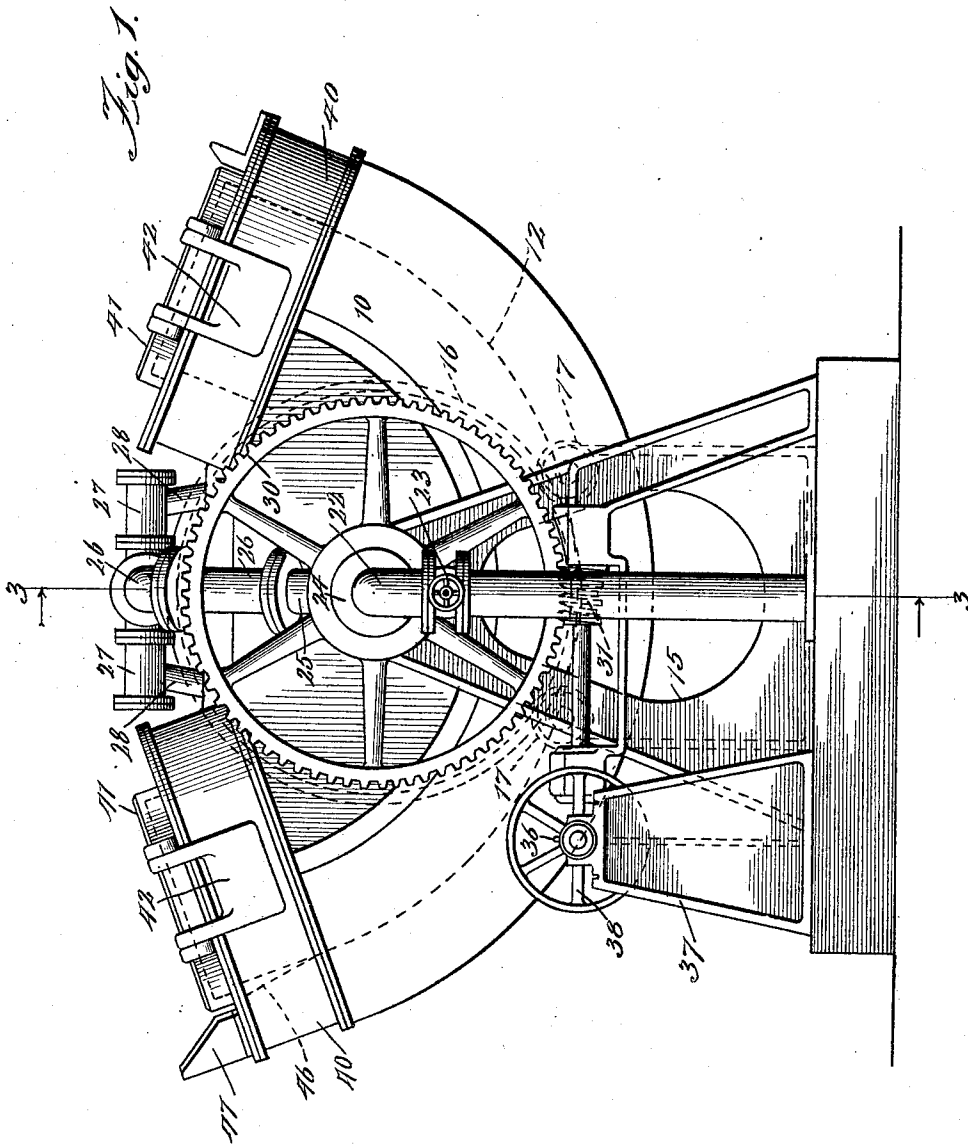


M. SELLERS & H. M. NICHOLLS.
BALLING FURNACE.
APPLICATION FILED APR. 13, 1911.

1,029,234.

Patented June 11, 1912.

5 SHEETS-SHEET 1.



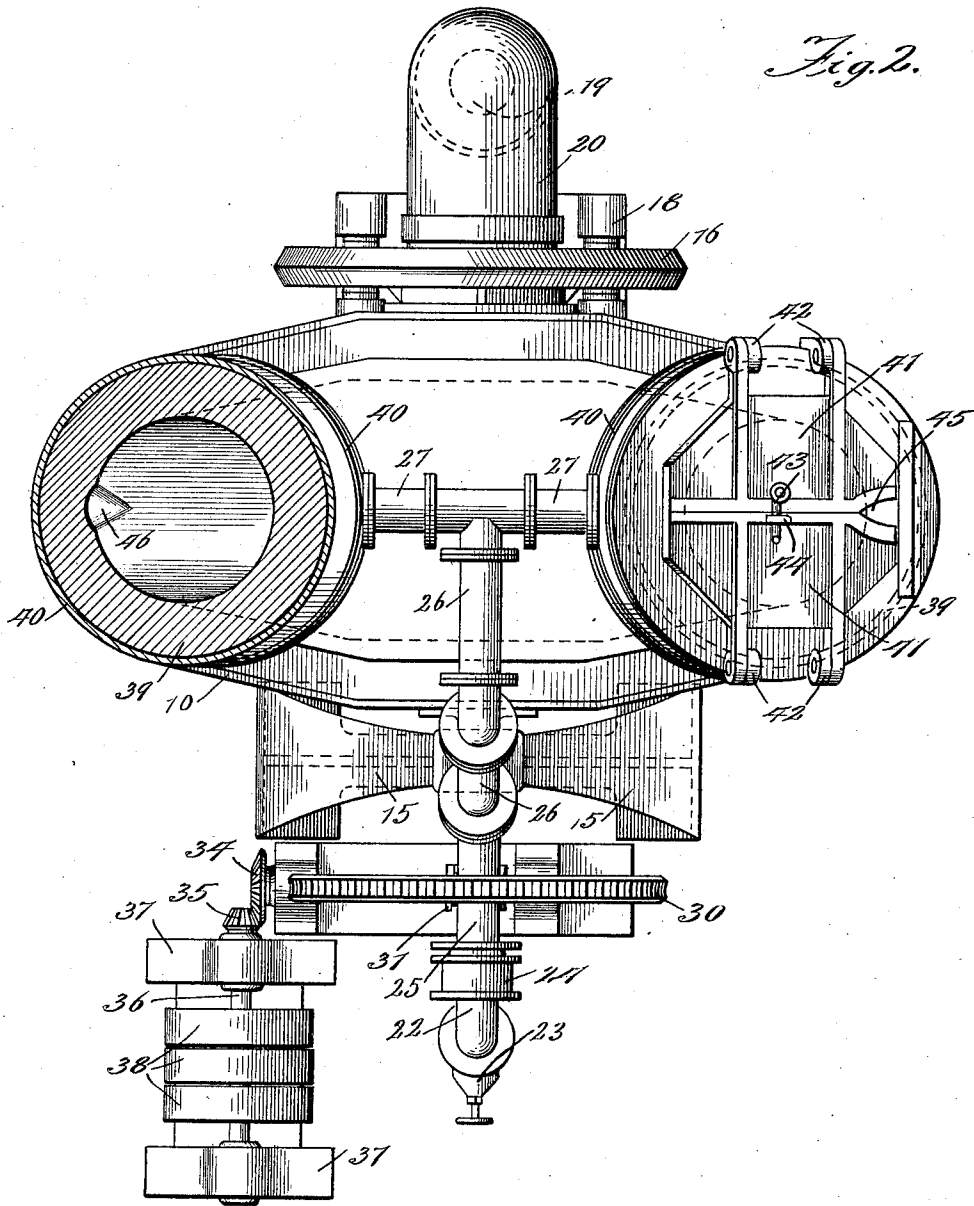
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6 SHEETS—SHEET 2.



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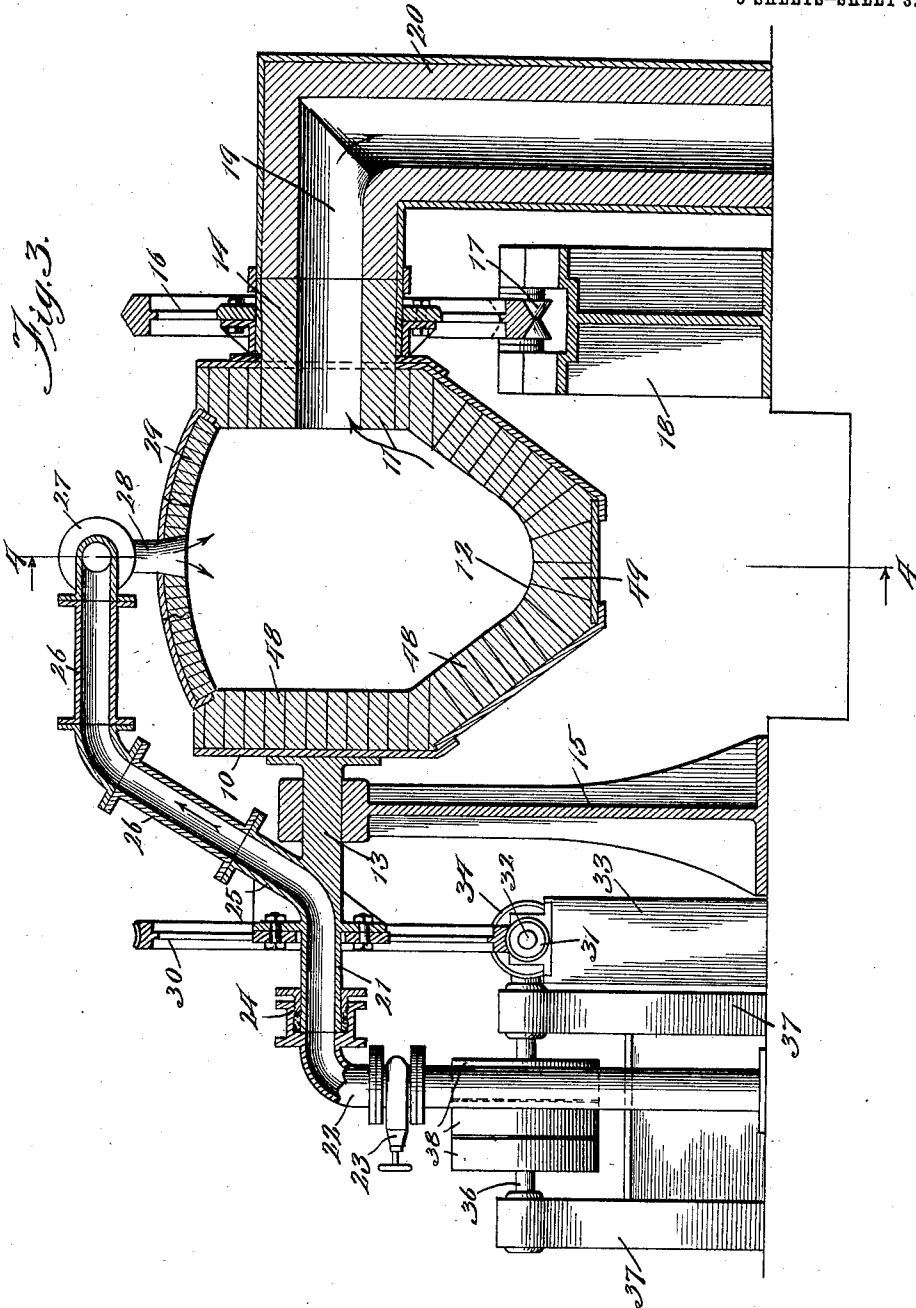
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5 SHEETS—SHEET 3.



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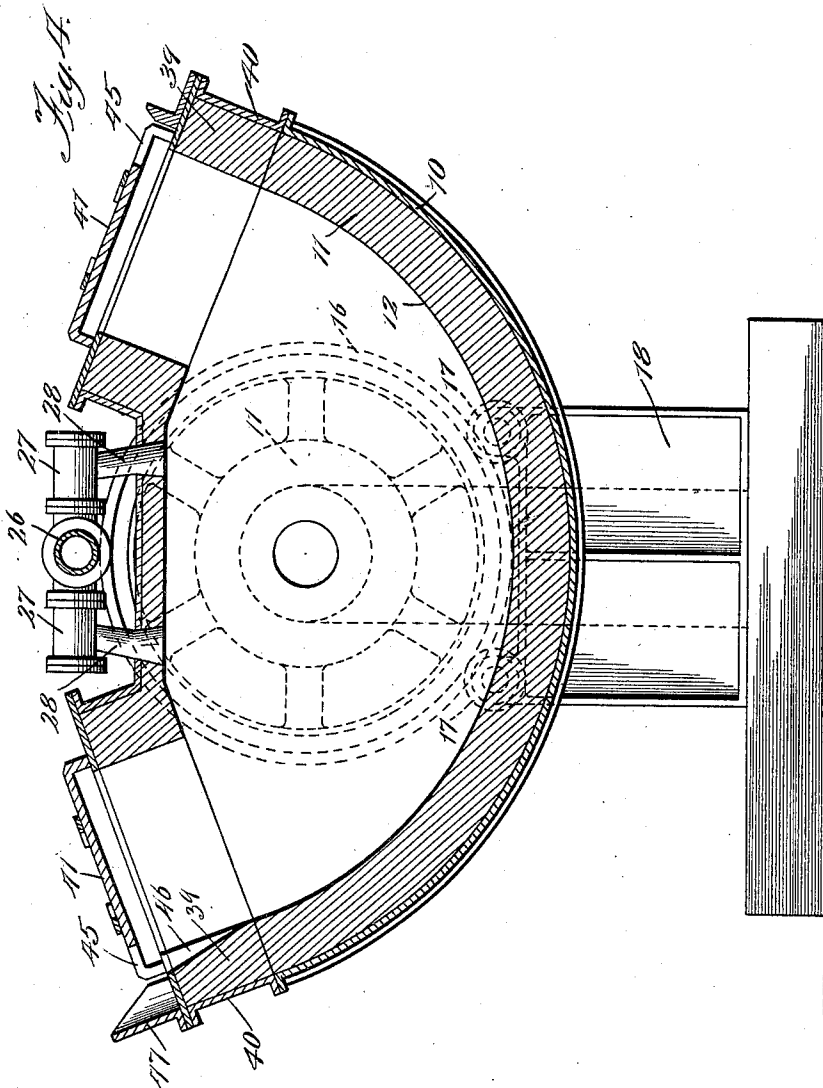
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5 SHEETS—SHEET 4.



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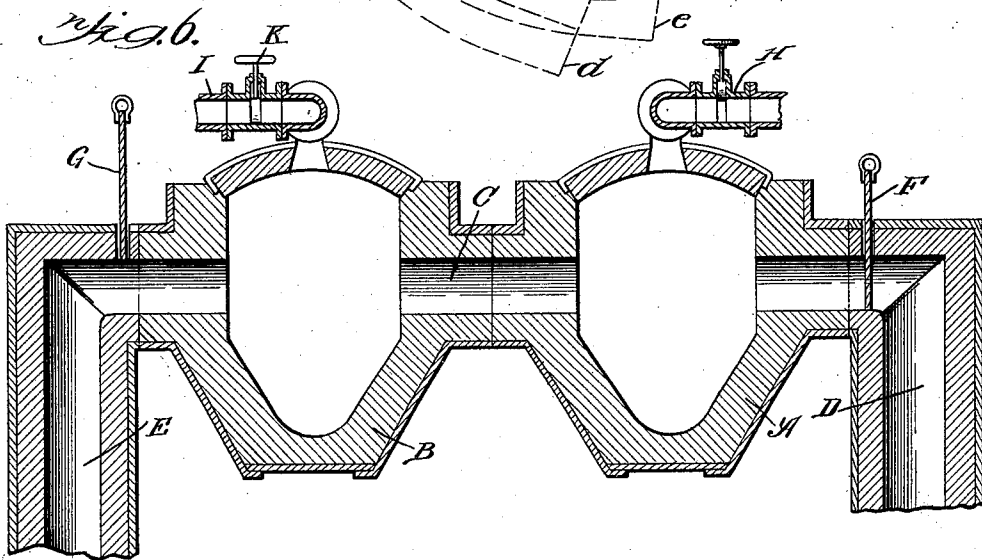
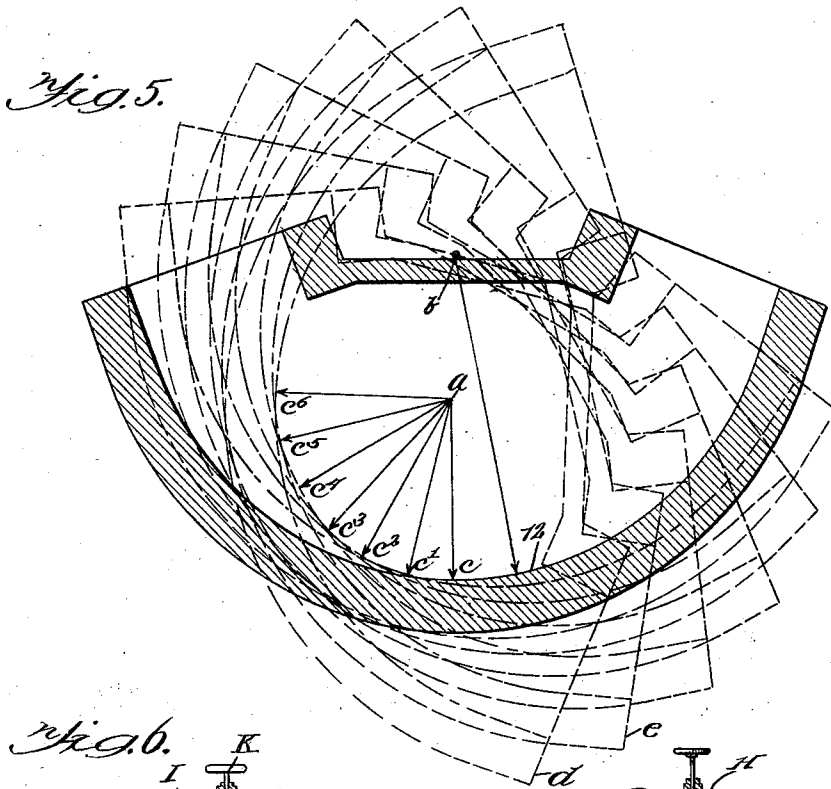
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5 SHEETS-SHEET 5.



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UNITED STATES PATENT OFFICE.

MORRIS SELLERS AND HAL M. NICHOLLS, OF CHICAGO, ILLINOIS.

BALLING-FURNACE.

1,029,234.

Specification of Letters Patent.

Patented June 11, 1912.

Application filed April 13, 1911. Serial No. 620,882.

To all whom it may concern:

Be it known that we, MORRIS SELLERS and HAL M. NICHOLLS, citizens of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Balling-Furnaces, of which the following is a specification.

Our invention relates to a balling furnace in which the ball is produced by mechanical means in place of hand labor; and the invention has for one of its primary objects to provide apparatus of this sort of novel and improved construction and design in which the hearth, instead of being rotated continuously in one direction, as has been heretofore proposed, is given periodic oscillating movements in opposite directions.

A further object of the invention is to provide an oscillatory working chamber formed on an arc less than three hundred and sixty degrees, preferably less than one hundred and eighty degrees, which shall have an opening or openings through which the charges may be introduced into the chamber and from which, by tilting the working chamber beyond the normal the finished balls may be discharged.

A further object of the invention is to provide such a relationship between the curvature of the hearth on which the ball is formed and the axis of rotation or oscillation of said hearth that the rotational movements of the hearth will give the working portion thereof a pitch which is greater than that represented by its curvature. This may be accomplished, for example, by striking the curve of the hearth eccentric to the center of oscillation or rotation and from a center above the same. One purpose of the arrangement is to provide for a considerable travel of the ball at each periodic movement of the hearth while at the same time insuring sufficient pitch to compel the metal before it has begun to ball, when it is in the form of a heap or pile of scrap or pieces, to roll over upon itself and upon the hearth and so initiate the balling operation. This arrangement is also independently of value in the formation of the ball by insuring a prompt and rapid travel back and forth without lessening the length of travel, thereby hastening and facilitating the formation of the ball and more effectively compacting

and welding the elements into a ball of the desired density and shape.

A further object of the invention is to provide a form of apparatus in which the flame employed for heating the metal may be introduced into the chamber from the top and directed downwardly against the metal, and to so construct the hearth that portions of the flame not directly impinging against the metal may be reflected against it from the surfaces constituting the hearth.

A further object of the invention is to provide a construction whereby a substantially defined zone of intensest heat will be provided, within which zone the body of metal to be formed into a ball will be caused to travel during the greater period of the balling operation of the furnace.

A further object is to provide a construction permitting the employment of the furnaces in multiple, for example, in pairs, whereby one furnace can be discharged and recharged while the balling operation is going on in the other; which arrangement, besides economizing time and labor, makes it possible to utilize the exhaust from one furnace to minimize the cooling of the other furnace, to preheat the charge in such other furnace and to draw on the fuel supply continuously, the latter feature being of considerable importance when the fuel is gas supplied from the ordinary gas producer.

The invention has for further objects such other new and improved constructions, arrangements and devices in balling apparatus as will be hereinafter described and claimed.

The furnace is particularly intended for welding together or balling wrought iron or steel scrap, although possibly it might be employed in other operations of similar character. While ordinarily and in the preferred construction of our apparatus the scrap will be formed into a sphere, still it is to be understood that the term "balling" is to be given a broader meaning so as to comprehend any welding of a mass of scrap into a single mass substantially in the manner herein described in the process of converting scrap metal into a unitary mass of wrought iron.

The features of the apparatus constituting our invention make possible certain improvements in the process of treating such scrap, as will hereinafter appear, whereby

the operation is cheapened and facilitated and whereby a better grade of wrought iron can be produced than has been possible with the methods heretofore used. However, we do not claim herein the improvements in processes which may be disclosed in this application, as the processes involved in or made possible by the use of the apparatus herein described are claimed in our co-pending application Serial No. 620,883 filed April 13, 1911.

The invention is illustrated, in a preferred embodiment, in the accompanying drawings, wherein—

Figure 1 is a side elevation of the apparatus; Fig. 2 is a plan view with certain parts shown in section; Fig. 3 a cross sectional view taken on line 3—3 of Fig. 1, looking in the direction of the arrows, certain parts, however, being shown in elevation; Fig. 4 a sectional view taken on line 4—4 of Fig. 3; Fig. 5 a diagram illustrating the character of the oscillatory movement imparted to the working chamber; and Fig. 6 a diagrammatic cross-section illustrating the arrangement of two furnaces designed to be operated in coupled relation.

Like characters of reference indicate like parts in the several figures of the drawings. Referring to the drawings, the working chamber is formed of an outer shell 10 of metal and an inner lining 11 of refractory material. In its preferred form the working chamber is approximately semi-circular in form, the hearth 12 on which the ball is formed being formed on arcs lying in the planes of oscillation of the chamber. Preferably the working chamber is concaved transversely as shown in Fig. 3, the bottom of the chamber in such preferred construction being concaved both longitudinally and transversely and the sides rising and flaring with relative abruptness from the concaved bottom, and is relatively narrow in respect to its longitudinal dimension. In effect, a deep groove with a rounded bottom is formed on a curve in the direction in which the ball travels. This construction of the working chamber or hearth we have found is most reliable in producing a substantially accurate sphere of welded metal, which, for reasons well known in this art, is extremely desirable. The working chamber is provided with a journal 13 adapted to turn in a suitable bearing in the standard 15 and with a boss or gudgeon 14 provided with a trunnion wheel 16 which is supported on the grooved rollers 17 rotatably carried on the support 18. The boss 14 is hollow and connects the interior of the working chamber with the flue 19 of the downdraft chimney 20. The outer portion 21 of the journal 13 is in the form of a pipe and communicates with a pipe 22, preferably provided with a controlling valve 23

which leads to the gas producer or other source of supply of fuel. The joint between pipes 21 and 22 is preferably protected by the stuffing box 24 which permits the rotational movements of pipe 22 incident on the oscillation of the working chamber. The hollow portion 21 of journal 13 is formed with a branch 25 and the branch 25 is connected, by means of the bent pipe 26, with a transversely arranged manifold 27 from which the inlet pipes 28 extend through the arched top or cover portion 29 of the working chamber.

On the hollow portion 21 of journal 13 is a worm wheel 30 meshed by a worm 31 on a shaft 32 turning in suitable bearings on the frame member 33. Shaft 32 carries a bevel gear 34 meshed by a pinion 35 on a driving shaft 36 mounted in bearings on the frame members 37. Shaft 36 carries the reversing driving pulleys 38. We have not shown the belt which operates on the pulleys 38 nor the mechanism employed for shifting the same so as to reverse the direction of rotation of the shaft 36. Any suitable form of mechanism capable of producing this result may be employed. In fact the entire mechanism for giving oscillatory movement to the working chamber might be changed without departure from our invention.

The working chamber is formed with one or more openings for the purpose of charging and drawing. As shown, the brick work of the chamber terminates at each end in a ring formation 39 inclosed by a metal annulus 40 secured to the outer metal casing 10. Hinged to these annuli are doors. A pair of these doors 41 are shown at the right hand side of Fig. 2, being hinged to brackets 42 secured to the ring 40 and held closed by the engagement of a pivoted latch 43 on one of the doors with the hook 44 on the other. Preferably the door is formed with a peek-hole 45. Where the working chamber has two openings, one at each end of the hearth, the charge may be introduced at one side—for example, at the left hand side, Figs. 3 and 4—and the finished ball removed from the other opening on the right hand side. Preferably the brick work adjacent to one of the openings, for example, on the charging side, will be formed with a groove 46 for discharging the slag and cinder, and a metal spout or chute 47 may be secured to the ring 40 at this side of the working chamber. In addition to the other advantages, to be hereinafter adverted to, resulting from making the working chamber of the form shown and oscillating the same, instead of employing a circular, continuously rotated chamber, the form of furnace here shown has the added advantage of being more simple and economical to construct and more easy to repair than a rotary fur-

nace. As the furnace does not make a complete circle, it is not necessary to key the brick work forming the bottom and sides of the refractory lining. As the top of the balling chamber does not carry the weight of the charge, it can be of light, simple construction, readily assembled and as readily removed and repaired. The bottom and side bricks keep their position by their weight, simply resting upon the bottom of the metal casing and upon themselves. For example, ordinary straight bricks 48 may be used in forming the sides and slanting portions of the bottom of the working chamber, as indicated particularly in Fig. 3, it being necessary to use keyed bricks only in forming the rings 39 (Fig. 4), and in forming the bottom 49 of the hearth. As these keyed bricks are assembled in a position in which they do not have to support an arch, the building of this part of the structure in our device is a matter requiring little skill and one which can be attended to quickly and cheaply. Furthermore, the top of the chamber may be loosely mounted in place and held in position by its own weight and can be constructed, as shown in the drawings, of a metal plate or clamp filled in with a thin layer of side arch bricks held together, if need be, with the usual cement in the joints.

It is obviously much easier to repair a structure of this sort than a piece of cylindrical brick-work in which a whole circular course of bricks has to be taken out when a single brick is worn out and has to be replaced. Another advantage of this construction is that it permits of charging and recharging with a minimum suspension of operations and a minimum cooling of the interior of the chamber, which is important since the refractory lining should be kept at an intensely high heat. Furthermore, it provides a structure from which the cinder or slag can be removed with the utmost facility and, if desired, repeatedly during the treatment of a single charge, and without suspending operations or cooling the chamber, and also provides a structure in which molten, decarbonized or wrought iron can be added to the charge as desired with the greatest facility.

Assuming that the furnace as above constructed is to be used for balling wrought iron scrap, the operation may be performed as follows: The scrap, after being cut or broken into pieces of suitable size, is thrown into the working chamber at one end, the doors 41 closed, the working chamber oscillated back and forth and gases in a state of combustion introduced through the fuel inlets 28. The scrap collects together in a heap or mass in the bottom of the chamber, where it is acted upon directly by the flames which, it will be noted, impinge against the metal from above, instead of being directed

axially through the furnace, as is the case with ordinary rotary furnaces. Moreover, the curvatures of the hearth, both longitudinal and transverse, are such that a reverberatory action results, the flame which does not impinge directly on the ball being reflected against all sides of the same from the walls of the chamber. Preferably the inlet openings or twyers are arranged in such relation to each other and to the bottom of the balling chamber that they will provide a continuous zone of most intense heat which substantially defines the usual limits of travel of the charge during the greater part of the operation of the furnace, there being preferably no intermediate zone of lower temperature between the zones to which the twyers, respectively, directly discharge the gases for combustion or other means for heating the charge. The products of combustion find an outlet from the chamber through the hollow journal 14 and down draft flue 19. A difficulty which is often experienced in mechanical balling apparatus of the rotary type arises from the tendency of the mass of metal to stick before the ball has commenced to form.

In order that the balling operation may be initiated, the metal must be caused to fall or roll over itself. With the furnace constructed in the manner shown in the drawings herein the initial movement of the metal is insured by a construction which gives the working portion of the hearth a very considerable pitch relative to the curvature of the hearth. This is accomplished by forming the hearth on arcs eccentric to the axis of oscillation and locating the axis of oscillation below the center from which the curves are struck.

Referring to the diagrammatic view of Fig. 5, *a* designates the center of oscillation and *b* the center of curvature of the hearth. Successive positions which the working chamber takes when given a movement of rotation in one direction from its normal position are indicated by the dotted line figures. It will be seen that the point *c* at the center of the hearth moves on a radius which is much shorter than the hearth radius. *c'*, *c''* designate the changes of position of the point *c*. As a result of this eccentric arrangement, a mass of metal located in the bottom of the chamber will be given a much greater pitch than it would have if the center of curvature of the hearth and the center of oscillation coincided. The hearth is designed so that this pitch will be sufficient in all cases to insure the initial rolling movement of the mass of scrap, that is, it will in all cases be great enough so that the force of gravity will overcome the frictional resistance between the scrap and the hearth and between the different pieces of scrap. This same result might be obtained by mak-

ing the hearth radius shorter, but that would result in shortening the path of travel of the ball on the hearth, which would be undesirable. The eccentric arrangement shown and described gives the pitch necessary to initiate the formation of the ball without sacrificing the comparatively long path of travel of the ball after its formation has commenced. While this result is best and most easily obtained, as we believe, by an apparatus in which the working chamber oscillates and in which the center of curvature of the hearth is above the center of oscillation, substantially as shown and described, it would, nevertheless, be possible, as will be apparent from a consideration of the mathematical principles involved, to obtain similar results by means of somewhat different constructions and arrangements.

The preferred construction of the hearth as shown, that is, with the long longitudinal radius, a short transverse radius at the bottom and abrupt angular sides, is desirable not only because it insures the formation of a symmetrical ball, but because it is a shape which is easily installed and maintained.

Another advantage of our form of furnace is that, if necessary or desirable, the slag or cinder, or any portion of it, may be discharged from the furnace during the formation of a ball. In order to do this, it is simply necessary to tilt the furnace to a proper angle to permit the outflow of the slag through groove 46 and the opening 45 in the doors. The furnace can be tilted back before the ball has had a chance to roll out, even if the end doors be not locked, owing to the fact that the cinder flows more freely than the ball rolls, but ordinarily the door adjacent the cinder opening will be securely closed or will be of such construction or dimension that the ball cannot roll out while the cinder is being discharged.

Another advantage is that, if desirable, some ingredient may be added to the welded or partly welded metal during the balling operation. For example, when it is desired to make a high grade of wrought iron from scrap, the reducing of the scrap is first brought about, or the formation of the ball commenced, in the manner described, then the molten slag and cinder is discharged from the furnace and there is added to the ball a quantity of decarbonized iron in a molten state, which, by uniting with the ball, improves the quality of resultant product. In this way it is possible to turn out a grade of wrought iron which is as good as the ordinary puddled iron.

In order to economize in the cost of production by utilizing scrap iron in the production of a high grade of wrought iron, it is desirable to combine certain proportions of scrap iron with certain proportions of wrought iron, but with processes heretofore

practised it is not practical to economically produce a high grade of product by directly combining the scrap with the wrought iron, for it is not desirable to combine the scrap iron product with wrought iron until the impurities, scale, oxids, etc., have been eliminated from the scrap. Consequently, it is ordinarily necessary to separately form the scrap iron into muck bars or other form, which is then combined with new wrought iron by any suitable reheating process.

With our apparatus, the necessity for this reheating is avoided, the cinder or slag resulting from the oxidation of the scrap and impurities in the scrap may be quickly discharged either by locating the cinder discharge opening in such relation to the path of travel of the scrap that the cinder is continually discharged, or by giving the hearth, when constructed as shown in the drawings, a longer travel whenever it is desired to discharge the cinder. This provides means for eliminating the impurities in the scrap and for bringing the scrap to a condition where it can be combined with new wrought iron to advantage. The new wrought iron can, for example, be ladled into our furnace in molten form without any appreciable delay or cooling of the furnace and will readily combine with the scrap. In fact, the presence of the cinder or slag with the scrap would tend to prevent an effective combination and welding together of the scrap and the new iron added thereto and would prevent or retard the welding together of the scrap, that is, the "coming to nature" of the ball even if no new iron were added. When, however, the scrap has been partially treated in our furnace, new decarbonized iron, preferably in molten form, will be added before the formation of the ball has been completed, but after the slag or cinder has been largely or wholly eliminated from the scrap. At this stage the incomplete ball will be a relatively porous mass of particles of scrap more or less completely welded together. With the ball in this condition, the molten metal under the operation of the furnace will enter the interstices in the ball and then will be worked thoroughly into and combined with the ball to provide a mass of wrought metal of the character desired and of a relatively dense consistency. The relatively cool scrap will chill the fluid metal to a temperature where it will be worked and welded together with the scrap in the furnace.

If the formation of the ball has proceeded more nearly to completion before the molten metal is added, the molten metal will form a coating around the ball, which will be chilled from its molten state and welded and compacted to the ball and will tend to more readily produce a ball which for all practical purposes is a perfect sphere, which, as

is known in the art, is a desirable form for subsequent handling in forming the ball into an ingot or bloom.

By our preferred arrangement of the 5 tuyers or burners discharging flame or gases into the chamber, the zone of most intense heat extends along the bottom of the chamber for a distance which corresponds to the normal path of travel of the ball, so that the 10 blast of heat impinges directly upon the charge, irrespective of the angularity of the hearth at any point in its normal oscillation during the treatment of the charge.

When the balling operation is completed, 15 the doors 41 on the discharge side are opened and the furnace tilted so as to discharge the ball. The dotted line figure designated *d* in Fig. 5 shows the position of the chamber at the time the ball is drawn. The dotted 20 line figure *e* designates the lowest position which the working chamber takes in its normal oscillations.

In Fig. 6 we have indicated, in a somewhat diagrammatic manner, an arrange- 25 ment of two furnaces constructed after the design of the furnace shown in the preceding five figures, by which arrangement the balling operation goes on in one furnace while the other discharges and is recharged, 30 whereupon the process then proceeds simultaneously in both furnaces, one furnace working under the direct blast of burning gases and the other going through what may be conveniently called a preheating process 35 under the exhaust from the furnace receiving the primary blast of heat, thus providing a uniform discharge of gas which is an important consideration where producer gas is used as the heating medium, and at the 40 same time making it feasible for one man to simultaneously run two furnaces. By this arrangement also the furnace which is being charged and discharged is at the same time supplied with heat by the exhaust 45 from the other furnace, so that the cooling of the furnace and the chilling of the highly heated, refractory lining is prevented.

The two furnaces are designated A and B, 50 respectively. They are connected by a flue C and communicate at opposite sides with the exhaust flues D and E, respectively. Valves F and G close flues D and E. Gases in a state of combustion are introduced into the furnaces A and B from pipes H and I 55 which may lead from the same source of supply, for example, from a gas producer or the regenerator ordinarily employed therewith. The pipes are controlled by valves J and K. With the parts in the position 60 shown, the balling operation is taking place in furnace A, valve J in the fuel pipe being open and valve K in the fuel pipe leading to furnace B being closed. The products of combustion escape from furnace A 65 through the flue C, furnace B and flue E.

Flue D is closed by its valve F. At this period the ball previously formed in furnace B is drawn and a fresh charge of metal introduced. While the balling operation continues in A, the metal in B is subjected 70 to a preheating by the exhaust gases from A which, of course, shortens the subsequent balling operation. When the ball is finished in A, the oscillation of this furnace is stopped and the furnace B oscillated; the 75 valves F, G, J and K being shifted to open flue D, close flue E and open pipe I and close pipe H. By this arrangement the draw on the gas producer, or other source of fuel, is uniform and uninterrupted. The operations 80 of drawing and charging go on simultaneously with the balling operations and the heat from the furnace which is in operation is, to a certain extent, utilized in the adjacent furnace. The furnaces are arranged 85 close together, so that they can be operated by one man or one gang of men. The result is a saving in time, labor and fuel. It will be understood that any preferred form of fuel might be used. We prefer to use gas 90 or oil; but by suitable changes in details any solid or liquid fuel can be utilized.

While we have shown one and, as we now believe, the preferred arrangement of two 95 furnaces in coupled relation so that they may be oscillated in unison or independently, the principle of utilizing the exhaust from one furnace to preheat the charge and maintain the temperature in the other furnace can be applied in other ways and such 100 variations are contemplated by us. Thus, by suitable by-pass pipes and valves, the exhaust from one furnace could at will be directed to the induction pipe of the other furnace and vice versa, the idea in either 105 event being broadly the same, to-wit, that one furnace is receiving the heating effect of the exhaust from the furnace which is receiving the direct blast from the heating pipes. 110

It will also be understood that with our apparatus we produce a ball of wrought iron with the impurities very largely or wholly eliminated, which can be much 115 larger than it is feasible to produce in an ordinary puddling furnace, which can also be made denser, more compact and more nearly homogeneous than is possible with furnaces heretofore used, and which leaves the balling chamber at such a high tempera- 120 ture that it can be passed directly to the squeezers and rolls, to form a bloom, without reheating, whereas, by reason of the limitations of other processes, the puddled mass or ball is relatively small, spongy and contains 125 a larger proportion of impurities which, to some extent, can be squeezed out in the squeezer when the ball is brought to a temperature at which the cinder will run, but which nevertheless produces such an in- 130

ferior quality of product that it is ordinarily adapted only for forming into muck bars after reheating, which muck bars are in common practice arranged in piles with other scrap metal and, after a further reheating, resulting in a further loss of metal by oxidation as well as requiring additional labor and additional fuel, are then rolled into blooms. We thus produce a superior product with less labor, less fuel and less loss of material by burning or oxidation, because the repeated heatings required by other processes are not necessary.

While we have described a preferred form of our invention, it will be realized that modifications in the constructions, arrangements and devices shown and described might be made without departure from the invention. Therefore, we do not limit ourselves to these particulars except so far as they are made specifically limitations on certain of the claims herein, it being our intention to hereby claim and cover both broadly and specifically everything in the disclosed apparatus which is patentable over the prior art. We also again note that while for convenience, in the specification and claims the device is referred to as a "balling apparatus", the claims are not thereby to be understood as limited to the formation of a mass of metal of any specific contour or even to the apparatus for handling scrap metal of the character described, but are intended to cover the apparatus described and claimed for all uses to which it may be put. Neither is our invention confined to the mechanical specific details shown and described except where such particular details are made specific limitations in particular claims.

We claim:

1. The combination of an oscillating working chamber provided with a hearth which is formed on curved lines lying in the planes of oscillation and which is curved on transverse lines, said chamber being formed with an opening or openings in line with the travel of the ball on the hearth for the purpose of charging and drawing, means for introducing a hot blast into said chamber, and means for oscillating said chamber.

2. In balling apparatus, the combination with an oscillatory working chamber provided with a curved hearth which is formed on arcs less than a circle, lying in the planes of oscillation and which is concaved transversely on curved lines, of means for oscillating said chamber, and means for introducing a hot blast into said chamber.

3. The combination of an oscillating working chamber provided with a hearth which is formed on curved lines lying in the planes of oscillation and which is concaved on curved lines transversely thereto, the curvature of the hearth on the planes of oscilla-

tion and the axis of oscillation being so related that points on the working portion of the hearth move on radii shorter than the hearth radius, and means for oscillating said chamber.

4. The combination of a pivoted working chamber and means for imparting movements of rotation to the same, said chamber being provided with a hearth formed on curved lines eccentric to the axis of rotation and lying in planes perpendicular thereto and concaved transversely on curved lines.

5. The combination of an oscillating working chamber provided with a hearth which is formed on curved lines lying in the planes of oscillation, which is also concave transversely on lines having radii shorter than those of the first mentioned curves, and means for introducing gases in a state of combustion into said chamber so that they are directed against the hearth on lines substantially radial to the longitudinal curvature of the hearth.

6. The combination with an oscillatory working chamber provided with a hearth which is formed on arcs less than a circle, lying in the planes of oscillation and which is also concaved transversely on lines having shorter radii, and means for introducing gases in a state of combustion into the top of the chamber so that they are directed downwardly against the hearth of means for oscillating said chamber.

7. The combination of an oscillatory working chamber, the bottom of which forms a hearth which is curved longitudinally of the chamber, a fuel pipe leading into the chamber through the top, and means for oscillating the chamber, said chamber being formed with an opening at each end and with doors closing said openings.

8. The combination of an oscillatory working chamber, the bottom of which forms a hearth which is curved longitudinally of the chamber and is concaved transversely thereof on shorter radii, a fuel pipe leading into the chamber through the top, and means for oscillating the chamber, said chamber being provided with a journal which is hollow so as to constitute a fuel intake pipe and having a branch leading through the top of said chamber.

9. The combination of an oscillatory working chamber, the bottom of which forms a hearth which is curved longitudinally of the chamber, a fuel pipe leading into the chamber through the top, and means for oscillating the chamber, said chamber being provided with a journal which is hollow so as to constitute a second fuel intake pipe and has a branch leading through the top of said chamber, and sustaining means on the side of the chamber which is hollow so as to provide an outlet flue.

10. The combination of a substantially

semi-circular working chamber formed with an opening at each end, means for closing said openings, said chamber being pivotally mounted, means for oscillating the chamber, the bottom of said chamber being formed with a groove struck from a center above the axis of oscillation, and means for introducing gases in a state of combustion into the chamber from the top.

11. In balling apparatus, the combination with a hearth providing a defined path for the ball to travel over and means for oscillating the same, of means for providing a blast of heat concentrated on the line of travel of the ball.

12. In a balling apparatus, the combination with a hearth providing a defined path for the ball to travel over and means for oscillating the same, of means for discharging a blast of reducing gases downwardly upon said hearth in such direction as to provide a zone of concentrated heat along the path of travel of the ball.

13. In a balling apparatus, the combination with a hearth providing a defined path for the ball to travel over and means for oscillating the same, of a plurality of tuyers arranged to discharge a hot blast in a direction to produce a continuous zone of high temperature along the path of travel of the ball.

14. In a balling furnace, the combination with a balling chamber having a hearth providing a grooved path for the ball to travel over, of means for oscillating the same, and means for providing a zone of high temperature along the line of travel of the ball, said chamber being provided at one end of said last-named means with an opening for charging and discharging the same.

15. The combination with a balling chamber of means for oscillating the same, said chamber being provided with a charging opening adjacent one end thereof and with a discharging opening adjacent the other end thereof, a grooved hearth between the same and means for providing a zone of high temperature within said chamber intermediate said openings.

16. The combination with a balling chamber provided with a charging and discharging opening and having a hearth providing a grooved path for the ball to travel over, of means for oscillating the chamber so as to cause the ball to travel over said path, and means for producing a zone of high temperature along said path of travel of the ball, said chamber adapted to be tilted, when required, to a position which will cause the ball to roll out of the discharge opening.

17. In balling apparatus, the combination with a balling chamber provided with charging and discharging openings and with a cinder discharge opening, of means

for oscillating the chamber so as to cause the ball to travel therein, means for varying the movement of said chamber whereby at will the cinder may be caused to flow out of said chamber by gravity without discharging the ball and the ball may be caused to leave said chamber by gravity when desired.

18. A balling apparatus, comprising an arc-shaped chamber containing a hearth along the bottom thereof providing a grooved path for the ball to travel over, charging and discharging openings at opposite ends thereof, means for oscillating said chamber, and means discharging into said chamber intermediate its ends for providing a zone of high temperature on said hearth.

19. A balling apparatus, comprising a balling chamber containing a hearth at the bottom thereof providing a grooved path for the ball to travel over, charging and discharging openings at opposite ends of said chamber, means discharging into said chamber intermediate its ends to provide a zone of high temperature therein, and means for oscillating said chamber, all so arranged that the zone of intensest heat in said chamber will at all times occupy the same position in said chamber during the oscillation thereof.

20. A balling furnace comprising a hearth and means for oscillating the same, said hearth formed so as to provide a non-circular groove, the bottom of which is concaved and the sides of which slope acutely upwardly and outwardly.

21. A balling furnace comprising a hearth and means for oscillating the same, said hearth formed so as to provide a non-circular groove, the bottom of which is concaved and the sides of which slope acutely upwardly and outwardly, said furnace being provided at one end with an opening for the purpose of charging and discharging the metal.

22. A balling furnace comprising a hearth and means for oscillating the same, said hearth formed so as to provide a non-circular groove, the bottom of which is concaved and the sides of which slope acutely upwardly and outwardly, said furnace being provided at one end with an opening for the purpose of charging and discharging the metal, and with a slag opening.

23. A balling furnace comprising a hearth, means for oscillating the same, said hearth being formed so as to provide a non-circular groove the bottom of which is concaved and the sides of which slope acutely upwardly and outwardly, and means for directing a hot blast downwardly into the groove of said hearth.

24. In a balling furnace, the combination of a balling chamber formed so as to provide a curved grooved hearth for the ball to travel over, said chamber being mounted ec-

centrically with respect to the curvature of the hearth in the direction of travel of the ball, and means for giving rotational movements to the hearth for the purpose described.

25. In a balling furnace, the combination of a balling chamber formed so as to provide a curved grooved hearth for the ball to travel over, said chamber being mounted eccentrically with respect to the curvature of the hearth in the direction of travel of the ball, means for giving rotational movements to the hearth, and means for directing a hot blast downwardly into the groove of the hearth.

26. In a balling furnace, the combination of a balling chamber formed so as to provide a curved grooved hearth for the ball to

travel over, means for giving rotational movements to the hearth, and means for directing a hot blast downwardly into the groove of the hearth.

27. In a balling furnace, the combination of a balling chamber formed so as to provide a curved grooved hearth for the ball to travel over, and means for giving rotational movements to the hearth; the chamber being formed with an opening or openings in line with the hearth for the purpose of charging and discharging.

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Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."