Feb. 14, 1933. C. HART 1,897,647

METHOD AND APPARATUS FOR MIXING A FURNACE CHARGE

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Fig.1.

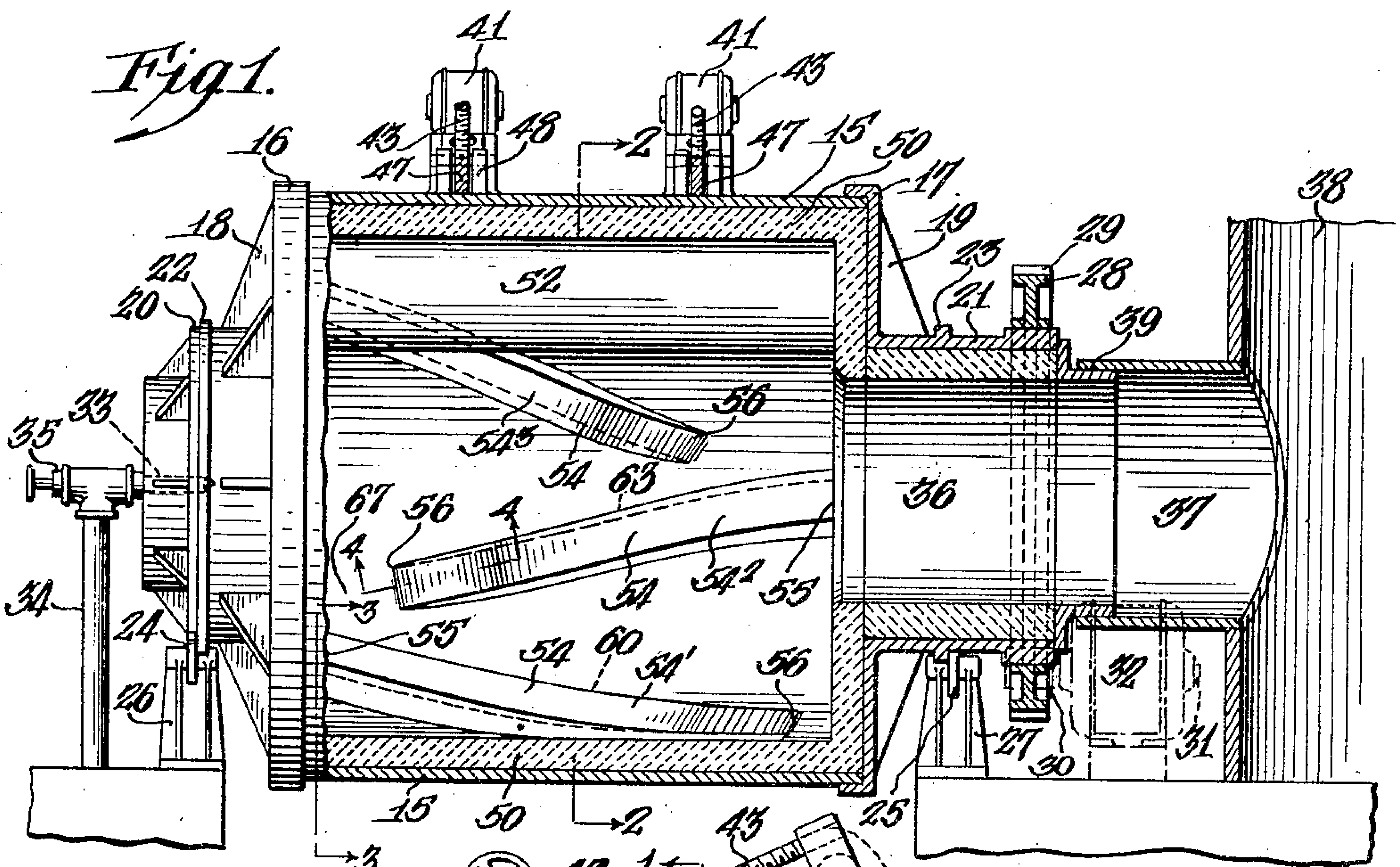

Fig.2.

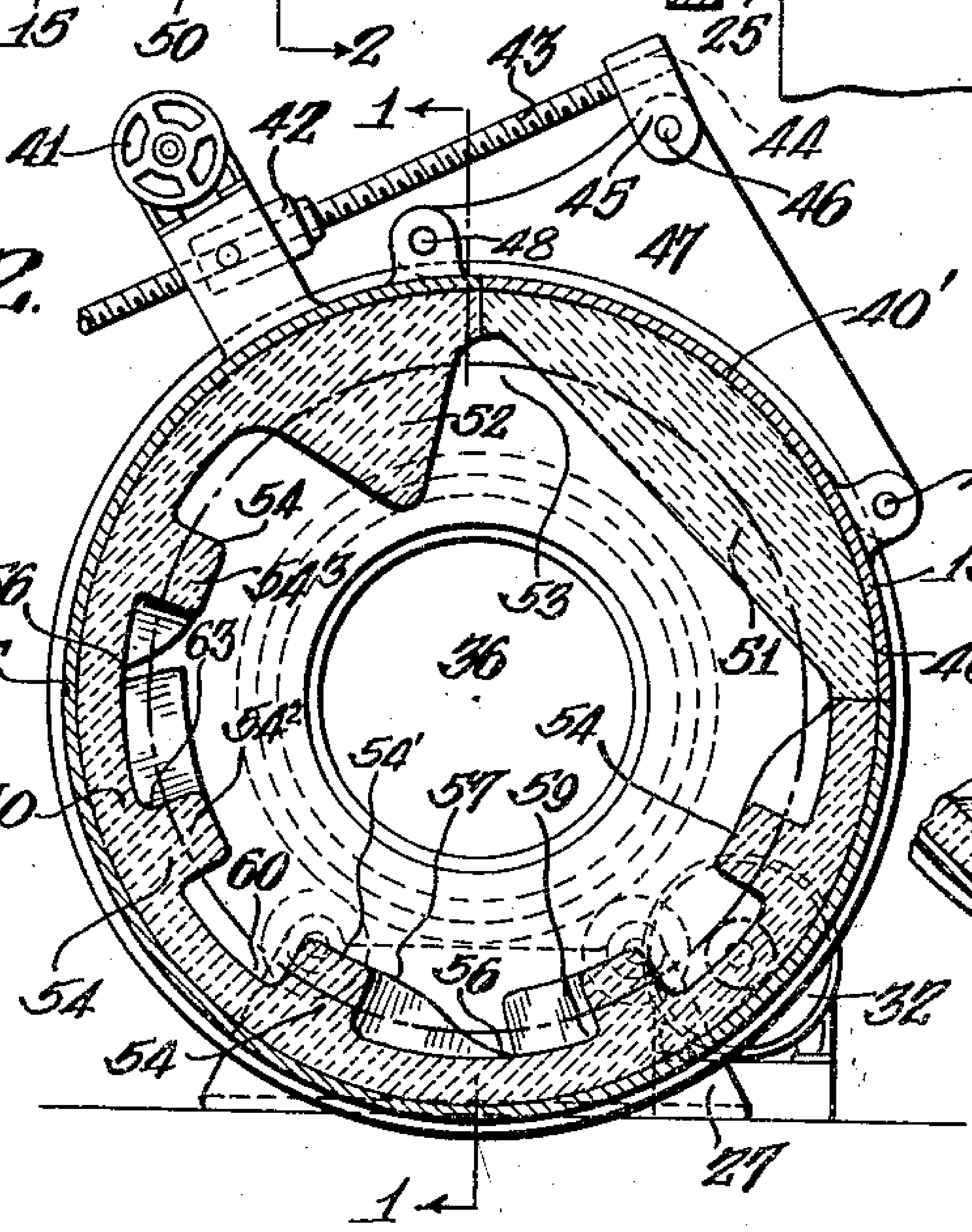

Fig.3.

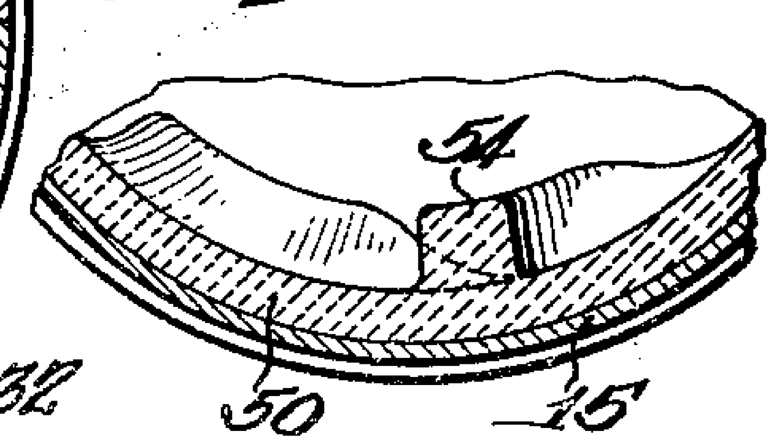

Fig.4.

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Fig. 5

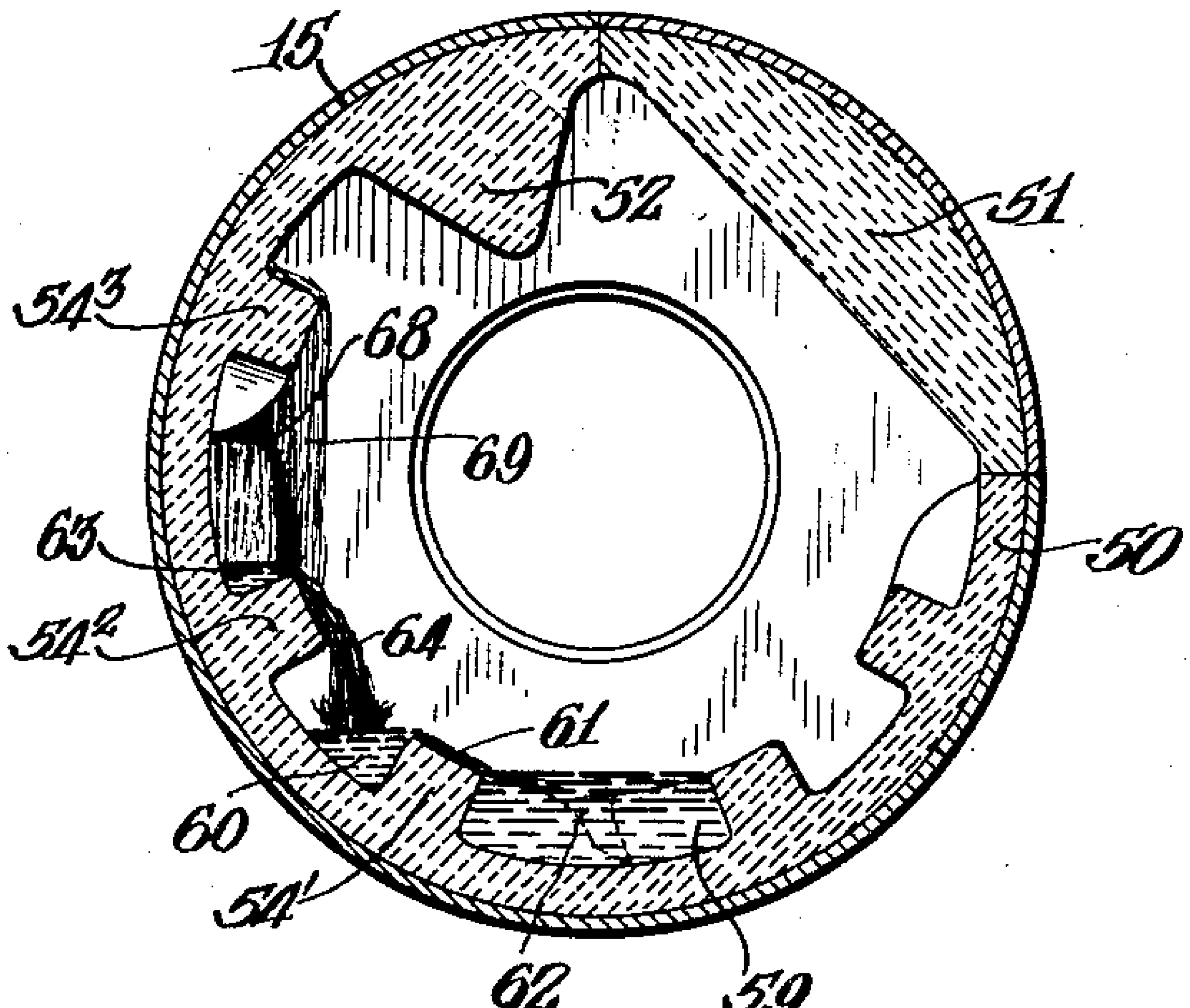
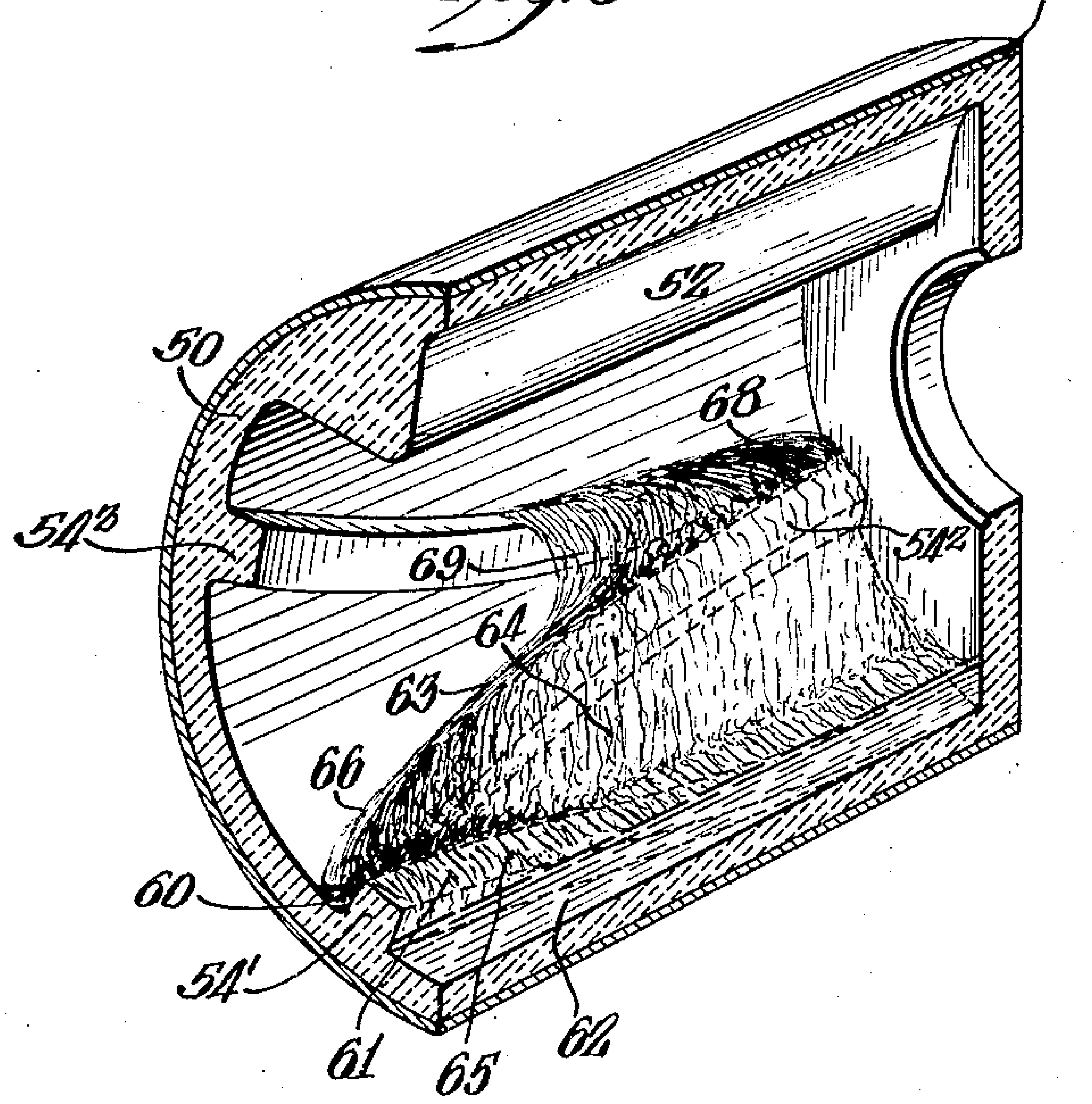


Fig. 6



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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR MIXING A FURNACE CHARGE

Application filed December 6, 1930. Serial No. 500,555.

My invention relates to methods of mixing furnace charges and to the internal construction of rotatory and oscillatory mixing furnaces.

A purpose of my invention is to turbulently mix the charge in a rotatory or oscillatory furnace more vigorously than has previously been possible.

A further purpose is to cause the charge in a mixing furnace to follow a path during each revolution substantially longer than the inner circumference of the furnace.

A further purpose is to spirally dispose oppositely directed mixing vanes in the lining of a mixing furnace.

A further purpose is to construct a labyrinth path for the charge between adjacent oppositely directed vanes by extending one vane from one end of the furnace part of the way only to the other end of the furnace, and running the next vane from the latter end part of the way only to the first, so that the charge will frequently change its direction of flow.

A further purpose is to make the radial inward extension of a mixing vane less than the depth of the charge pool when lying in the bottom of the furnace so that the charge will repeatedly fold and lap over itself as the furnace rotates instead of merely flowing bodily over an irregular surface.

A further purpose is to overflow the charge carried up by each vane in the form of a thin sheet, and to rumple up the sheet against the next vane in the advancing quadrant of the furnace in contact with the charge flowing longitudinally of the furnace against that vane, to inject the high velocity overflow stream into the low velocity longitudinal stream.

A further purpose is to arrange the stirring vanes in a mixing furnace so that portions of the charge will be directed by one vane against the next succeeding vane at a point near that at which the next vane projects from the end wall, and, after abruptly changing direction, will be carried along that vane generally longitudinally of the furnace toward the opposite end wall before they can progress radially to any substantial extent.

A further purpose is to cascade charge material from one vane to another on the advancing side of a furnace before the charge can join the pool in the bottom of the furnace, and to inject the cascading flow at high velocity into the pool when it reaches the surface of the pool.

A further purpose is to rotate the puddled ball in an axial direction to make it spherical rather than ellipsoidal.

Further purposes will appear in the specification and in the claims.

In the drawings I illustrate one of many possible forms embodying my invention, choosing a form which is advantageous in practice and convenient for illustration and for explanation of the principles involved.

Figure 1 is a sectional elevation of a mixing furnace, the section being taken along the line 1—1 of Figure 2.

Figure 2 is a section of Figure 1 on the line 2—2, omitting structure in the background.

Figure 3 is a fragmentary section taken on the line 3—3 of Figure 1.

Figure 4 is a fragmentary section taken upon the line 4—4 of Figure 1.

Figure 5 corresponds generally to Figure 2, omitting the external structure, and showing the furnace during the mixing of a charge.

Figure 6 is a sectional perspective view of the advancing side of the furnace during the mixing of a charge. Other structure is omitted.

Designers of mixing furnaces, especially of puddling furnaces, have previously suggested the use of mixing vanes of many characters and forms. Generally these have extended longitudinally from one end to the other of the furnace, and have been constructed so that the charge will be momentarily dammed against the advancing edge of the vane, and will then flow in a thin sheet across the vane as the furnace continues to turn to permit the charge to rise above the vane.

While much superior to a smooth lining, mixing vanes of this type are inefficient because all parts of the charge to a large extent retain the same relation to one another.

The same small portion will be repeatedly mixed, while other parts of the charge will not be kneaded and folded or lapped over themselves.

It has been suggested that the mixing vane should spiral continuously along the furnace wall. In some ways the continuous spiral vane is much more advantageous than the form having the vane extending directly longitudinally of the furnace.

A number of disadvantages are however apparent. The mixing vane should compel the charge to take a path much longer than the furnace circumference, but in the continuous spiral form the path is only very slightly longer because of the very flat pitch of the spiral vane. The spiral represents the diagonal merely of a triangle having the circumference for one side, much longer than the pitch, which is the other side. The spiral should not be continuous, because the mixing is much more advantageous if the charge be compelled to change its direction frequently.

I find that intermingling and then intermixing charge taken from one place with charge from another place is very much better than merely spirally progressing them. In this way, as the portions of charge are carried over the vane or compelled to change direction, they will become thoroughly mixed to produce a uniform composition. I preferably bring together portions of charge moving at different velocities.

By my invention I combine numerous desirable features lacking in previous furnaces of this type in a construction which is easy to build, sturdy in use, and convenient to repair.

Among the advantageous features to be found in my form, I may mention the following: (1) during each rotation the charge traverses a long path, several times the length of the circumference of the furnace; (2) the charge frequently changes direction abruptly; (3) parts of the charge flow in sheets over the mixing vanes and are then rumpled up before being mixed farther; (4) charge from one place is projected into contact with that from another place; (5) the charge is kneaded, folded and lapped over itself; (6) portions of the charge travelling at very different velocities will be brought together, as when charge falling from high up on the advancing side of the furnace meets charge travelling longitudinally along one of the vanes, and penetrates by jet action; (7) charge from the advancing side of the furnace cascades into charge at the bottom of the furnace.

Referring to Figures 1 and 2, the furnace comprises generally an external metallic casing 15 supported at either end by the heads 16 and 17, braced at 18 and 19 from the hubs 20 and 21. The hubs carry bands 22 and 23 which rest in and rotate or oscillate upon rollers 24 and 25 in supports 26 and 27, so that the furnace may be rotated or oscillated in either direction as desired. The hub 21 also supports a driving band 28, having gear teeth 29 engaging the driving gear 30 on the shaft 31 of the motor 32, to turn the furnace.

Suitable gaseous or liquid fuel is admitted through the burner 33 from the pipe 34, controlled by the valve 35. Air is drawn in around the burner. The products of combustion from the furnace discharge through the neck 36 into the flue 37 and up the stack 38. The flue and the neck are desirably sealed as at 39 in any suitable manner so that the furnace may rotate without excessive loss of draft.

For charging and discharging, the furnace has a door 40, which may very desirably be mechanically controlled by the electric motor and speed reduction units 41, as through the driving connections at 42. The motors 41 impart rotation to the screws 43, supported in the bearings 44 of the collars 45. The collars 45 are pivoted at 46 to the lifting arms 47, pivotally secured to the furnace casing at 48. The lifting arms 47 are secured to the door frame 40′ at the pivotal and rotatable bearings 49.

The refractory lining 50 covers the interior of the furnace body 15. At the inside of the door the refractory material 51 may very desirably be smooth in surface, since projections placed at this point would be likely to interfere with the opening of the door.

At 52 I illustrate a large projection into the furnace interior, and intend it to represent any of a number of projections which may be found in mixing furnaces. I do not intend the shape of this projection to be critical. Thus 52 may be a breaking wall, a longitudinal mixing vane, a skimming dam, or any other similar structure.

The use of an interior projection as a skimming dam is described and claimed by me in my copending application Serial Number 461,100, filed June 14, 1930. Skimmed material will collect in the pocket 53 near the door when the furnace is moved counterclockwise about 180° from the position shown in Figure 2. The skimmings may then be discharged simply by opening the door.

The illustration of a skimming dam in the drawings is intended merely to show that this may be desirably combined with stirring vanes in the same furnace.

The spiral mixing vanes 54 are desirably built up of refractory material extending beyond the surface of the lining. The vanes run from the ends of the furnace at 55 to points 56 near the opposite ends of the furnace.

The pitch of the vane is preferably quite steep, and very desirably greater than 45° so that a considerable component of the velocity of charge flowing along the vane will be longitudinal to project the charge against the end of the furnace.

As will be seen best in Figure 4, the ends of the vanes at 56 taper down from points 57 to points 58, at which they blend with the adjacent refractory lining. This enables the charge to flow more readily over the vane at the points 56 where it changes direction, and at the same time prevents spalling and cracking of the refractory material at the end.

It will be evident that the pitch of the spiral of the vanes is very steep. This I consider to be a distinct feature of utility in my invention, as later explained.

When my furnace is operated, a number of very desirable types of mixing will take place. Assuming that the direction of rotation in Figure 2 is clockwise, the vanes as seen in Figure 1 will be on the advancing side of the furnace. The positions of any vane progressively rising on the advancing side are 54′, 54^2 and 54^3. It will be understood that these positions are merely arbitrary ones along the circular path of each vane, and that the fact that these positions were chosen to coincide with the vanes in Figures 1 and 2 is merely a convenience in illustration.

From Figures 5 and 6 an approximate idea of the way mixing will take place may be formed. Of course the flow lines indicating the behavior of the charge are not intended to be more than illustrative, since they will vary with the size and shape of the furnace and vanes, with the density, viscosity and quantity of the charge, and with the speed of turning of the furnace.

Each vane as it sweeps past the lowest point of the furnace will push before it a portion of the charge in the pocket 59. When the vane reaches the position 54′, and even before this time, charge material from the pocket will flow over the vane toward the bottom of the furnace, because the size of the pocket 60 in front of the vane will progressively decrease as the vane advances. The sheet 61 of charge overflowing will fall beyond the vane into the pool 62 of charge at the bottom of the furnace or into the portion of the charge being swept along by the next vane.

The overflowing sheet of charge material will cause several kinds of mixing. It will place charge from the pocket 60 in contact with charge at the bottom of the furnace. The sheet 61 of charge will fall at relatively high velocity, while the pool 62 in the bottom of the furnace will be substantially quiescent, so that the sheet will penetrate as a jet into the pool, mixing the sheet and pool.

When the sheet 61 strikes the pool 62 it will rumple up, so that the various parts of the sheet will be mixed together. And, since the surface of the vane is irregular, portions of the sheet will lap and fold over themselves before the sheet falls clear of the vane and into the pool. All of these types of mixing will occur below the position 54′, due to falling of the charge into the pool.

Mixing will be still further increased as the vane under discussion moves to the position 54^2. Here the space in the pocket 63 above the vane 54^2 will be even smaller than was that in the pocket 60. Overflowing charge will form in a sheet 64 and flow down against the charge in the pocket 60 below.

The charge in the pocket 63 will undergo a number of types of mixing. Due to the high velocity of its overflow sheet 64 with respect to the charge in the pocket 60, it will penetrate that charge by jet action to some extent. The sheet 64 will rumple up and the charge in the pocket 60 will be kneaded, folded and lapped over itself, just as was the sheet 61 from the pocket 60 when it came into contact with the pool 62 at the bottom of the furnace.

Part of the sheet of charge from the pocket 63 will strike against the surface of the lining or of the charge in the pocket 60 and be deflected without substantial mixing in the pocket 60, merely changing its direction and passing over the vane 54′ with the overflow sheet from the pocket 60. This portion 65 of the charge cascades from the upper pocket to the pool without undergoing intermediate mixing with other charge to any great extent. The process of cascading, involving as it does lapping and changing of direction, is very desirable from the standpoint of thorough mixing of the cascaded material.

It will be evident that the sheet of charge which penetrates the material in the pocket 60 will augment that material, so that more charge will be supplied to the overflow sheet from the pocket 60 than merely that expelled because of the decreased volume of that pocket on account of its angular change of position.

In the position 54′ to some extent, and to a greater extent in the positions 54^2 and 54^3, charge will flow generally longitudinally of the furnace from the points 55 to the points 56 on each vane. In each of the pockets 60 and 63, therefore, the charge will be moving longitudinally of the furnace.

Thus for example charge 66 in the pocket 61 will reach the point 56 on the vane on the position 54^2, and, since it has considerable longitudinal velocity, be projected against the end wall of the furnace. Here it will be kneaded, folded and lapped over itself as it falls against the vane below in the position 54′. In the area 67 the charge will abruptly change direction, with the consequent production of eddies and swirls. Charge will then continue along the pocket 60 toward the bottom of the furnace, or join the overflow sheet 61.

Similarly the portion 68 of the charge will be carried from the vane in position 54^3 against the end wall, while an overflow sheet 69 will fall from the vane. Some of this sheet will rumple in the pocket 63, while other parts of it will cascade to the pool 62.

It will be evident that the path taken by the charge flowing generally longitudinally will be much longer than the corresponding arc traversed by the vane. The path is similar to a labyrinth in which the charge must travel back and forth from one end to the other of the furnace before it can move angularly the distance from one vane to the next. For more effective variation of the stirring produced, the vanes may differ slightly in size and shape as shown.

The progress of the charge along the vanes will not be as simple as this because the charge in any pocket will constantly be augmented by charge from the overflow sheet of the vane above and will constantly be depleted by charge supplied to the overflow sheet from that pocket. The charge in the pocket will constantly be stirred by the jet action of the overflow sheet falling against its surface, and will be agitated by cascading metal travelling from vane to vane.

It will be evident that all of the kinds of mixing discussed herein serve to take charge material from one point and deposit it at another point, and then to incorporate together these different portions of the charge. The difficulty of observing occurrences in the furnace makes it impossible to further analyze the behavior of the charge during mixing. It will be understood that I do not restrict my invention to any theory of operation, but merely include a discussion of the principles which I believe to be involved in order to make more clear the disclosure of my best form.

Figures 5 and 6 are to be considered only as illustrations from which the operation may be better understood.

While I have described the mixing as taking place on the advancing side of the furnace as if the furnace were being rotated continuously in one direction, it will be understood that the same type of mixing will occur if the furnace be oscillated except that the advancing side will change from time to time.

Of course all of the types of stirring will take place simultaneously rather than successively, but for convenience I describe the occurrences as displaced in time from one another.

When the puddled ball has been formed my mixing vanes serve an additional purpose, for they cause the ball to roll axially with respect to the furnace, as well as circumferentially, making it assume a spherical rather than ellipsoidal shape.

Doubtless considerable advantage from my invention could be obtained by varying the angles of the mixing vanes to suit special uses, or by placing them differently with respect to the lining of the furnace. In particular this might be desirable with a charge whose viscosity varies considerably from that of wrought iron, for which the structure shown is well suited.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain part or all of the benefits of my invention without copying the structure shown, and I, therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of mixing a wrought iron puddling furnace charge in a cylindrical furnace, which consists in flowing a portion of the charge in a narrow stream around the internal circumference of the furnace and also endwise of the furnace in reversing the direction of endwise travel and in reuniting the narrow stream to the remainder of the charge.

2. The method of mixing a furnace charge which consists in flowing part of the charge along a zigzag path with frequent abrupt changes of direction while concurrently rumpling sheets of charge against the surface of the part of the charge traversing the path.

3. The method of mixing a furnace charge which consists in flowing part of the charge along a zigzag path with frequent abrupt changes of direction while concurrently rumpling sheets of charge against the surface of the part of the charge traversing the path and progressing the charge transverse to the path.

4. The method of mixing a furnace charge which consists in cascading part of the charge under the action of gravity with frequent changes of direction into contact with the surface of a relatively quiescent part of the charge.

5. The method of mixing a furnace charge which consists in flowing part of the charge generally horizontally and jetting another part of the charge vertically into the part flowing horizontally to mix the two parts together.

6. The method of mixing a furnace charge which consists in flowing part of the charge generally horizontally, jetting another part of the charge vertically into the part flowing horizontally and lapping the combined flowing and jetted charge over itself to incorporate the two parts.

7. The method of mixing a furnace charge which consists in flowing part of the charge generally horizontally, jetting another part of the charge vertically into the part flowing

horizontally and successively sheeting the combined flowing and jetted charge and rumpling up the sheet to incorporate the two parts.

8. The method of mixing a furnace charge which consists in flowing part of the charge generally horizontally, jetting another part of the charge vertically into the part flowing horizontally and abruptly reversing the direction of the combined flowing and jetted parts to incorporate them.

9. The method of shaping a puddled wrought iron ball against a surface which consists in rolling it along a zigzag path over the surface.

10. The method of shaping a puddled wrought iron ball in the interior of a lined cylindrical mixing furnace which consists in rolling it over the lining alternately in directions oppositely substantially diagonal to the furnace axis.

11. The method of shaping a puddled ball in the interior of a lined cylindrical mixing furnace which consists in rolling it over the lining alternately in directions oppositely substantially diagonal to the furnace axis, while arcuately progressing the ball in a direction opposite to one component of the velocity of rolling advance by rotating said furnace.

12. In a rotatory or oscillatory mixing furnace, a furnace body, a furnace lining within the body, and a plurality of oppositely spiralled mixing vanes projecting from the lining.

13. In a rotatory or oscillatory mixing furnace, a furnace body, a furnace lining within the body, and a plurality of oppositely spiralled mixing vanes projecting from the lining and alternatively extending from respective ends of the lining part only of the distance to the opposite ends.

14. In a rotatory or oscillatory mixing furnace, a furnace body, a furnace lining within the body, and a plurality of mixing vanes projecting from the lining and discontinuous at staggered points about the lining, each vane extending the greater part of the distance from one end of the furnace to the other.

15. In a rotatory or oscillatory mixing furnace, a furnace body, a furnace lining within the body, a plurality of oppositely spiralled mixing vanes about the lining and a projection from the lining extending longitudinally of the furnace.

16. In a rotatory or oscillatory mixing furnace, a furnace body, a furnace lining within the body and a plurality of oppositely spiralled mixing vanes about the lining having a pitch angle greater than 45°.

17. The method of mixing a wrought iron puddling furnace charge in a cylindrical furnace, which consists in flowing a portion of the charge in a narrow stream around the internal circumference of the furnace and also endwise of the furnace, in reversing the direction of endwise travel, a plurality of times for each rotation of the furnace and in reuniting the narrow stream to the remainder of the charge.

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