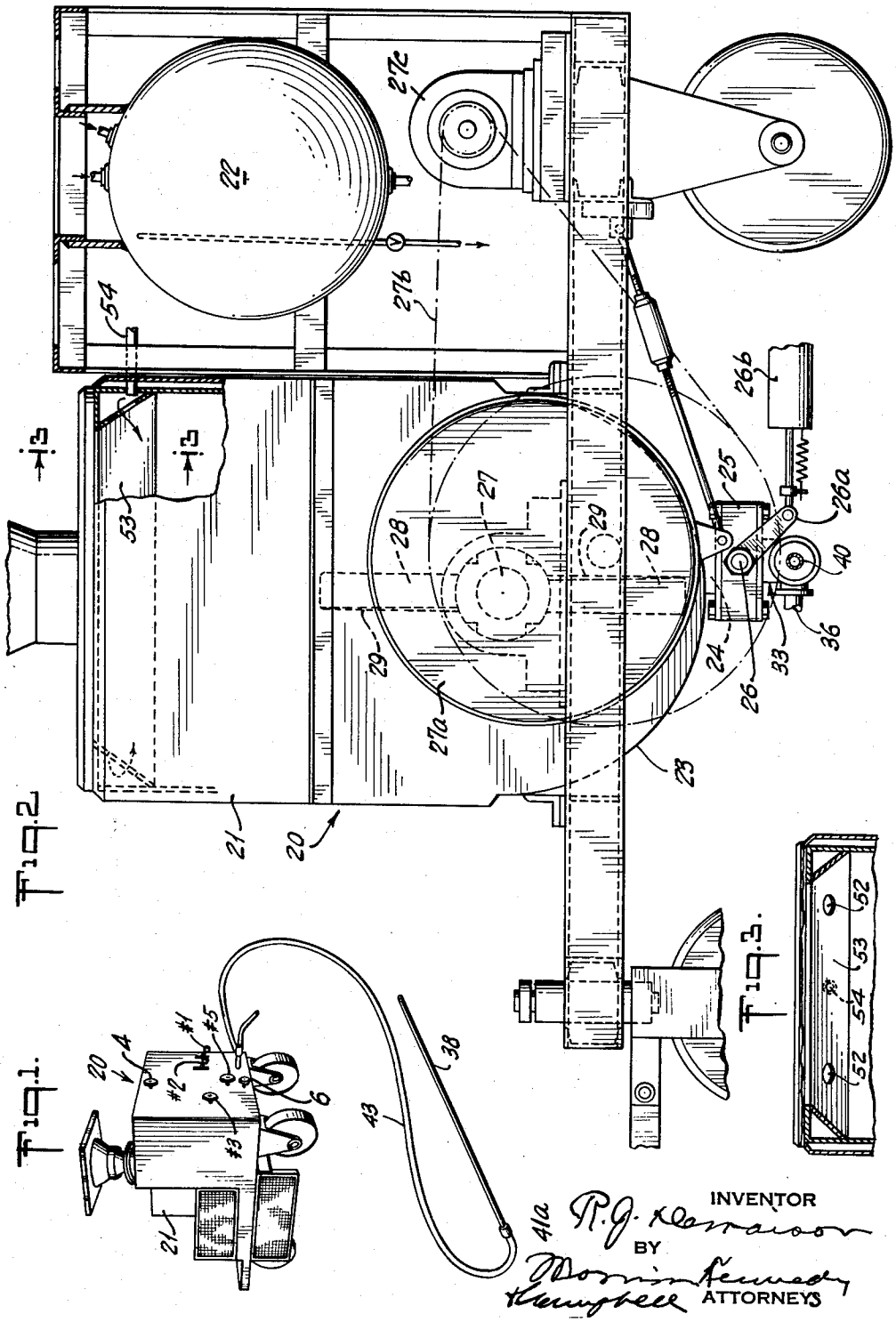
Dec. 17, 1963 R. J. DEMAISON 3,114,536

FURNACE REPAIR GUN

Filed Nov. 26, 1958 6 Sheets-Sheet 1



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FURNACE REPAIR GUN

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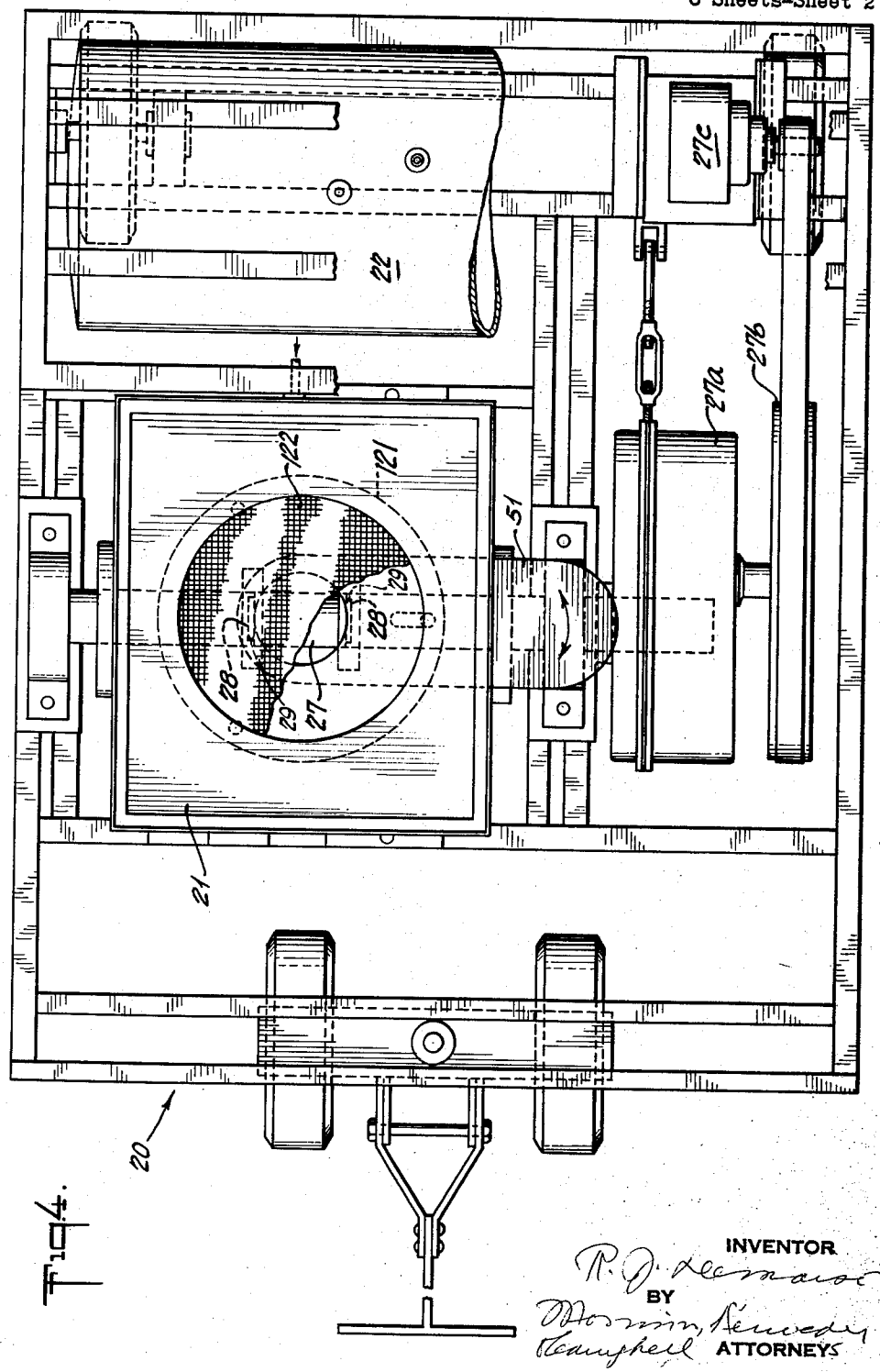

Fig. 4.

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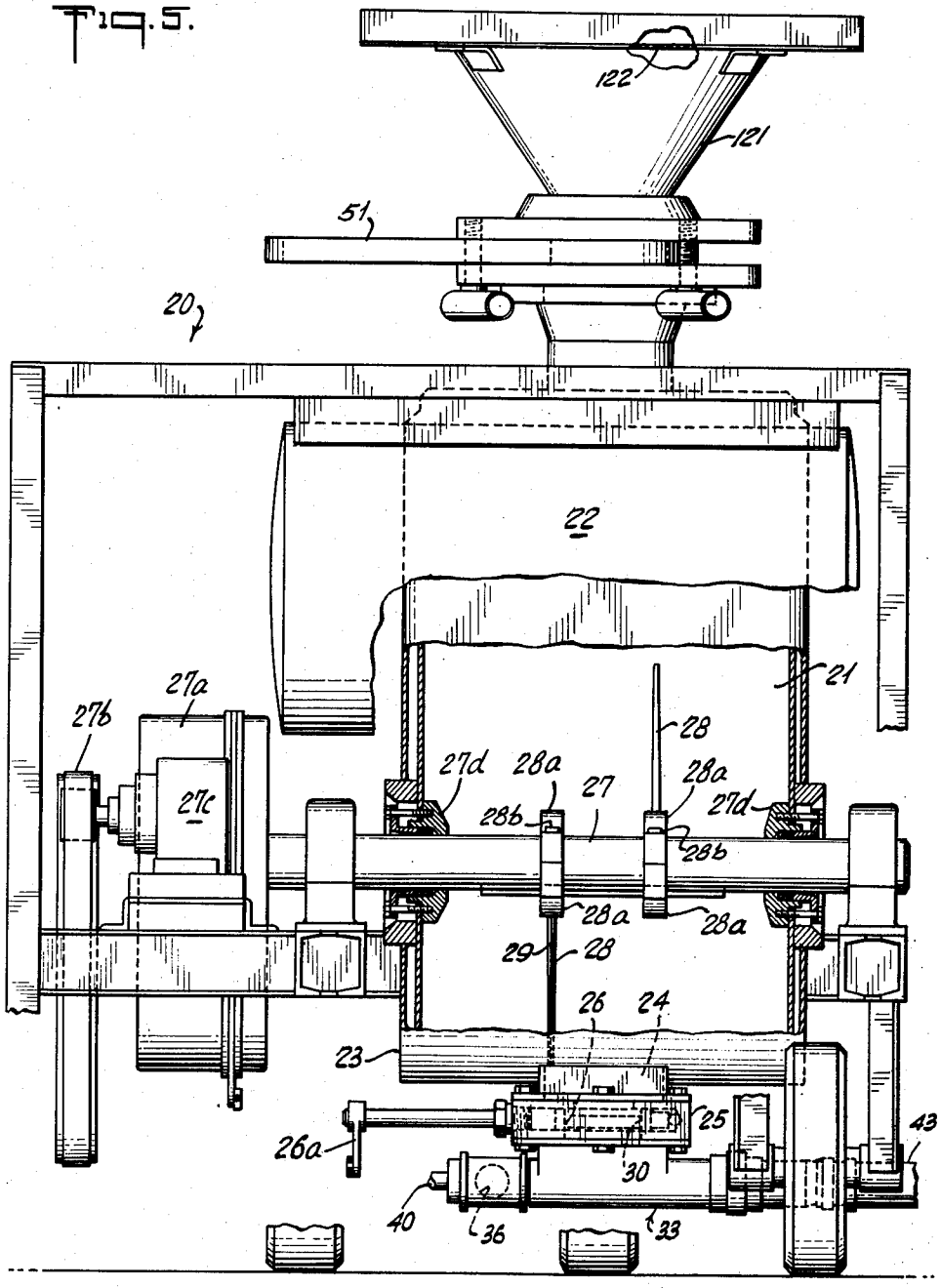
Fig. 5.



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FURNACE REPAIR GUN

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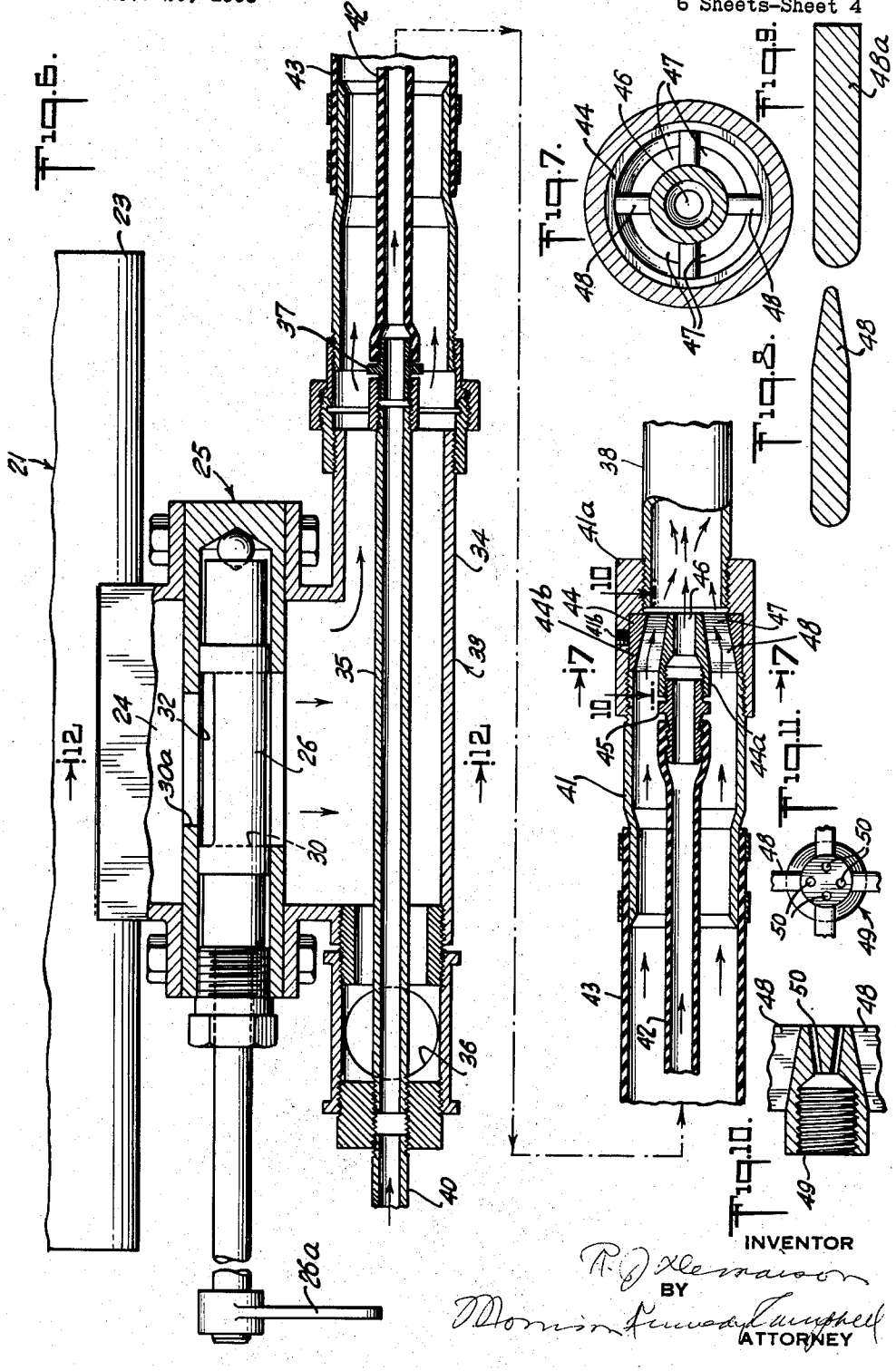

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Fig. 12.

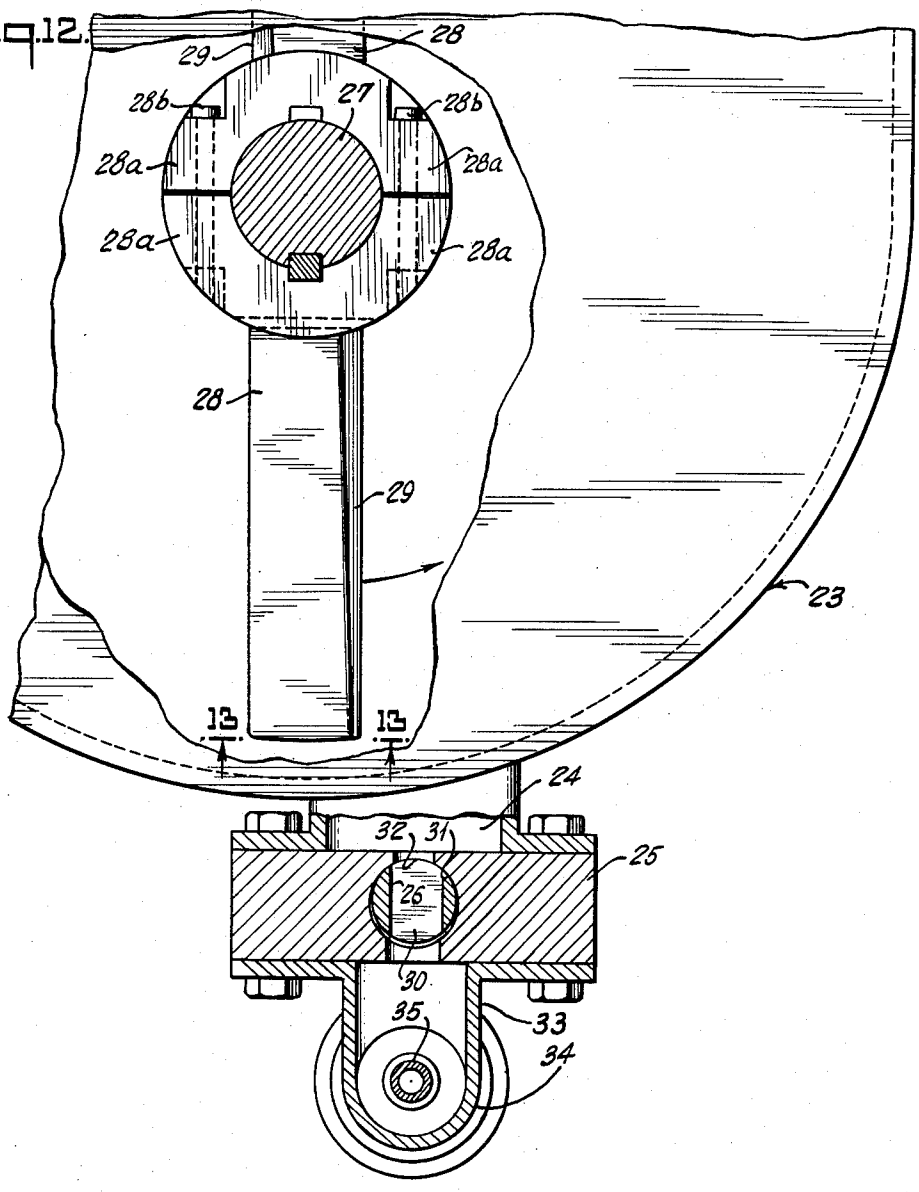

Fig. 13.

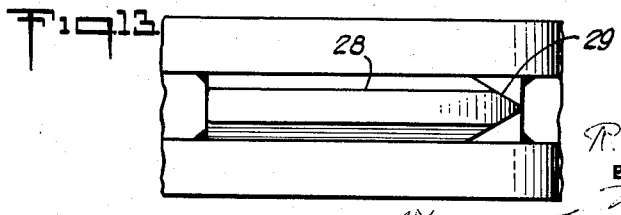

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Fig. 14.

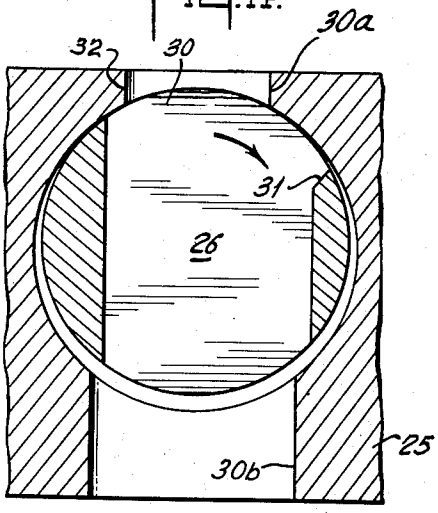


Fig. 15.

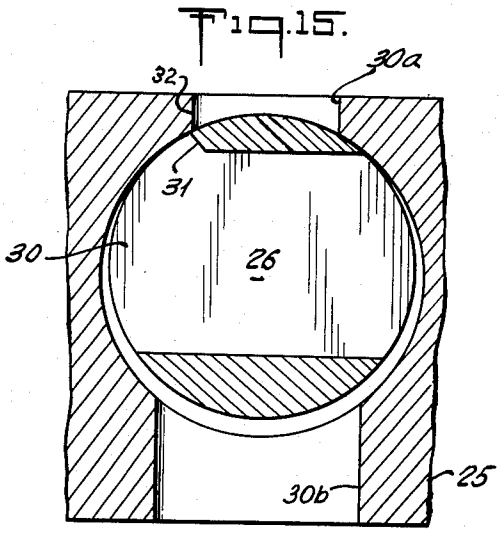
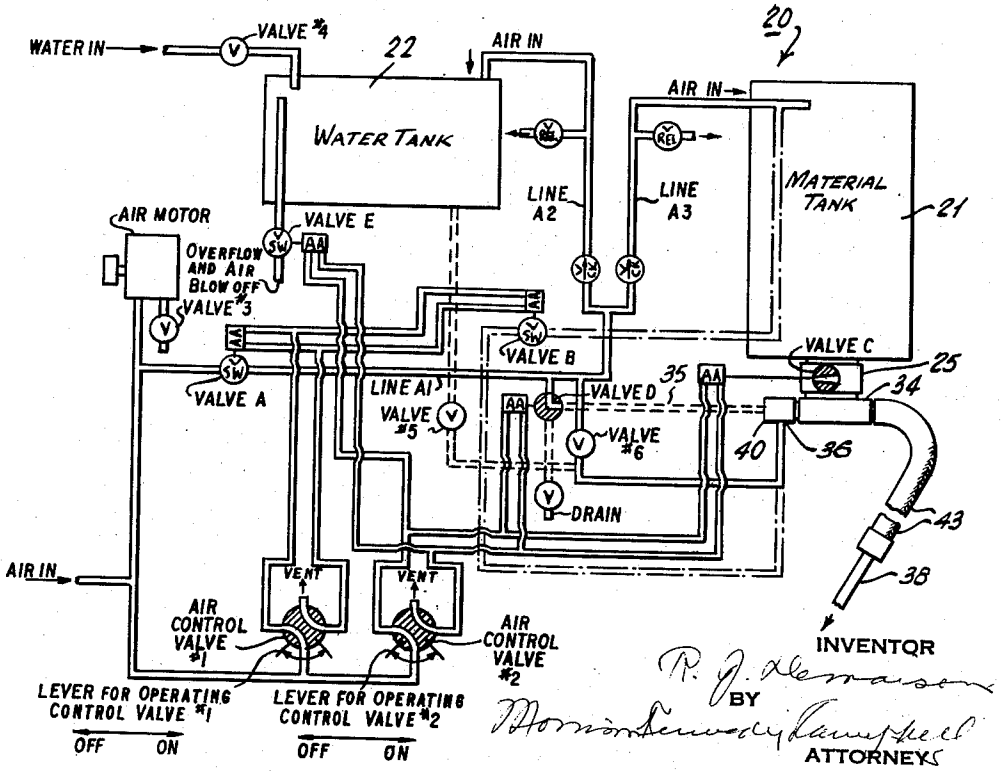


Fig. 16.



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United States Patent Office 3,114,536 Patented Dec. 17, 1963

3,114,536

FURNACE REPAIR GUN

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Filed Nov. 26, 1958, Ser. No. 776,518
12 Claims. (Cl. 259—151)

This invention is directed to a machine for repairing the refractory lining of high temperature furnaces, such as open-hearth furnaces, for steel making.

Such furnaces are frequently lined with refractory brick which is then coated upon the inside with a layer of refractory cement. In the course of operation of the furnace, this lining tends to break away at points.

It is an object of this invention to provide a machine for repairing such breaks. The machine is particularly useful for lining or rebuilding tap holes and for repairing or filling holes in the bottom and back walls above and below the slag line. Attempts have been made heretofore to apply repair material by means of a jet of water-borne repair material, but the results have not been satisfactory, partly because it has been difficult heretofore to keep the repair material and the water stream consistently mixed to the proper consistency.

In accordance with this invention, these difficulties are overcome by projecting a stream of water into a tubular mixing chamber and projecting an air-borne stream of repair material into the water stream, in a manner to break up the water stream. The most effective way which has been found of doing this is to carry the water and the air-borne repair material in concentric tubes up to and into the mixing chamber (the water being in the inner tube) and to deflect the streams (as by directing the material stream into the water stream itself) as the two streams meet. The mixing chamber or nozzle itself is tubular and of sufficient length to apply the resultant wet slurry to the back walls of the furnace, and within this nozzle the refractory material and water are thoroughly mixed in proper proportion before being applied to the furnace wall with no change in flow direction and with no loss of velocity.

This feature of carrying the water in the central tube and the air-borne repair material in a surrounding concentric annular tube in the manner described, is a matter of importance.

If the dry material were carried by the inner tube and the water through the outer, it would be very difficult to cause the water to penetrate the solid material stream, but this difficulty is very much diminished when the solid material is carried in the outer concentric tube, since it more readily forces its way into the water and thus secures a far better mixture.

It is an object of this invention to provide a machine that is reliable and effective in operation, and which will insure that the material as it is applied to the furnace area will be in uniform and proper consistency.

It is a further object to provide a machine which is easily controlled, and in which the mechanism cannot easily get out of order by improper handling of the controls.

In the accompanying drawings:

FIG. 1 is a perspective of the entire machine on a small scale;

FIG. 2 is a side elevation of the operating machine, showing the principal parts;

FIG. 3 is a fragmentary section along the line 3—3 of FIG. 2;

FIG. 4 is a top plan view of the machine as shown in FIG. 2;

FIG. 5 is an end elevation of the machine, parts having been cut away to show a portion of the interior of the material tank;

FIG. 6 is a fragmentary view, partly in section, showing the relation of the nozzle and the hose to the material tank. In this figure, the hose is shown in two separate sections, in order to permit a larger scale to be used;

FIG. 7 is a section along the line 7—7 of FIG. 6;

FIGS. 8 and 9 show two alternative forms of radial fins for the material jet;

FIGS. 10 and 11 show an alternative method of introducing the water jet into the material jet;

FIG. 12 shows the stirring vanes within the material tank for keeping the material contained therein from caking, and shows the relation of the tank and the stirring vanes to the material valve;

FIG. 13 is a fragmentary section along the line 13—13 of FIG. 12, showing a form of stirring vane which has been found effective;

FIGS. 14 and 15 are sections through the material control valve; FIG. 14 showing the valve in open position and FIG. 15 showing the valve closed; and

FIG. 16 is a flow sheet in diagrammatic form.

Turning now to FIGS. 1 and 2, 20 represents a truck having the usual wheels and handle. Mounted upon this truck is a material tank 21 preferably double walled, and adapted to contain a dry finely-divided or pulverized refractory material, such as Guntapite, which is composed primarily of magnesite. The screen analysis of Guntapite is as follows:

On ⅜ mesh	0
On 4 mesh	0
On 8 mesh	6
On 16 mesh	10
On 30 mesh	19
On 100 mesh	23
Through 100 mesh	42

Total amount of real fines through 325 mesh about 30%. Guntapite when air-borne is a hingly fluent material and may even be said to be semi-fluid. This is also an important consideration and one which has contributed to the success of the present invention.

Also mounted upon the truck is another tank 22 adapted to contain water which is to be mixed with the Guntapite as it is discharged from its tank.

As here shown (see FIGS. 2 and 12) the material tank 21 is generally rectangular, but it has a semi-cylindrical bottom 23 with a discharge opening 24 at its lowest point. Below the opening 24 there is a valve chest 25, carrying a rotary cylindrical valve 26 for controlling the flow of the material out of the tank, which valve is operated by a lever 26*a* and a spring pressed piston cylinder 26*b*.

Horizontally journalled within the tank 21 is a shaft 27 carrying stirring vanes 28 (see FIG. 5) which are rotated within the dry material in the tank to facilitate the feeding of the material therefrom and to prevent it from caking therein. The journals for this shaft are stuffed as shown at 27*d*. The shaft is driven (see FIG. 4) through a speed reduction device 27*a* and a belt and pulley arrangement 27*b* from an air motor, 27*c*. The

vanes 28 for convenience may each be attached to a semi-cylindrical hub 28*a*, the two hubs being clamped together about the drive shaft 27 by screws 28*b*. The vanes are preferably substantially rectangular in cross section, as shown in FIG. 13, with the advance side brought to an edge, as shown at 29, and the thickness of the vane is reduced toward the outer end, as shown in FIG. 5.

Above the material tank 22, there is mounted a filling hopper 121 (see FIGS. 4 and 5) having at its upper end a screen 122 for limiting the size of material fed to the tank, and it also is provided with a rotary air-tight gate valve 51 in the connection to the tank for controlling the flow of material. At the top of the tank 22 (see FIGS. 2 and 3), there is a cone-shaped baffle plate 53 extending entirely around the tank and formed with a plurality (e.g. 4) of air openings 52. An air inlet pipe 54 connects with the space formed by the baffle plate but preferably is arranged at a point intermediate the two adjacent openings. As will later be explained, air pressure is built up in the tank for the feed of the refractory material therefrom during the operation of the machine. After the tank has been emptied, the air pressure is relieved in the manner to be described, and the baffle plate serves during the air evacuating period to prevent any of the dry powdered material mixed with the air from clogging the inlet pipe.

The valve 26 has an opening 30 which, when the valve is open, registers with an inlet opening 30*a* and an outlet opening 30*b* in the valve chest 25 to allow material from the tank to pass through the valve into the shell 33. One edge, however, of the opening 30 is chamfered off at 31 as shown in FIGS. 14 and 15, since it has been found that in using the valve to control crushed material, the chamfered edge prevents binding of the material particles against the edge of the valve seat at 32, so as to prevent closing of the valve. With this chamfered edge such material particles are either thrust upwardly into the tank or downwardly into the valve, and the valve may always be closed.

It will also be observed from FIGS. 12, 14 and 15 that the rotary cylindrical valve 26 is slightly smaller in diameter than the bore of the valve chest 25 and is offset to the inlet side of the valve chest, so that by such eccentric mounting of the rotary valve there is always left between the valve and the valve chest a crescent shaped space below the valve which prevents the building up of material particles in that area and thus insures the free rotation of the valve.

Attention is also called to FIGS. 2, 5 and 12 which show the discharge opening 24 in the tank as well as the underlying valve chest 25 and rotary valve 26 offset from a vertical plane passing through the center line of the shaft 27 for the stirring vanes 28, such offset being in the direction of rotation of the vanes. As a result of this arrangement, the material will fall from the ends of the vanes 28 as the latter rotate across and above the discharge opening 24, thereby allowing the material, under the influence of gravity and air pressure, to be discharged into the valve mechanism without danger of caking or bridging. The tapered character of the vanes, as well as their V-shaped leading edges promote this feeding action, the vanes acting much in the manner of plows.

Below the valve chest 25 (FIG. 12) there is mounted a casing 33 having an outer shell 34 and a concentric inner tube 35. This casing 33 has its outer shell 34 open at the top so that the material passing through the valve opening 30 will enter the shell 34 on the outside of the inner tube 35.

The inner tube 35, which is to carry water to the nozzle, extends clear through the shell 34 beyond the valve chest 25 at both ends (FIGS. 5 and 6). At the left hand end, it receives air in the first stage and then water in the second stage of operations through a conduit 40. At the right hand, tube 35 connects at 37 to a flexible hose 42, leading to the nozzle 38 as will be described. (See FIG. 6.)

The outer shell 34 is connected at the left hand side to an inlet 36 for compressed air, and at the right hand side it connects with a flexible hose 43 also leading to the nozzle 38.

As these hoses 42 and 43 lead away from the valve chest 25, they take the form of a concentric double channeled hose carrying water on the inner channel and the air-borne material in the outer channel, said hose leading to a rigid mixing element 41 and a long rigid nozzle 38 connected together by a screw threaded coupling 41*a*.

The mixing element 41, as shown in FIG. 6, comprises a jet device or injector 44 which has a central jet opening 46 through which water from the inner hose 42 is discharged into the nozzle 38, and a plurality (e.g. 4) of arcuate jet openings or passages 47 through which the refractory material from the outer hose 43 is discharged into the nozzle 38. The passages 47 are separated by intermediate radial partitions or fins 48 having the shape shown in FIG. 8 or by fins 48*a* having the shape shown in FIG. 9. The advance edges of both fins 48 and 48*a* are rounded to meet the incoming material, but the trailing edges of the fins 48 are tapered in the direction of flow to widen the passages 47 at their discharge end, while the trailing edges of the fins 48 are squared off, leaving the walls of the fins parallel. The fins 48*a* are also slightly thicker than the fins 48. By altering the form or thickness of the fins, the flow of the refractory material may be varied to meet different conditions of operation. In both forms of fins, the material as it issues from the mixing element will fan out and form a complete ring.

The jet device 44 could be made in one piece, but to reduce the cost of manufacture, it is preferably made in sections, namely, an inner section 44*a*, an outer section 44*b*, and the intermediate fins 48 or 48*a*. The fins are fitted in slots formed in the inner section and are welded in place; they may or need not be welded to the outer section. The inner section, which contains the water passage 46, is connected by a nipple 45 to the flexible rubber hose 42, and the outer section is clamped in place by the coupling 41*a* and locked against rotation by a set screw 41*b*. It will be noted that the inner section 44*a* has a flared bore in advance of the water passage 46 which bore creates turbulence in the water stream before it enters the mixing discharge nozzle and thus aids in producing the required intimate and thorough mixture of the material and water.

It is pointed out that the confronting walls of the inner and outer head sections 44*a* and 44*b* are cone-shaped and converge in the direction of the material flow so as to direct the material flowing through the jet passages 47 into and across the solid stream of water as it issues from the jet opening 46. In this way, the dry refractory material is caused to penetrate and to break up the water jet and bring about a thorough mixing of the material and water in the nozzle 38 before the mixture is discharged in wet slurry from therefrom.

In FIGS. 10 and 11 there is shown a different embodiment in which the inner or water carrying element 49 is provided with a head having a plurality of divergent openings 50 in place of the single central opening 46, thus throwing streams of water into the path of the air-borne material discharged around it as in the first embodiment, so that the water streams are effectively broken up.

The device is operated by compressed air supplied to it from a single connection, so that the device may be moved to any location in the mill where compressed air is available, and if its material and water tanks are filled it may be connected up ready for use as soon as the air hose is coupled. The compressed air, under the control of the sequential control system which will be described, imposes pressure on the water supply and on the material

supply and forces the water stream and the material to the mixing chamber and it is also used to flush out the water and material line.

The compressed air is also used to actuate valves which control these functions.

Referring now to FIG. 16, the air entering at the point indicated is indirectly connected to two lever operated valve #1 and #2.

The air line also goes directly to the air motor 27c which operates the stirring and feed vanes 28. The operation of this motor is controlled by a valve #3 in its exhaust.

The air is also fed through a valve A and line A1 to the two tanks 21 and 22, but this line is divided to provide one branch A3 for the material tank and one branch A2 for the water tank. Both these lines have check valves marked CK and safety relief valves marked R.

The water tank has an air blow-off and level drain valve E and a water inlet valve #4.

The supply line from the water tank is provided with a hand valve 5 which can be set to regulate the volume of water supplied from the tank. Beyond the valve 5, the water supply line is connected to one inlet of a two way valve D. This valve D has another inlet connected to the air line A1 and its outlet is connected to the water tube 35 at 40, so that the operation of valve D will discharge either air or water through the water line.

The air line A1 is permanently connected to the opening 36 into the material conveying shell 34 by an adjustable orifice valve 6.

The opening 36 is also connected through a valve B with the air pressure above the material in the material tank.

The sequential control system for the machin (see FIG. 16) comprises the two operating levers #1 and #2, and the hand operated motor or control valve #3 for controlling the speed of the air motor, which drives the stirring and feed vanes 28. There are also the five air operated valves A, B, C, D and E, controlled by the levers #1 and #2. These valves have already been described, the valve C being the material feed valve 26.

After the tanks are filled and the air line connected, the lever 1 is the first one actuated in starting the device. This lever

(*a*) Opens the valve A which, through line A1 and branch lines A2 and A3, admits compressed air to both of the tanks 21 and 22, but the water tank at this time has its relief valve E open, allowing for the proper water level within the water tank.

(*b*) Also causes air to blow through open valve D into the water line of the nozzle at 40 to blow it clean.

(*c*) Also closes valve B to build up air pressure in the material tank.

Then lever 2 is operated. This lever

(*a*) opens the material valve C, allowing material to be blown down and fall into shell 34 where it meets the air stream from inlet 36 continuously supplied by the orifice valve 6.

(*b*) switches valve D to shut off air from line A1 and connect the inlet 40 to the water supply from tank 22 through the medium of the volume regulating valve 5.

(*c*) shuts the relief valve E so that air pressure is built up in the water tank to put the pressure on the water.

With the mechanism in this condition, the material and the water are separately carried to the nozzle and there the material pet impinges on the water jet, causing great turbulence and a thorough mingling of the two jets before the wet slurry is projected onto the furnace wall.

A distinct advantage is obtained by mixing the material and water before it is projected onto the wall so that it reaches the wall in a uniform mixture of just the right proportions.

In shutting off the apparatus, the levers 1 and 2 are operated in reverse order. When the lever 2 is actuated:

(*a*) the valve C is operated to shut off further flow of material from the tank 21 into the shell 34;

(*b*) the valve D is switched back to its original position, disconnecting the water line at 40 from the supply tank 22 and connecting said water line to the main air line A1 to blow through and clean out the water line and the mixing nozzle;

(*c*) reopens the relief valve E to evacuate air from the water tank;

(*d*) Air from the continuously open orifice valve 6 continues to enter opening 36 and blows through the material conveying line and the mixing nozzle.

When the lever 1 is later actuated, it closes valve A to shut off the air supply to the main line A1 and opens valve B to evacuate air from the material tank 21 and permit it to blow off through the opening 36 which leads into the material conveying conduits. Such evacuation of air from the material tank 21 through the opening 36 is intended primarily to insure that any material evacuated with the air will be discharged from the nozzle 38. The valve 3 is then closed to stop the operation of the air motor.

As will have been noted, compressed air is the entire power factor for the operation of the gun. In addition to pressurizing the two tanks, it also operates the air motor which, through the medium of the reduction gearing and belt drive, operates the feeder which supplies the refractory material from the tank 21 to the shell 34, which itself is a pressure chamber forming part of the material conveying system. In this connection, it may be pointed out that the compressed air penetrates and mixes with the dry refractory material in the tank 21, so that the material as it enters the shell or pressure chamber 34 is actually "air-borne" (the expression used above) and is propelled under high pressure and at high velocity to and through the jet device 44. The additional compressed air which enters the shell 34 through the opening 36 will also combine with the dry refractory material and air supplied from the material tank and will aid in forcing the material to and through the jet device. This additional air supply is important, as it provides a pressure differential which is needed in controlling the velocity and volume as well as the redirection of the flowing material. The wet slurry resulting from the mixture of the dry material and water is forced through and issues from the mixing nozzle 38 at high velocity but is retained in the nozzle, because of its length, long enough to insure a thorough and intimate mixture which will adhere and bond to the furnace area being repaired.

While the instant gun has been especially designed for the mixing of dry refractory material with water in the discharge nozzle, it may be adapted to handle wet refractory material by properly regulating the volume of water fed to the discharge nozzle.

The invention contemplates many different variations and modifications of the various parts as well as many different uses of the apparatus. It should be understood, therefore, that the invention is not limited to any particular embodiment or to any particular mode of operation except insofar as such limitations are specified in the appended claims.

What is claimed is:

1. A valve mechanism for use in a fine particle feed system, comprising a valve chest having a cylindrical bore and diametrically opposite intersecting inlet and outlet openings at right angles thereto, a rotary cylindrical valve mounted in the cylindrical bore of the valve chest and truly cylindrical throughout its operating length, said cylindrical valve being slightly smaller in diameter than the bore of said valve chest and offset to the inlet side thereof to leave a crescent-shaped space at the outlet side thereof and containing a transverse opening adapted to be brought into registry with said inlet and outlet openings in said valve chest, the leading edge of said transverse opening in said offset cylindrical valve at the inlet side of the valve chest being chamfered to prevent material particles becoming entrapped in said opening and jamming between said

leading edge of the valve and said valve chest as the valve is closed while the space on the opposite side of the valve caused by the offset prevents building up of material particles between the valve and chest.

2. A furnace repair gun for mixing refractory material with water and shooting the mixture in wet slurry form under superatmospheric pressure onto the furnace are to be repaired, said gun comprising a mixing discharge nozzle, a water conduit leading from a supply source to said nozzle, a material conduit surrounding and concentric with said water conduit and also leading from a supply source to said nozzle, a mixing element connected to the terminal portions of the water conduit and the material conduit and having a central passage leading directly from the water conduit into the mixing discharge nozzle in a direction axially of said nozzle, as well as a plurality of arcuate openings arranged concentrically around said central water passage and leading from the material conduit into said nozzle, the inner and outer walls of said arcuate openings being cone-shaped and arranged to converge in the direction of flow, whereby the refractory material as it enters the mixing discharge nozzle is projected into and across the path of the water as it enters said nozzle from the central passage of the mixing element, and air pressure means for forcing the water and refractory material through their respective conduits and the mixing element into the mixing discharge nozzle and thence in mixed condition through said nozzle, which nozzle is of sufficient length to insure a thorough mixing of the refractory material with the water before the resultant mixture is discharged from the nozzle.

3. A furnace repair gun according to claim 2 wherein the mixing element is constructed to discharge the water in a turbulent condition into the mixing discharge nozzle.

4. A furnace repair gun comprising, in combination, a compressed air line, a water containing tank equipped with an automatically power-operated air blow off valve, a material containing tank equipped with an automatically power-operated air blow off valve, a mixing discharge nozzle, a water conduit leading from the water containing tank to the discharge nozzle, a material conduit leading from the material containing tank to the discharge nozzle, air pipes connected to the compressed air line and leading to the water containing tank, the material containing tank, the water conduit and the material conduit respectively, a power-operated two-way valve adapted in one position to control the admission of compressed air into the water conduit and to exclude the admission of water from the water containing tank into the water conduit, and in a second position to control the feed of water into said conduit from the water containing tank and to exclude the admission of compressed air into said conduit, a material feed valve for controlling the feed of material from the material containing tank to the material conduit, a power-operated master control valve adapted when opened to admit compressed air into the air pipes in order to pressurize the water containing tank and the material containing tank as well as to blow clean the water conduit and the material conduit, a first device for concurrently controlling the opening of said power-operated master control valve and for controlling the closing of the power-operated air blow off valve of the material containing tank to condition the gun for operation, and a second device operable after the operation of the first device for concurrently controlling the opening of the power-operated material feed valve, controlling the closing of the power-operated air blow off valve of the water containing tank, and controlling the turning of the power-operated two-way valve to its second or water feed position to set the gun into operation.

5. A furnace repair gun according to claim 4, wherein the first and second devices are operable in reverse order to shut off the operation of the gun, the second device acting concurrently to control the closing of the power-operated material feed valve, control the opening of the power-operated two-way valve back to its first or air feed position and controlling the reopening of the power-operated air blow off valve of the water containing tank, and the first device acting thereafter to concurrently control the closing of the power-operated master control valve and control the opening of the power-operated air blow off valve of the material containing tank.

6. A furnace repair gun according to claim 4, wherein the compressed air is admitted continuously into the material conduit through a constantly open orifice valve when the master control valve is open.

7. A furnace repair gun according to claim 4, including pneumatic means for the power operation of the valves therein referred to in response to the operation of said first and second devices.

8. A furnace repair gun according to claim 4, including a rotatable stirring device located in the material tank to avoid caking of the refractory material therein and to facilitate the feed of the air blown material therefrom, and an air motor operated from the compressed air line for rotating said stirring device.

9. A furnace repair gun according to claim 4, wherein the material containing tank is provided at the top with an annular ring which forms in conjunction with the top and side walls of the tank an air pressure chamber controlling the admission and even dissemination of the compressed air over the whole area of the tank, said ring containing a plurality of suitably spaced openings leading from the air pressure chamber into the tank and acting as a dust separator when the compressed air is vented from said tank after the gun is put out of operation.

10. A furnace repair gun according to claim 4, wherein the material containing tank is provided at the top with a suitable opening and a filling hopper superimposed upon the tank and communicating through said opening with the tank, said filling hopper being provided with a self-cleaning rotary air-tight gate valve to close and seal said tank opening when air pressure is applied to the material containing tank for operation of the gun.

11. In combination, a material tank adapted to contain finely divided material and having a semi-cylindrical bottom, a valve chest located beneath said tank and having a cylindrical bore with diametrically opposite intersecting inlet and outlet openings at right angles thereto, a rotary cylindrical valve mounted in said chest and having a through transverse opening adapted to be brought into registry with said inlet and outlet openings in the valve chest for feeding the finely divided material from the tank, means for turning the rotary valve to open or closed position as desired, and a rotary stirring device contained in the tank and arranged with its axis of rotation parallel to the axis of rotation of the rotary valve, said rotary stirring device being adapted to move in close relation to and directly ahead and over the inlet opening of said valve chest, said inlet opening being offset from a vertical plane passing through the axis of rotation of the stirring device in the direction of its rotation, and means for applying air presure to the top of said finely divided material, whereby the combined action of the stirring device and air pressure on the finely divided material assures a constant feeding of the finely divided material from the tank.

12. A combination according to claim 11, wherein the stirring device comprises a plurality of radially disposed vanes which are substantially rectangular in cross section and are tapered toward their free ends and which vanes have their leading edges of V shape, whereby the rotation of the stirring device causes the stirred and loose material in the tank to fall away from the free ends of the stirring device vanes and become air borne under the influence

of the air pressure exerted on the top of said finely divided material.

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