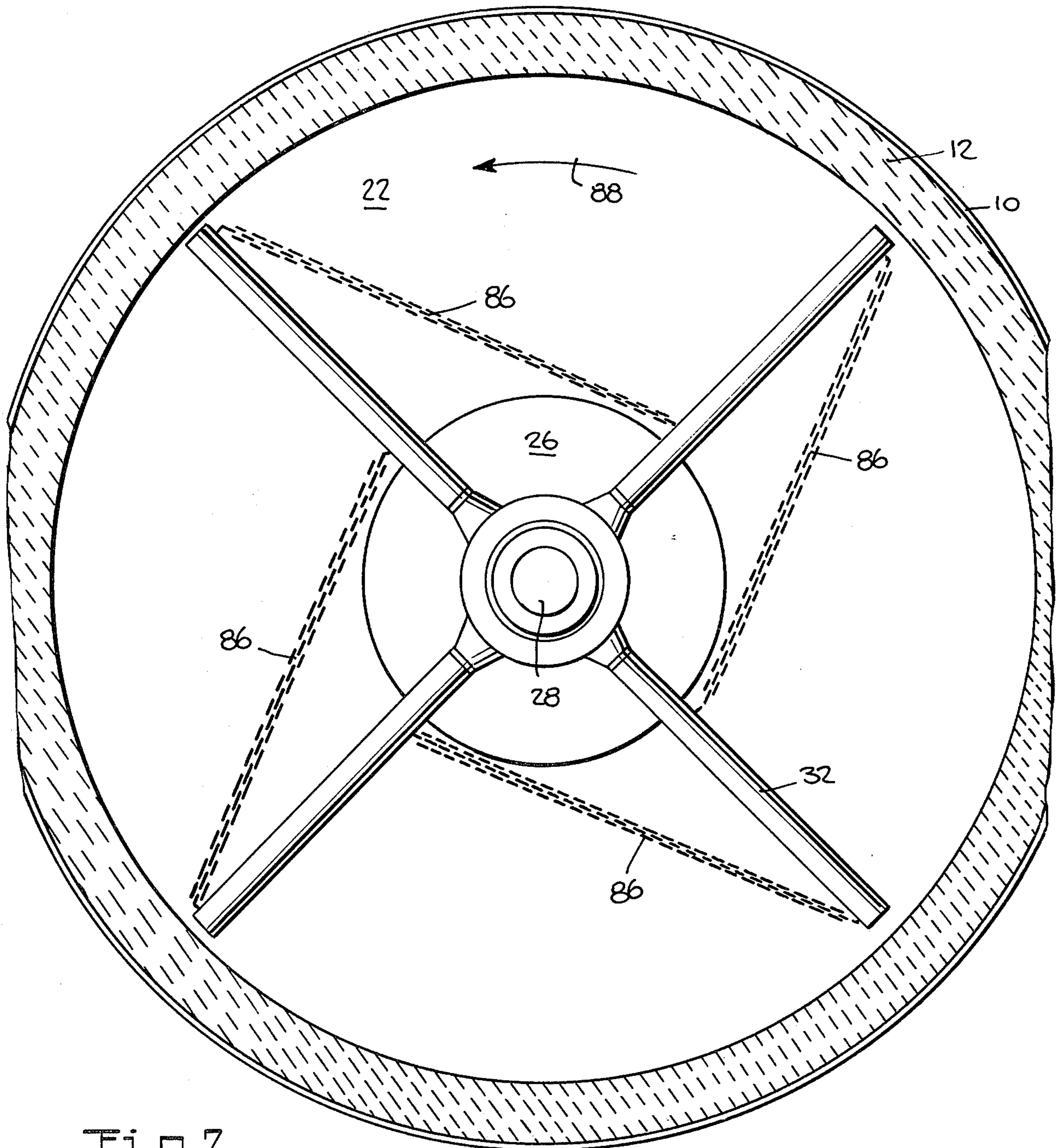
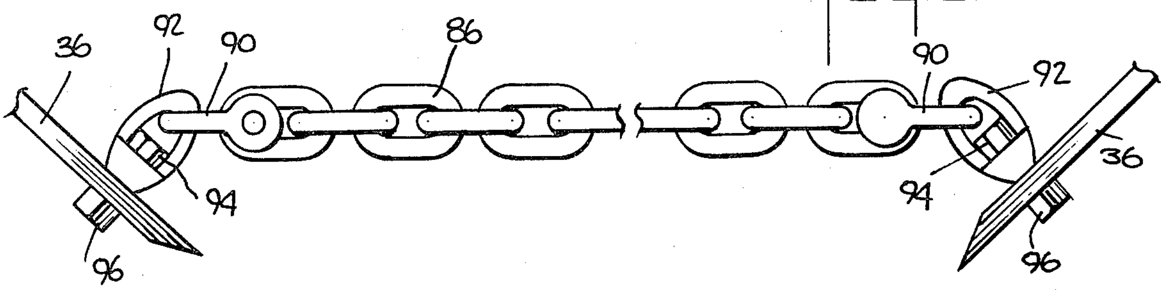


Fig. 7.

Fig. 8.



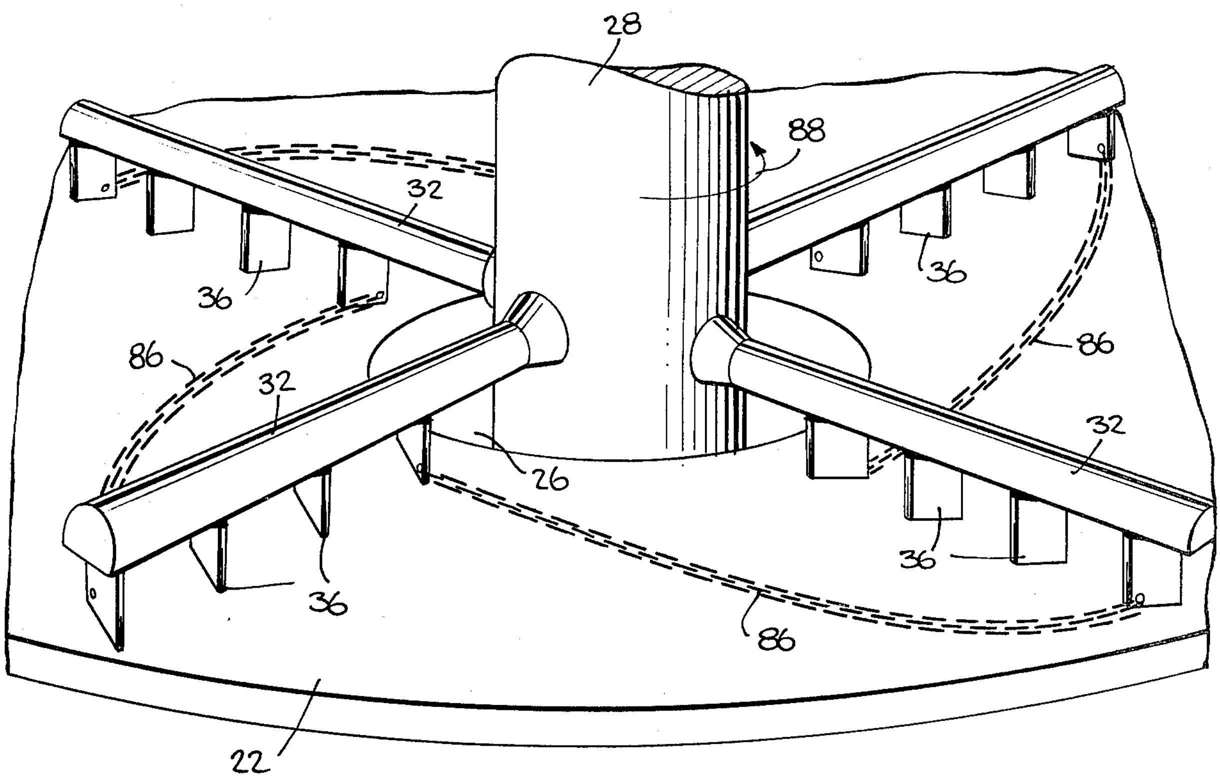

28
88
32
36
86
32
26
86
32
36
36
86
22

Fig. 9.

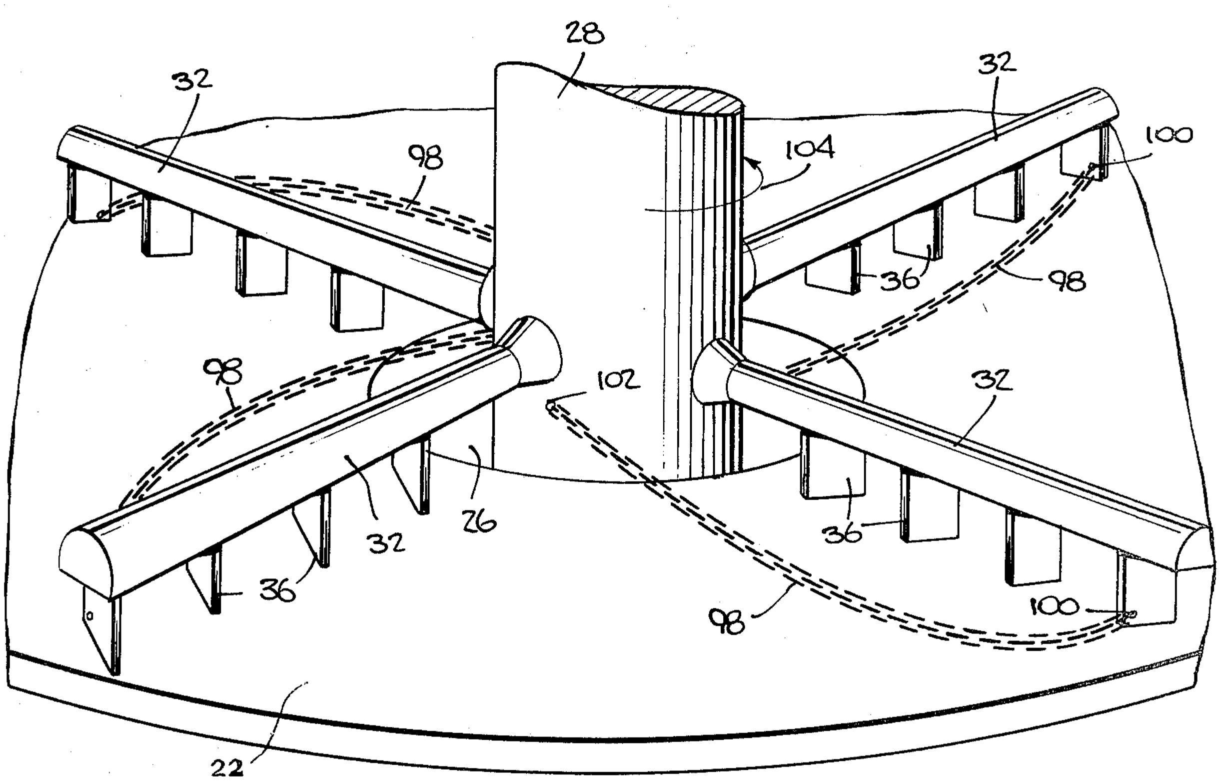

28
32
98
104
32
100
98
98
102
32
36
32
26
36
36
98
100
22

Fig. 10.

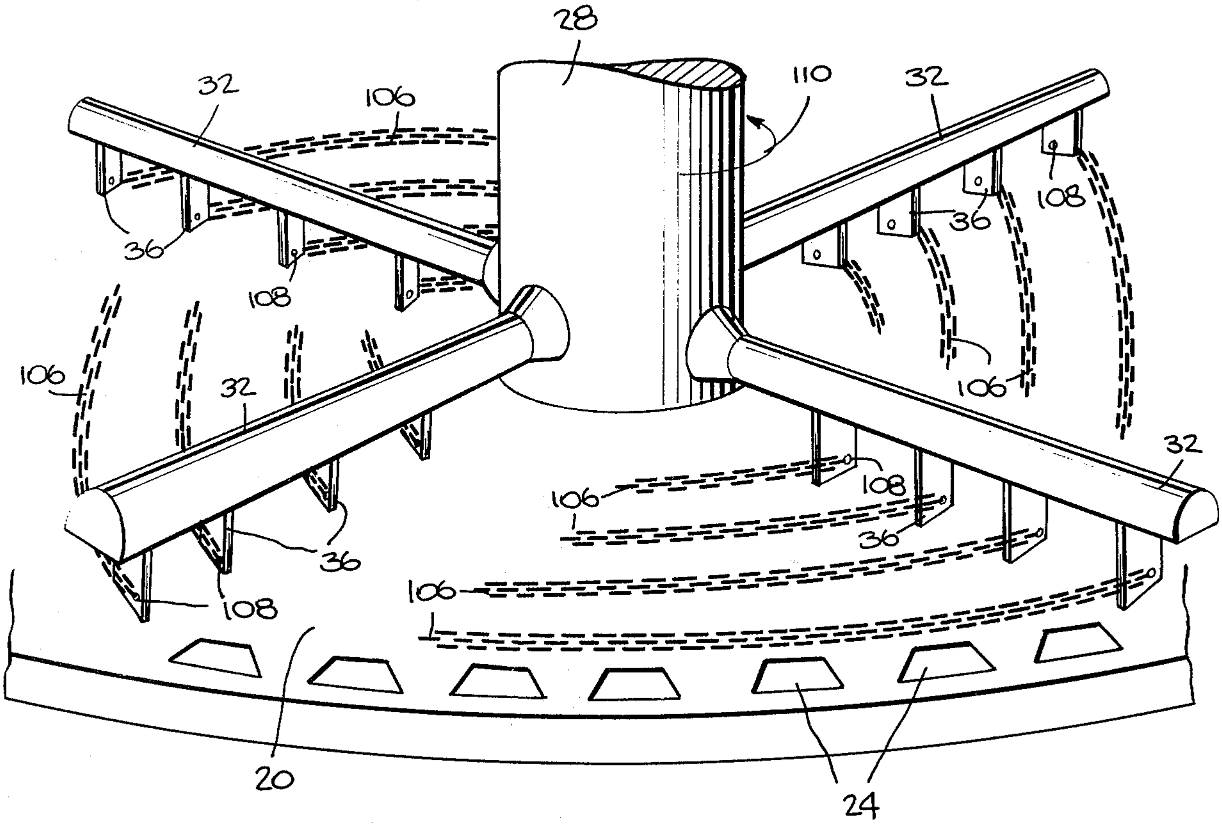


Fig.11.

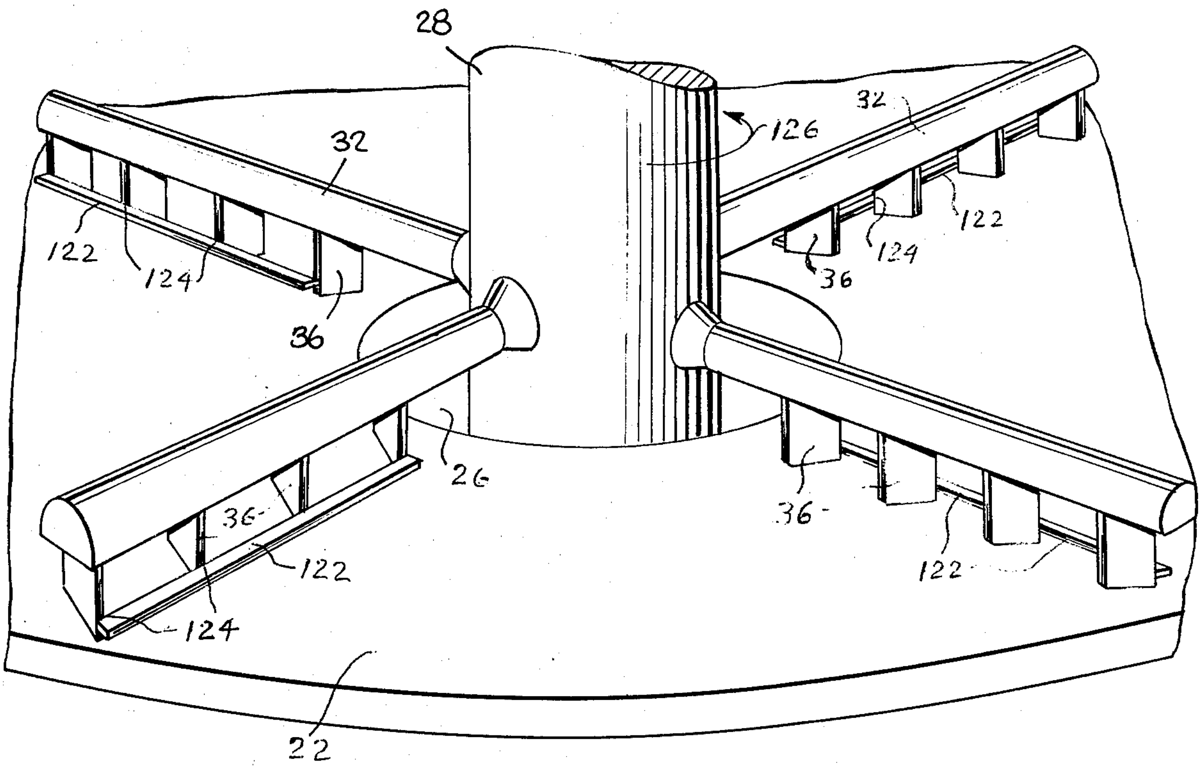

28
32
32
126
122
124
36
122
124
36
26
36
122
124
36
122
22

Fig. 13.

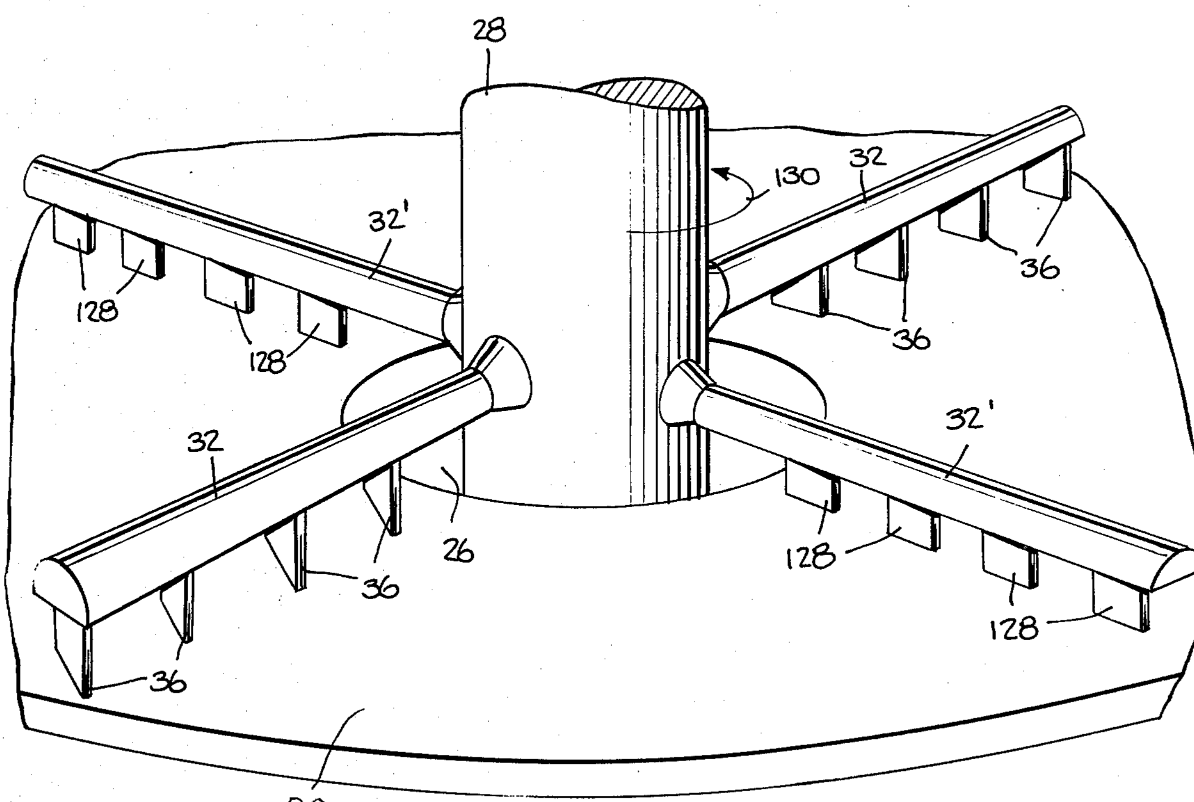

28
130
32
32'
36
128
128
36
32
32'
26
36
128
128
36
128
22

Fig. 14.

APPARATUS AND METHOD FOR DISTRIBUTING MATERIAL BEING PROCESSED OVER A FURNACE HEARTH FLOOR

This application is a Continuation-in-Part of my copending application Ser. No. 362,335, filed May 21, 1973, now U.S. Pat. No. 3,834,859, and entitled "Rabbling Means and Method for a Furnace Hearth".

This invention relates to furnaces and more particularly to method and apparatus for distributing solid material being processed over a furnace hearth. Apparatus constructed in accordance with the concept of this invention is particularly adapted, among other possible uses, for use in multiple hearth type furnaces having a plurality of vertically spaced hearths, such as are used for processing waste material or sewage sludge, roasting ores, as well as other processes, for example.

The problem of preventing air pollution in our present environment has become critical. The present invention is particularly directed to substantially reducing the particulate matter, hydrocarbons, carbonyles, visible smoke and other impurities appearing in exhaust gas from furnaces. Heretofore, these gases tended to contain particles, undesirable gases and stable organic aerosols, (including tar fog or blue haze), caused principally by incomplete combustion, which may have caused harmful effects to health, thereby contributing as a principal source of air pollution. The seriousness of this problem is such that the National Air Pollution Control Administration Air Criteria (U.S. Public Health) as well as the Environmental Protection Agency, have constantly been tightening the minimum required standards. An object of the present invention is to provide new and improved apparatus and method for burning combustibles in a furnace, which is substantially superior to such furnaces employed heretofore.

Heretofore, those skilled in the art failed to appreciate certain factors which contributed to the problem of incomplete combustion. I have found, particularly in furnace applications for the combustion of sewage sludge and the like, that in the use of a multiple hearth furnace, if the material to be processed is uneven distributed across the first or upper hearth processing area, such uneven distribution continues in the successive hearths or processing areas. Uneven distribution of the material across the hearth or processing area results in a number of undesirable effects, such as wastage of hearth area thereby reducing the furnace capacity, and producing ununiform product. In some installations you may get ignition on one side of a hearth only, smoldering in thin areas of material deposit, and the like, for example, which produce undesirable effects that can result in significant air pollution problems of a nature which are very difficult and/or expensive to correct.

By uniform and even distribution, I mean that the objective of this invention is to provide a generally uniform rate of flow of material across the entire surface of the processing area, or hearth. The material is at substantially equal depth in all quadrants or sectors of the hearth at any given diameter except possibly at the extreme inner or outer diameters which encompasses the feed inlet or inlets, where there is nonetheless at least some flow of material around the entire circumference, to thereby prevent stagnant zones, and/or minimize nonuniformity of flow rate across one portion of hearth area as compared to any other area on the same hearth.

Many different types of apparatus have been employed for moving solid material across the hearth of a multiple hearth furnace, such as rabble teeth and discs, for example. Also, chains have been connected between rabble arms or lower in-hearths, wherein the radially, inwardly directed material tends to build-up, for decreasing the driving torque required by the center shaft in furnaces processing copper and zinc. Related patents in this art include Pat. No. 3,153,633 issued Oct. 20, 1964; Pat. No. 3,379,622 issued Apr. 23, 1968; Pat. No. 3,419,254 issued Dec. 31, 1968; Pat. No. 1,251,692 issued Jan. 1, 1918; Pat. No. 1,879,680 issued Sept. 27, 1932; Pat. No. 2,067,823 issued Jan. 12, 1932; Pat. No. 2,117,487 issued May 17, 1938; Pat. No. 2,138,120 issued Nov. 20, 1938; Pat. No. 2,696,377 issued Dec. 7, 1953. However, such prior art devices, in many instances, fail to evenly distribute the material being processed across the hearths.

I have discovered that in order to accomplish the desired results, separate control means must be effected for the forces producing radial flow of the material being processed and for the forces producing circumferential flow of said material. It is very difficult, if not impossible, to set the blade angle of the rabble teeth to obtain both the proper radial and the proper circumferential flow of the material across the hearth, particularly in view of the fact that the material being processed has continually changing characteristics over a period of time, particularly physical characteristics that effect the flow produced by a moving member. Accordingly, it has been the practice to adjust the angle so that there is excess radial flow, in order to be assured that the material will not, under any circumstances of flow characteristics, back-up on the hearth, i.e. fail to pass inwardly or outwardly to the drop holes and thence to the next successive hearth thereunder. This design practice of necessity results in excessive radial motion and little circumferential motion during normal operation.

Therefore, I provide one means for controlling the radial flow vector across the hearth and a separate or independent means for controlling the circumferential flow vector of said material. Thus, I am able to spread the material from one sector of a circular hearth which is heavily laden to another sector of the same hearth, which is less heavily laden, through the use of an independent circumferential mover. This provides a number of beneficial effects, as will become apparent as the description proceeds.

In order to accomplish the desired results, I provide in one form of my invention, a new and improved apparatus for uniformly and evenly distributing solid material over a furnace hearth in a single hearth furnace or an upper hearth in a multiple hearth furnace. In the multiple hearth furnace there are a plurality of vertically spaced hearths and a rotatable center shaft extends upwardly through the center of the furnace, which carries a plurality of spaced rabble arms secured thereto, that extend radially outwardly over each hearth. Drop holes are provided in each hearth, either in toward the center shaft or out toward the furnace wall so that when the material completes its movement over a hearth, it will drop down onto the next lower hearth. Members are provided for effecting the radial flow component of the material being processed on the upper hearth, and independent members are provided for effecting the circumferential flow component of the material being processed on the hearth with respect to the member for effecting the radial flow component so that when the center shaft is rotated the material being processed is distributed across the entire hearth area thereby preventing stagnant zones.

In one embodiment of the invention, the uppermost hearth is an in-flow hearth and in another embodiment of the invention the uppermost hearth is an out-flow hearth.

According to one form of my invention the members for effecting the radial flow component of the material being processed are rabble teeth extending downwardly from the rabble arms nearly to the hearth floor and being inclined with respect to the longitudinal axis of their respective rabble arms to urge the material being processed radially across the hearth towards its associated drop hole.

According to one aspect of the invention the members for effecting the circumferential flow component of the material being processed are chain-like members disposed between the rabble arms associated with the upper hearth, and according to another aspect the means for effecting the circumferential flow component of the material being processed are elongated bar-like members carried by the rabble teeth which extend substantially parallel to the longitudinal axis of the rabble arms.

According to another aspect of the invention, alternate rabble arms carry rabble teeth which are inclined with respect to the longitudinal axis of their respective rabble arms to urge the material being processed radially across the hearth and the other rabble arms carry rabble teeth which extend substantially parallel to the longitudinal axis of the rabble arms, respectively, to urge the material being processed circumferentially across the hearth.

In another form of the present invention, I provide a method for processing solid material in a single hearth furnace or in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, the hearths being provided with drop holes either toward the center shaft or outwardly toward the furnace wall, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, the method being characterized by the steps of introducing the material at the top of the furnace and urging the material to move across at least the uppermost hearth in a critical zone with a radial flow component, while simultaneously urging the material to move across the same hearth with an independent circumferential flow component so that the material is distributed across the entire hearth area, without stagnant areas.

In describing some forms of the invention, I use the phrase uppermost hearth in a critical zone because in some installations it is not necessary to apply the aforementioned distribution means on the uppermost hearth in the furnace. That is, the first few hearths in the furnace may form a non-critical zone wherein it is immaterial whether or not the material is distributed across the entire hearth area without stagnant areas as the input of heat or the degree of reaction with the gas per pound of material is not detrimental or wasteful to the process being performed. However, in order to derive the benefits of my invention, when the material reaches the critical zone it is necessary that distribution means be employed to distribute the material being processed across the entire hearth area without stagnant areas. The objects and benefits derived from employing such distribution means are pointed out in detail hereinafter.

In many installations it has been found that if the aforesaid uniform distribution is achieved on one of the upper hearths, this same even distribution continues to the subsequent hearths down through the furnace without the necessity of repeating the aforesaid means for evenly, circumferentially distributing the material in the latter hearths. However, in other installations, it may be necessary to repeat the aforementioned distribution means in order to achieve the desired effects in the lower hearth. For example, in furnaces wherein the in-drop hole and the center shaft are not perfectly concentric, possibly because of the non-uniform buildup of material such as slag on the perimeter of the in-drop hole, the uniform distribution once achieved may be destroyed as the flow occurs primarily over the wider portion of the in-drop hole and less flow occurs over the portion of the in-drop hole that comes nearest to the center of the shaft. In calcination, such as lime, or in roasting sulfide ores, the lighter flow area will be "roasted out" (reaction completed) before the heavier flow areas so that the portion of the lower hearths that subsequently receive the material from the light flow areas is wasted, as it is merely processing already completed material. Also, where substantial heats of reaction are involved, causing substantial gas to solid temperature differences, early completion of the reaction in the light flow areas may result in overheating of the material in these areas once the reaction is completed.

In cases such as activation and re-activation of carbon, the material in the low flow areas will be over reacted at least to a low yield-high ash condition and possibly completely to ash, while the activation is being completed for the remaining material in the high flow areas.

In sewage sludge incineration, or other types of incineration, or reactions which consume most of certain ingredients in the gas flow as, for example, oxygen from the air in the incineration of sewage sludge, it is important to recognize that in many instances the gas flows in a laminar fashion up the furnace so that the gas flow in the first quadrant in the bottom hearth remains in the first quadrant in upwardly succeeding hearths. The zone of heavy flow, however, rotates from one hearth to the next. Thus, one-quarter of the gas stream may contact the heavy flow from one hearth to the next to completely deplete it of oxygen or other reaction gases, whereas the gas in the light flow quadrants still contain oxygen or reactant other gas which is not available in the zone of heavy reaction. This can, for example, create dark smoke, due to localized deficiencies in the air required for burning, even through the total gas flow may contain more than the stoichiometric requirements of oxygen.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described more fully hereinafter. Those skilled in the art will appreciate that the conception on which this disclosure is based may readily be utilized as the basis for the designing of other structures and methods for carrying out the several purposes of the invention. It is important, therefore, that this disclosure be regarded as including such equivalent constructions and methods as do not depart from the spirit and scope of the invention.

Several embodiments of the invention have been chosen for purposes of illustration and description, and the specification, shown in the accompanying drawings, forming a part of thespecification, wherein:

FIG. **1** is an axial, sectional elevation of a multiple hearth furnace;

FIG. **2** is a transverse, sectional view of an upper inflow hearth showing the distribution of material being processed according to prior art techniques;

FIG. **3** is a transverse sectional view of an upper inflow hearth showing the distribution of material being processed according to the concepts of the present invention;

FIG. **4** is a transverse, sectional view of an upper outflow hearth showing the distribution of material being processed according to prior art techniques;

FIG. **5** is a transverse, sectional view of an upper outflow hearth showing the distribution of material being processed according to the concepts of the present invention;

FIG. **6** is a sectional view, taken in elevation, of the top portion of a furnace embodying the present invention;

FIG. **7** is a sectional view taken along the line indicated at **7—7** in FIG. **6**;

FIG. **8** is an enlarged plan view of a chain disposed between rabble arms according to the invention;

FIG. **9** is a perspective view of an upper hearth of a furnace showing the chain in its operative position;

FIG. **10** is a perspective view of an upper hearth similar to FIG. **9**, but showing an alternate mounting of the chain;

FIG. **11** is a perspective view of an upper hearth similar to FIG. **9**, but showing another alternate mounting of the chain;

FIG. **12** is a perspective view of an upper hearth similar to FIG. **9**, but showing another form of the invention wherein cables with scoops are mounted between the rabble arms;

FIG. **13** is a perspective view of an upper hearth similar to FIG. **9**, but showing still another form of the invention wherein bars are mounted between the rabble teeth; and

FIG. **14** is a perspective view of an upper hearth similar to FIG. **9**, but showing a form of the invention wherein the teeth on alternate rabble arms are disposed for effecting circumferential flow and for effecting radial flow, respectively, of the material being processed.

Reverting to the drawings in detail, and initially to FIG. **1**, there is shown the upper portion of a multiple hearth furnace **10** of generally cylindrical configuration. This furnace is constructed of a tubular outer steel shell **12**, which is lined, as indicated at **14**, with fire brick or similar heat resistant material. While in some installations burner nozzles are only provided in one or two lower hearths, in the present exemplary embodiment, each hearth is provided with a plurality of burner nozzles **16**, which extend both radially and tangentially into the hearth. The burner nozzles from the outlets of various individually controlled burner assemblies (not shown) are distributed about the furnace **10**, and they serve to produce and/or maintain proper temperatures and atmospheres within different regions of the furnace to carry out the particular processing desired. There are also provided special working doors and windows **18** for monitoring the operation of the furnace at each of the hearth levels.

The interior of the furnace **10** is divided, by means of hearth floors **20** and **22**, into a plurality of vertically aligned hearths, only the four uppermost hearths being shown. Each of the hearth floors is made of refractory material and is preferably of slightly arched configuration to be self-supporting within the furnace. Outer peripheral drop holes **24** are provided near the outer shell **12** of the furnace, and central drop holes **26** are formed in alternate hearth floors **22**, near the center of the furnace. While FIG. **1** illustrates the uppermost, or first, hearth as being an out-flow hearth, it will be appreciated that the concepts of my invention apply equally well to a furnace having an in-flow first hearth, or to a lower hearth of a multiple hearth furnace.

Still referring to FIG. **1**, a rotatable vertical center shaft **28** extends axially through the furnace **10** and is secured by upper bearing means indicated at **30** and lower bearing means, not shown. This center shaft is rotated by suitable drive means, not shown, well known in the art. A plurality of spaced rabble arms **32** are mounted on the center shaft **28**, as at **34**, and extend outwardly in each hearth over the hearth floor. The rabble arms have rabble teeth formed thereon which extend downwardly nearly to the hearth floor. The rabble teeth are inclined with respect to the longitudinal axis of their respective rabble arms so that as the rabble arms **32** are carried around by the rotation of the center shaft **28**, the rabble teeth **36** will continuously rake through the material being processed on the associated hearth floor and gradually urge the material toward the drop holes **24** and **26** in the hearth floors.

The material being processed is fed into the furnace at the top thereof as by means of a belt conveyor **38** and feed inlet **40**. If the uppermost hearth is an out-flow hearth, a shown in FIG. **1**, the feed inlet **40** is located near the center of the furnace. However, if the first hearth is an in-flow hearth, then the feed inlet would be located towards the periphery of the furnace. The material is caused to move downwardly through the furnace in a generally serpentine fashion and discharged from the bottom of the furnace. A gas exhaust opening **42** is provided in the top of the furnace to permit exhaustion of gases and other products of combustion formed inside the furnace during operation.

FIG. **2** shows the flow of material being processed, in accordance with the prior art, wherein the first hearth is an in-flow hearth **22**. The material, indicated generally at **44**, enters the hearth from above through a feed inlet **46** and is moved, as indicated by arrow **48**, partially around the hearth by virtue of the action of the rabble teeth, rotating in the direction indicated by arrow **49**, until it drops through the center drop hole **26**. The rabble teeth are inclined with respect to the longitudinal axis of their respective rabble arms so that the movement of the material has a relatively large radially, inwardly directed flow component **50** and a relatively small circumferentially directed flow component **52**, thereby leaving a substantial portion or sector of the hearth uncovered, or very thinly covered by the material, as indicated at **54**.

In contrast to FIG. **2**, FIG. **3** shows the flow of material being processed, in accordance with the present invention, wherein the first hearth is an in-flow hearth **22**. The material, indicated generally at **56**, enters the hearth from above through the feed inlet **46** and is moved, as is indicated by arrow **58**, completely around the hearth and drops through the central drop hole **26** substantially around the entire periphery thereof. Thus, according to the invention, means are provided for controlling the radial flow vector or component **60** of the material and separate and independent means are provided for controlling the circumferential flow vector or component **62** of the material. In this manner, the two flow compartments may be individually selected so that the material is caused to be evenly distributed over the entire hearth, without stagnant zones, by virtue of the independent selection of the components. In addition, the dwell time of the material in the hearth, between entry and exit therefrom, can be carefully controlled, as desired for the material and process involved.

Turning next to FIG. **4**, there is illustrated an outflow hearth **20**, which shows the flow of material in accordance with prior known techniques. The material **64** enters the hearth from above through an inlet **66** and traverses, as indicated by arrow **68**, only partially around the hearth by the action of the rabble teeth rotating in the direction of arrow **70**, before it drops through the peripheral drop holes **24**. It is noted that the rabble teeth are inclined with respect to the longitudinal axis of their respective rabble arms so as to provide a relatively large radially, outwardly directed material flow component or vector **72** and a relatively small circumferential flow component or vector **74**, thereby leaving a substantial portion **76** of the hearth uncovered or very thinly covered by the material being processed.

As distinguished from the prior art flow pattern as illustrated in FIG. **4**, FIG. **5** shows the pattern of flow on an out-flow hearth **20** of the material being processed according to the present invention. The material, indicated generally at **78**, enters the hearth from above through the feed inlet **66** and it moves, as indicated by arrow **80**, completely around the hearth and drops through the peripheral holes **24** substantially around the entire periphery thereof. Means are provided, as will be discussed more fully hereinafter, for controlling the radial flow vector or component **82** of the material and separate or independent means are provided for controlling the circumferential flow vector or component **84** of the material. It will be appreciated that the circumferential flow component **84** of the present invention is substantially greater than the circumferential flow component **74** of the prior art, thereby resulting in even flow distribution over the entire hearth without stagnant zones. This is assured by the fact that the control of the circumferential component **84** is independent of the control of the radial component **82**. In addition, the dwell time of the material on the hearth can be controlled, as desired, for the material and process involved.

The prior art techniques as illustrated in FIGS. **2** and **4**, as compared to the techniques of the present invention as shown in FIGS. **3** and **5**, causes numerous problems. For example, there is wastage of hearth area, thereby reducing the effective furnace area, and the life of the furnace brick work is foreshortened due to the uneven burning. Next, there tended to be ignition or burning on one side of the hearth while the other side thereof was smoldering, which meant that on one side of the furnace the material being processed was in a burning stage on one hearth while on the other side of the furnace the material did not reach the burning stage until it had moved to a lower hearth. Thus, there was combustion on one side of the hearth while the other side of the hearth was still drying the material. This caused difficulties in controlling the dwell time on the various hearths and the inability to carefully control the burners and atmospheres, including turbulence, in each hearth to obtain proper gas distribution over the hearth. Consequently, it resulted in causing overheating of the material in some areas of the furnace and under-heating in other areas, which in some processes resulted in a poor product. For example, when trying to roast zinc sulfide to obtain zinc oxide one might get zinc sulfate which is difficult to remove from the furnace. In addition, it will be appreciated that proper burning across the entire hearth area provides better heat transfer and thus more economical fuel usage. With respect to the processing of waste material, or sewage sludge, proper burning across the entire hearth prevents the emission of odors and the formation of blue smoke or tar fog, which is too fine to be removed by present day scrubbers, and thus reduces or eliminates the need for afterburners in order to meet the regulatory codes, such as the Environmental Protection Agency's Visual Appearance Code.

In order to provide even distribution of the material being processed across the hearth as shown in FIGS. **3** and **5**, I provide means for separately controlling the circumferential vector or component of the movement of the material being processed with respect to the radial vector or component of movement. In the form of my invention illustrated in FIGS. **6** to **9**, the two upper hearths of the furnace are shown, wherein the rabble teeth **36** are inclined with respect to the longitudinal axis of their respective rabble arms so that they provide a substantial portion of the radial component **60**, FIG. **3**, or **82**, FIG. **4**, of the movement of the material being processed on the hearths, respectively. As best seen in FIGS. **7** and **9**, rabble chains **86** are interconnected between adjacent rabble arms **32** to provide a substantial portion of the circumferential component **62**, FIG. **3**, or **84**, FIG. **5**, respectively. That is, the rabble teeth serve as the means for controlling the radial movement and the chains serve as the means for controlling the circumferential movement of the material being processed on the hearth. As a result, the proper selection of the inclination of the rabble teeth and the disposition of the rabble chains, serves to uniformly distribute without stagnant zones, the solid material being processed over the hearth, when the center shaft **28** is rotated in the direction of arrow **88**, FIGS. **7** and **9**. Each end of the rabble chain **86** is mounted on a rabble tooth **36** by means of passing a shackle **90**, FIG. **8**, through an eye nut **92**, which is fastened to the rabble tooth by a nut **94** and bolt **96**, provided for the purpose. The chains are strung so that one end extends from near the periphery of the rabble arm and the other end is mounted on the inner end of the next adjacent rabble arm. The chain is installed with some slack, but not enough to drag on the hearth floor. When initially installed a gap of the order of about 1 inch is left at the bolt **96** for adjustment purposes by turning the bolt. A ⅝ inch chain having an overall length of about 10.5 feet is suitable for use in a furnace having an outside diameter of the order of about 22 feet, for example. Thus, it will be appreciated that the rabble teeth **36** act independently of the chains **38** when the center shaft is rotated, but the combination of the two components acting on the material being processed, serve to evenly sweep it across one hearth to a drop hole where it falls down onto the next lower hearth and, thence, is evenly swept across this hearth to its drop hole, progressively from the top to the bottom of the furnace.

In the embodiment of the invention shown in FIG. **10**, a rabble chain **98** is provided having one end mounted on the rabble tooth **36** disposed towards the outer periphery of the rabble arm **32**, as at **100**, and the other end of the chain is connected to the center shaft **28**, as at **102**. The chain **98** is installed with some slack, but not enough to drag on the hearth floor **22**. Accordingly, when the center shaft **28** is rotated, as indicated by arrow **104**, the rabble chain acting substantially as a circumferential flow component and the rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms acting substantially as the radial flow component, on the solid material being processed, serve to evenly and uniformly distribute the material across the hearth floor **22** without stagnant zones. While FIG. **10** illustrates an in-flow hearth, the concept of this embodiment is equally applicable to an out-flow hearth.

Referring next to the embodiment of the invention illustrated in FIG. **11**, a plurality of rabble chains **106** are provided. Each chain has one end connected to a rabble tooth **36**, as at **108**, and the other end thereof is allowed to drag behind the tooth on the out-flow hearth floor **20**. The lengths of the chains are progressively shorter from the periphery of the hearth floor towards the center thereof. Thus, when the center shaft **28** is rotated, as indicated by arrow **110**, the rabble teeth **36**, being inclined with respect to the longitudinal axis of their respective rabble arms, serve to provide the radial outwardly directed flow component of the material, while the rabble chains **106** provide the independent circumferential component of the material flow, to thereby evenly and uniformly distribute solid material being processed across the hearth floor without stagnant zones. The rabble chains **106** of this embodiment of the invention preferably are only employed in an out-flow hearth.

In the form of the invention illustrated in FIG. **12**, the rabble teeth **36**, being inclined with respect to the longitudinal axis of their respective rabble arms, provide a substantial portion of the radial component of the material being processed across the hearth **22**. A cable **112** is interconnected between adjacent rabble arms **32**, as at **114** and **116**, and carries a plurality of rabble scoops **118**, which serve as means for providing a substantial portion of the circumferential flow component of the material being processed on the hearth. Consequently, the proper selection of the inclination of the rabble teeth and the disposition of the cable **112** serves to coordinate and independently control the radial and circumferential flow components of the material being processed so as to uniformly and evenly distribute it across the hearth floor **22**, without stagnant zones, when the rabble arms **32** are rotated by the center shaft **28** in the direction indicated by the arrow **120**. While FIG. **12** shows an inflow hearth, the concept of this embodiment is equally applicable to an out-flow hearth.

FIG. **13** illustrates still another means for uniformly and evenly distributing the material being processed across the hearth floor **22**. In this embodiment, the rabble teeth **36** are inclined with respect to the longitudinal axis of their respective rabble arms to provide a substantial portion of the radial flow component of the material being processed on the hearth **22**, and a rabble bar **122** serves as separate or independent means for providing a substantial portion of the circumferential flow component of the material. The rabble bar **122** is mounted on the leading edge of the rabble teeth as at **124** and extends radially from adjacent the center of the hearth to the periphery thereof. The vertical height of the rabble bar **122** is selected depending upon the desired size of the circumferential flow component of the material being processed. In most installations there will be some flow of material over the top of the bar as well as some flow thereunder. However, in some installations, it may be desirable to only allow flow under the bar. It will thus be appreciated that the proper selection of the inclination of the rabble teeth **36** and the height of the rabble bar **122** serves to coordinate and independently control the radial and circumferential flow components of the material being processed so as to evenly distribute it across the hearth floor **22** without stagnant zones when the rabble arms **32** are rotated by the center shaft **28** in the direction indicated by the arrow **126**. While FIG. **13** shows an inflow hearth, it will be appreciated that the same concepts apply to an out-flow hearth.

Turning next to the embodiment of my invention illustrated in FIG. **14**, there is shown an in-flow hearth **22** having a central drop hole **26**. The rabble arms **32** carry rabble teeth **36** which are conventionally inclined with respect to the longitudinal axis of their respective rabble arms to provide substantially all of the radial flow component of the material being processed. As a separate independent means of providing the circumferential flow component of the material, I provide on alternate rabble arms **32'** rabble teeth **128** which are not inclined, but are substantially parallel to the longitudinal axis of their respective rabble arms. Thus, by proper selection of the number, spacing and inclination of the rabble teeth **36** and the number and spacing of the rabble teeth **128**, I am able to coordinate and independently control the radial and circumferential flow components of the material being processed so as to evenly distribute it across the hearth floor **22** without stagnant zones and, in addition, provide the desired dwell time of the material on the hearth, when the rabble arms **32** or **32'** are rotated by the center shaft **28** in the direction indicated by the arrow **130**. While FIG. **14** illustrates an in-flow hearth, the concept of this embodiment is equally applicable to an out-flow hearth.

It will be appreciated that the first or uppermost hearth of the furnace may be either an in-flow hearth or an out-flow hearth. When handling certain materials, it may be necessary to only incorporate the means for separately controlling the radial and circumferential flow components of the movement of the material being processed on the first or uppermost hearth, or the first and second uppermost hearths, as once the material has been spread evenly on an upper hearth, it will remain evenly distributed on subsequent lower hearths. However, when handling certain other materials, it may or may not be necessary to incorporate such means for controlling the flow compartments of the material on the first hearth, but it is necessary to incorporate the means for controlling the flow components in one or more of the other hearths therebelow. The principles of this invention are also applicable to a single hearth furnace having either radial in-flow or out-flow of the material being processed.

The apparatus described heretofore for separately controlling the radial and circumferential flow components of the material being processed is particularly adapted for the processing of waste material, such as sewage sludge, for example. Many municipalities require the drying of sludge during part of the year whereby the residue is utilized for fertilizer, and in drying and incinerating or burning the sludge at other times of the year when fertilizer is not in demand. The principles of my invention are applicable to both the drying process as well as to the drying and incinerating process. My improved method is characterized by the steps of continuously introducing wet sewage sludge at the top of the furnace, passing the sludge to a first zone in the upper portion of the furnace for drying the sludge by urging it to move across one of the uppermost hearths with a radial flow component while simultaneously urging it to move across this hearth with an independent circumferential flow component to cause the sludge to flow in a uniform and evenly distributed manner towards its associated drop hole, as seen in FIGS. **3** and **5**. Thence, the steps of the method include, successively passing the sludge across each hearth and down its respective drop hole to the next lower hearth in the first zone, while maintaining the sludge in susbstantially the same state of dryness across each hearth. In the process, which includes only drying the sewage sludge, the so-dried sludge is removed from the bottom of the first zone of the furnace. In the process whereby both incineration and drying is included, the process further comprises the steps of passing the so-dried sludge to a second zone in the lower portion of the furnace for incinerating the sludge by successively passing it across each hearth and down its respective drop hole to the next lower hearth in this zone, while maintaining the sludge in substantially the same state of incineration across each hearth in the zone, and while applying heat to more than one hearth at controlled rates to effect the drying and incineration of the sludge.

It will thus be seen that the present invention does indeed provide an improved apparatus and method for distributing solid material over a furnace hearth, which is superior in operability and efficiency as compared to prior art such apparatus.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various modifications thereof, after study of the specification, will be apparent to those skilled in the art to which the invention pertains.

What is claimed and desired to be secured by Letters Patent is:

1. In a furnace having at least a single substantially horizontal hearth, the combination comprising a rotatable center shaft extending up through the center of said hearth, at least one rabble arm secured to the center shaft and extending radially outwardly over said hearth, means for providing a radial flow component of material being processed on said hearth, and independent means for providing a circumferential flow component of the material being processed on said hearth with respect to said means for providing the radial flow component, whereby when said center shaft is rotated the flow of material being processed is distributed across the entire hearth area.

2. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, means for providing a radial flow component of material being processed on at least one of the upper hearths in said furnace, and independent means for providing a circumferential flow component of the material being processed on said one hearth with respect to said means for providing the radial flow component whereby when said center shaft is rotated the flow of material being processed is distributed across the entire hearth area.

3. Apparatus according to claim **2**, wherein said one hearth is an in-flow hearth.

4. Apparatus according to claim **2**, wherein said one hearth is an out-flow hearth.

5. Apparatus according to claim **2**, wherein said means for providing the circumferential flow component of the material beng processed comprises chain-like members disposed between the rabble arms associated with said one hearth.

6. Apparatus according to claim **2** wherein said means for providing the radial flow component of the material being processed comprises a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge said material being processed radially across said one hearth towards its associated drop hole.

7. Apparatus according to claim **2**, wherein said means for providing the radial flow component of the material being processed comprises a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge said material being processed radially across said one hearth towards its associated drop hole, and wherein said means for providing the circumferential flow component of the material being processed comprises elongated bar-like members carried by said rabble teeth and extending substantially parallel to the longitudinal axis of the rabble arms respectively.

8. Apparatus according to claim **2** wherein said means for providing the radial flow component of the material bieng processed comprises a plurality of rabble teeth extending downwardly from a number of said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge said material being processed radially across said one hearth towards its associated drop hole, and wherein said means for providing the circumferential flow component of the material being processed comprises a plurality of rabble teeth extending downwardly from the remainder of said rabble arms nearly to the hearth floor, said last named rabble teeth being disposed substantially parallel to the longitudinal axis of their respective rabble arms to urge said material being processed circumferentially across said hearth.

9. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge material being processed radially across the hearths and independent means for providing a circumferential flow component of the material being processed on the uppermost hearth in a critical zone to move the material being processed circumferentially over said hearth when said center shaft is rotated, whereby when said center shaft is rotated the flow of material being processed is moved across each entire hearth to its associated drop hole and dropped down onto the next lower hearth.

10. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floors, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge material being processed radially across the hearths, a rabble chain disposed between the rabble arms associated with the uppermost of said hearths to move the material being processed circumferentially over the hearth when said center shaft is rotated, whereby when said center shaft is rotated the flow of material being processed is moved across each entire hearth to its associated drop hole and dropped down onto the next lower hearth.

11. Apparatus according to claim **10** further comprising means for adjusting the tension of each of said rabble chains.

12. Apparatus according to claim **10** wherein the ends of said rabble chains are connected between the outer end portion of one rabble arm and the inner end portion of the adjacent rabble arm, respectively.

13. Apparatus according to claim **10** wherein one end of each of said rabble chains is connected to said center shaft and the other end of the chain is connected outwardly of the middle of one rabble arm.

14. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge material being processed radially across the uppermost of said hearth towards its associated drop hole, a plurality of chains each having one free end and the other end being connected to the rabble teeth respectively for urging said material being processed circumferentially across said uppermost hearth, whereby when said center shaft is rotated the flow of material being processed is distributed across each entire hearth area to its associated drop hole and dropped down onto the next lower hearth.

15. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge said material being processed radially across the uppermost of said hearths towards its associated drop hole, a cable having a plurality of spaced scoops disposed between the rabble arms associated with said uppermost of said hearths to urge said material being processed circumferentially across said uppermost hearth, whereby when said center shaft is rotated the flow of material being processed is distributed across each entire hearth area to its associated drop hole and dropped down onto the next lower hearth.

16. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from the rabble arms of the uppermost hearth, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms to urge said material being processed radially across the uppermost hearth towards its associated drop hole, elongated bar-like members carried by said rabble teeth and extending substantially parallel to the longitudinal axis of the rabble arms respectively to urge said material being processed circumferentially across said uppermost hearth, whereby when said center shaft is rotated the flow of material being processed is distributed across each entire hearth area.

17. In a multiple hearth furnace having a plurality of vertically spaced hearths, the combination comprising a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from alternate of said rabble arms in the uppermost of said hearths, said rabble teeth being inclined with respect to the longitudinal axis of the respective rabble arms to urge said material being processed radially across the uppermost hearth towards its associated drop hole, the other of said rabble arms in said uppermost hearth having a plurality of rabble teeth extending downwardly from their respective rabble arms, said last named rabble teeth extending substantially parallel to the longitudinal axis of their respective rabble arms to urge said material being processed circumferentially across said uppermost hearth, whereby when said center shaft is rotated the flow of material being processed is distributed across each entire hearth area.

18. A method of processing material in a single hearth furnace having a center shaft extending up through the center of said hearth, at least one rabble arm secured to the center shaft and extending radially outwardly over said hearth, said method comprising the steps of introducing said material onto said hearth, urging said material to move across said hearth with a radial flow component, while simultaneously urging said material to move across said hearth with an independnet circumferential flow component, whereby said material is caused to flow across the entire hearth area without forming stagnant zones.

19. A method of processing material in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, said method comprising the steps of introducing said material at the top of said furnace, urging said material to move across one of the upper hearths with a radial flow component, while simultaneously urging said material to move across said one hearth with an independent circumferential flow component, to cause said material to flow across the entire area of said one hearth in a distributed manner toward its associated drop hole, and successively passing said material across each hearth below said one hearth and down its respective drop hole to the next lower hearth and withdrawing said material from the bottom of said furnace.

20. A method of processing material in a multiple hearth furnace according to claim **19,** wherein said radial flow component across said one hearth is a radially inward flow component.

21. A method of processing material in a multiple hearth furnace according to claim **19** wherein said radial flow component across said one hearth is a radially outward flow component.

22. A method of processing sewage sludge in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, said method comprising the steps of introducing wet sewage sludge at the top of said furnace, passing said wet sludge downwardly through said furnace for drying the sludge by urging said sludge to move across one of the uppermost hearths with a radial flow component while simultaneously urging said sludge to move across said one hearth with an independent circumferential flow component, to cause said sludge to flow across the entire area of said one hearth in a distributed manner towards its associated drop hole, and successively passing said sludge across each hearth below said one hearth and down its respective drop hole to the next lower hearth, while maintaining the sludge in substantially the same state of dryness at any given diameter around each hearth in said furnace while applying heat to more than one hearth at controlled rates to effect said drying of the sludge.

23. A method of processing sewage sludge in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed toward the outer periphery thereof, said method comprising the steps of introducing wet sewage sludge at the top of said furnace, passing said wet sewage sludge to a first zone in the upper portion of said furnace for drying the sludge by urging said sludge to move across the uppermost hearth with a radial flow component while simultaneously urging said sludge to move across said uppermost hearth with an independent circumferential flow component, to cause said sludge to flow across the entire area of said uppermost hearth in a distributed manner towards its associated drop hole, and successively passing said sludge across each hearth below said uppermost hearth and down its respective drop hole to the next lower hearth in said first zone, while maintaining the sludge in a substantially the same state of dryness at any given diameter around across hearth in said first zone, passing said so-dried sludge to a second zone in the lower portion of said furnace for incinerating the sludge by successively passing said sludge across each hearth and down its respective drop hole to the next lower hearth in said second zone, while maintaining the sludge in substantially the same state of incineration at any given diameter around each hearth in the second zone, while applying heat to more than one hearth at controlled rates to effect said drying and incineration of the sludge.

24. A method of processing material in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, said method comprising the steps of introducing said material at the top of said furnace, rabbling with a plurality of rabble teeth depending from the rabble arms in the uppermost hearth through said material to be processed and urging said material to move across the uppermost hearth with a radial flow component, while simultaneously sweeping chains disposed between adjacent rabble arms associated with the uppermost hearth through the material to urge said material to move across the uppermost hearth with a circumferential flow component, to cause said material to flow across the entire area of said uppermost hearth in a distributed manner toward its associated drop hole, and successively passing said material across each hearth below said uppermost hearth and down its respective drop hole to the next lower hearth, and withdrawing said material from the bottom of said furnace.

25. A method of processing material in a multiple hearth furnace according to claim **24** wherein said sweeping chains extend between the innermost tooth on one rabble arm and the outermost tooth on the next adjacent arm, respectively.

26. A method of processing material in a multiple hearth furnace according to claim **24** wherein said sweeping chains extend between the outermost tooth of one rabble arm and the center shaft, respectively.

27. A method of processing material in a multiple hearth furnace according to claim **24** wherein said sweeping chains are chains dragging behind said rabble teeth, respectively.

28. A method of processing material in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, said method comprising the steps of introducing said material at the top of said furnace, rabbling with a plurality of rabble teeth depending from the rabble arms in the uppermost hearth in a critical zone through said material to be processed and urging said material to move across said uppermost hearth with a radial flow component, while simultaneously urging said material to move across said uppermost hearth with an independent circumferential flow component, to cause said material to flow across the entire area of said uppermost hearth in a distributed manner toward its associated drop hole, and successively passing said material across each hearth below said uppermost hearth and down its respective drop hole to the next lower hearth, and withdrawing said material from the bottom of said furnace.

29. A method of processing material in a multiple hearth furnace having a plurality of vertically spaced hearths, a rotatable center shaft extending up through the center of the furnace and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from said rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms, elongated bar-like members carried by said rabble teeth and extending substantially parallel to the longitudinal axis of the rabble arms respectively, said method comprising the steps of introducing said material at the top of said furnace, moving said material across the entire area of the uppermost of said hearths in a distributed manner while providing the radial flow component by the inclination of the rabble teeth with respect to the longitudinal axis of their respective rabble arms, and while providing the circumferential flow component by said bar-like members, and dropping said material down through said drop hole onto the next lower hearth.

30. A material of processing material in a multiple hearth furnace according to claim **29** further comprising the step of controlling the circumferential flow component by adjusting the height of said bar-like members.

31. A method of processing material in a multiple hearth furnace having a plurality of vertically spaced hearths a rotatable center shaft extending up through the center of the hearths and passing through each hearth, alternate hearths having drop holes disposed towards the center shaft and the other hearths having drop holes disposed towards the outer periphery thereof, a plurality of spaced rabble arms secured to the center shaft and extending radially outwardly over each hearth, a plurality of rabble teeth extending downwardly from alternate rabble arms nearly to the hearth floor, said rabble teeth being inclined with respect to the longitudinal axis of their respective rabble arms, rabble teeth extending downwardly from the other of said rabble arms nearly to the hearth floor and being disposed substantially parallel with respect to the longitudinal axis of their respective rabble arms, said method comprising the steps of introducing said material at the top of said furnace, moving said material across the uppermost of said hearths towards its drop hole while providing the radial flow component of said material by the inclination of the rabble teeth on said alternate rabble arms with respect to the longitudinal axis of their respective rabble arms and while providing the circumferential flow component of said material by the material contact area of the rabble teeth carried by said other rabble arms.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,905,757 Dated September 16, 1975

Inventor(s) CHARLES F. von DREUSCHE, JR.

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

Column 4, line 56, "through" should read --though--;

Column 5, lines 8 and 9, "the specification, shown in the accompanying drawings, forming a part of thespecification," should read --are shown in the accompanying drawings, forming a part of the specification--;

Column 6, line 40, "a" should read --as--;

Column 12, line 56, Claim 8, "bieng" should read --being--;

Column 15, line 27, Claim 8, "dependnet" should read --dependent--;

Column 16, line 41, Claim 23, "a substantially" should read --substantially--;

Column 16, line 42, Claim 23, "around across hearth" should read --around each hearth--;

Column 18, line 21, Claim 30, "A material" should read --A method--.

Signed and Sealed this

thirtieth **Day of** *December 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks