Sept. 22, 1925 1,554,367

A. A. RACKOFF

PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 1

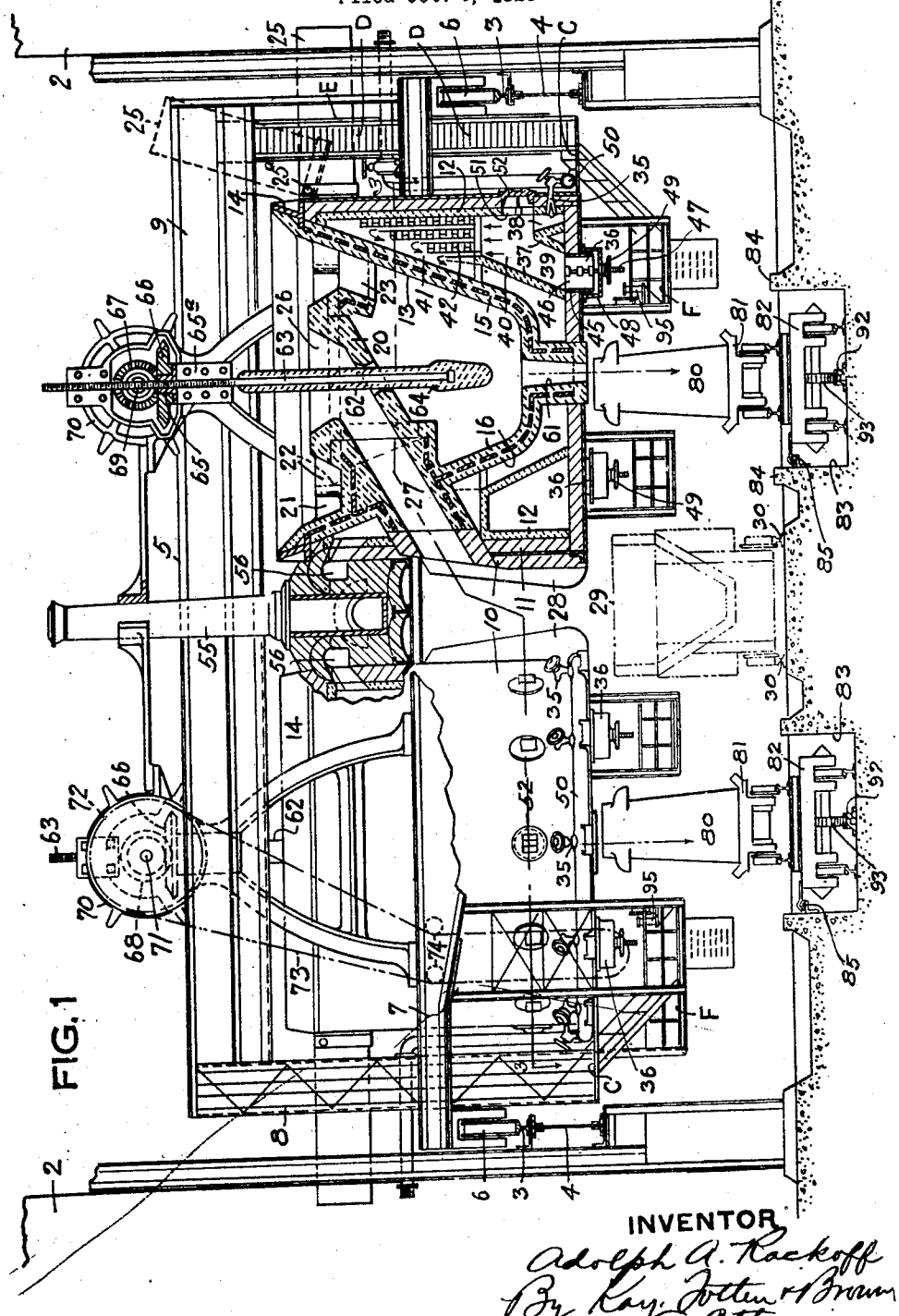


FIG. 1

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Sept. 22, 1925 1,554,367

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PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 2

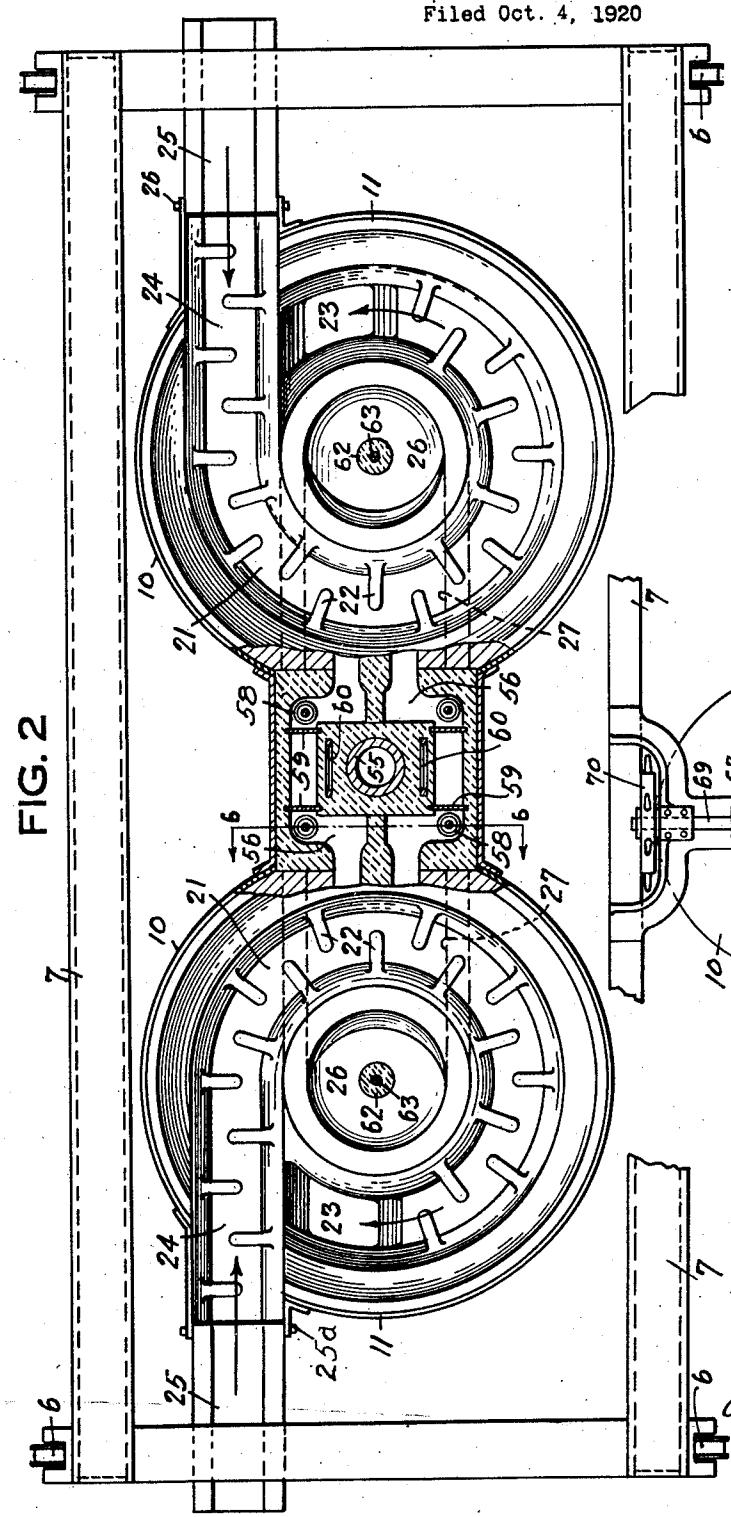


FIG. 2

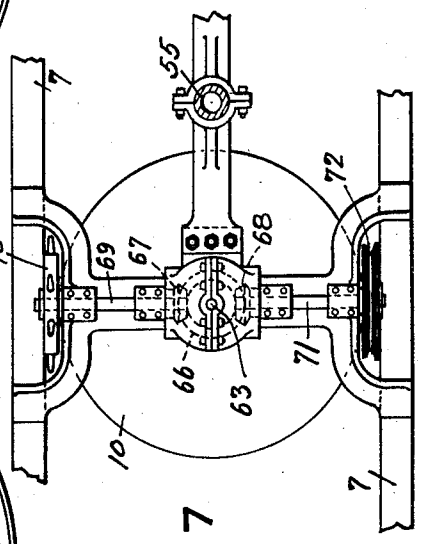


FIG. 7

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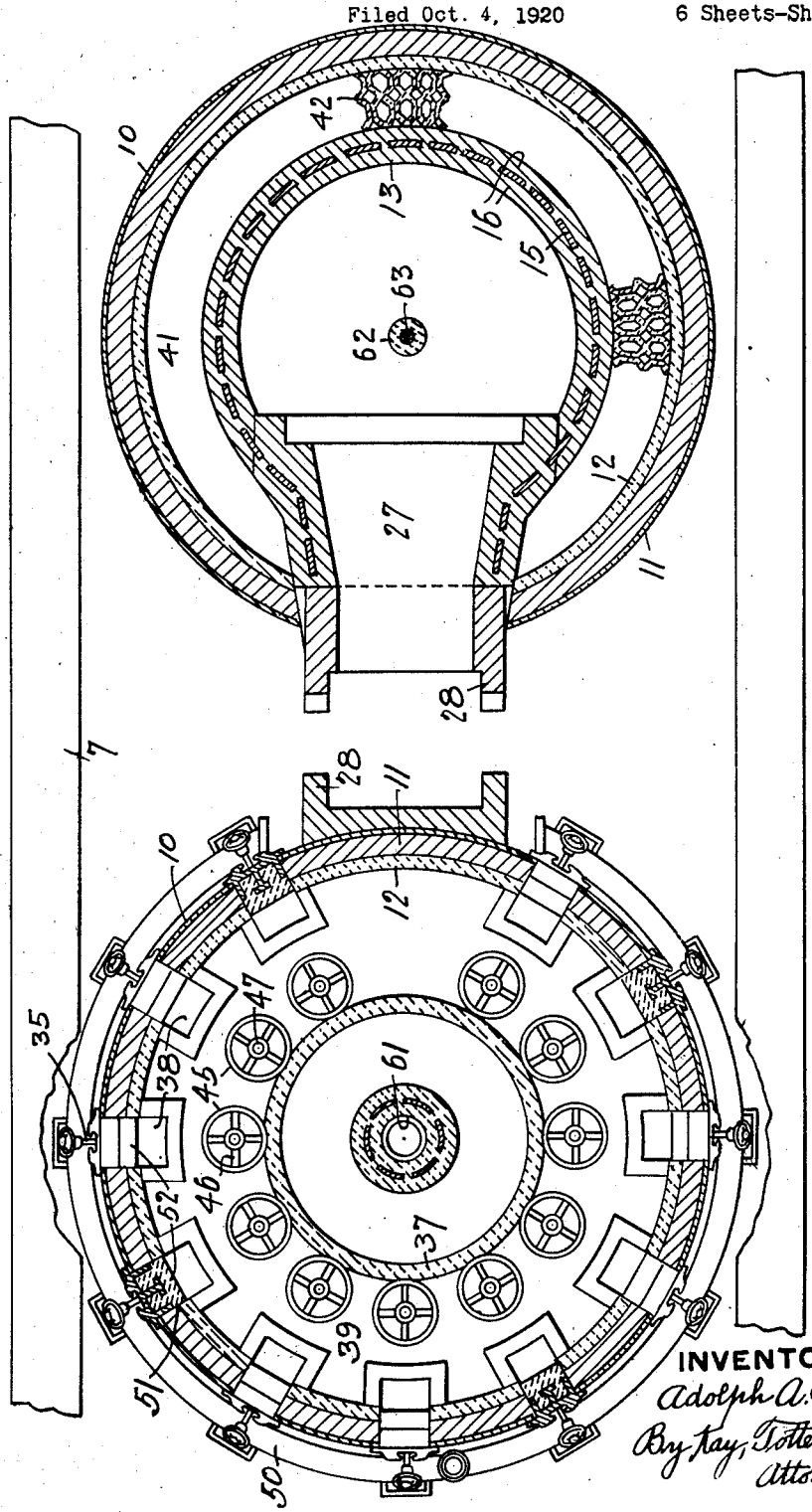
Sept. 22, 1925 1,554,367

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PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 3

FIG. 3



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Sept. 22, 1925. 1,554,367

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PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 4

FIG. 6

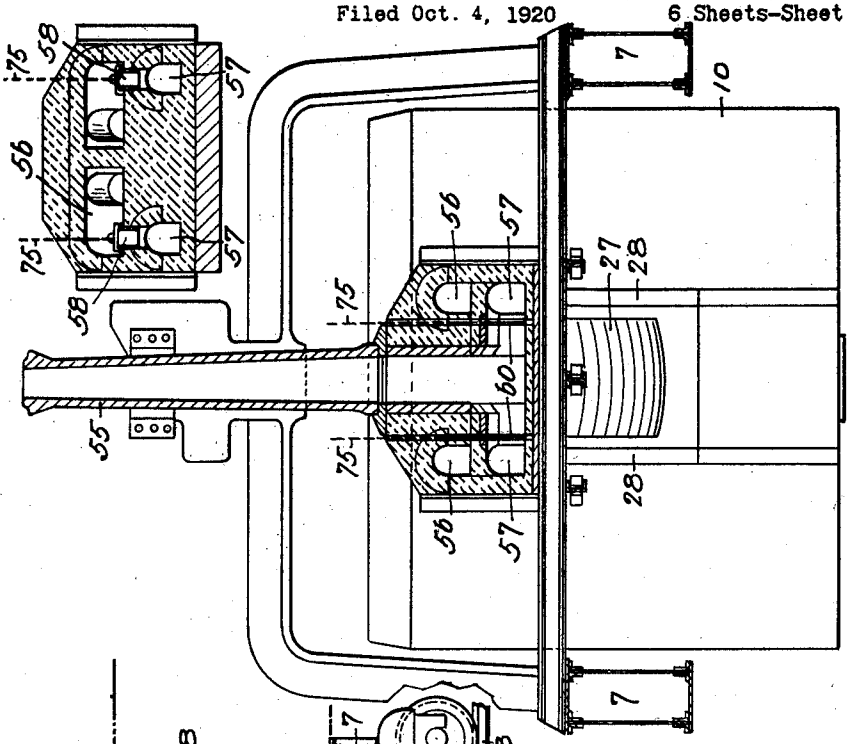


FIG. 5

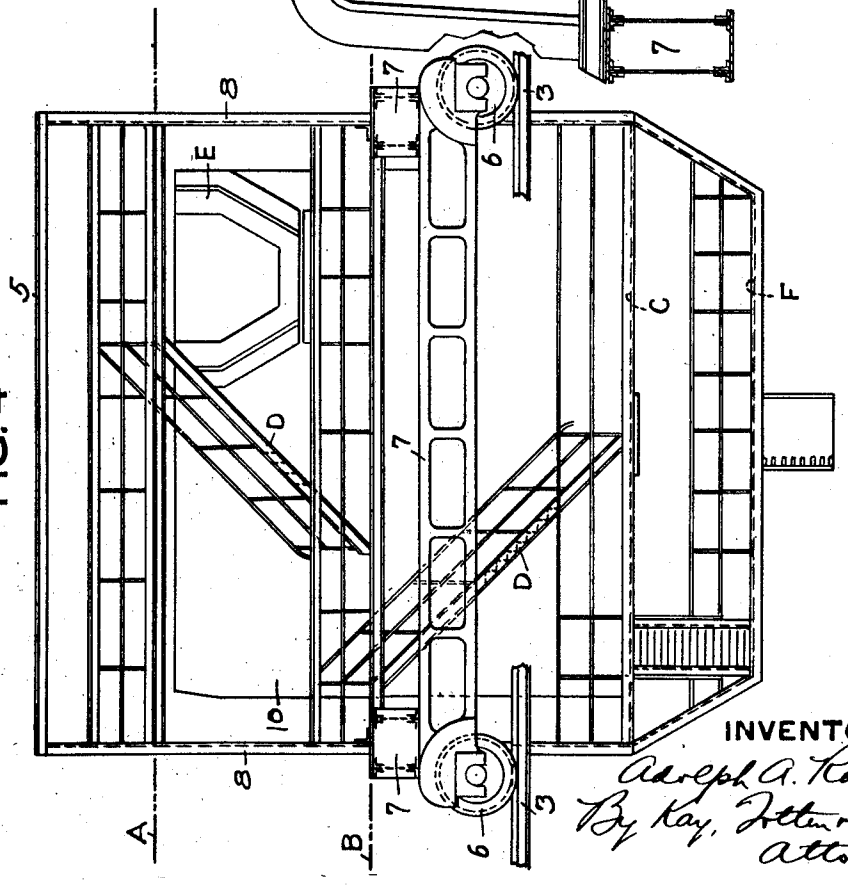


FIG. 4

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PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 5

FIG. 8

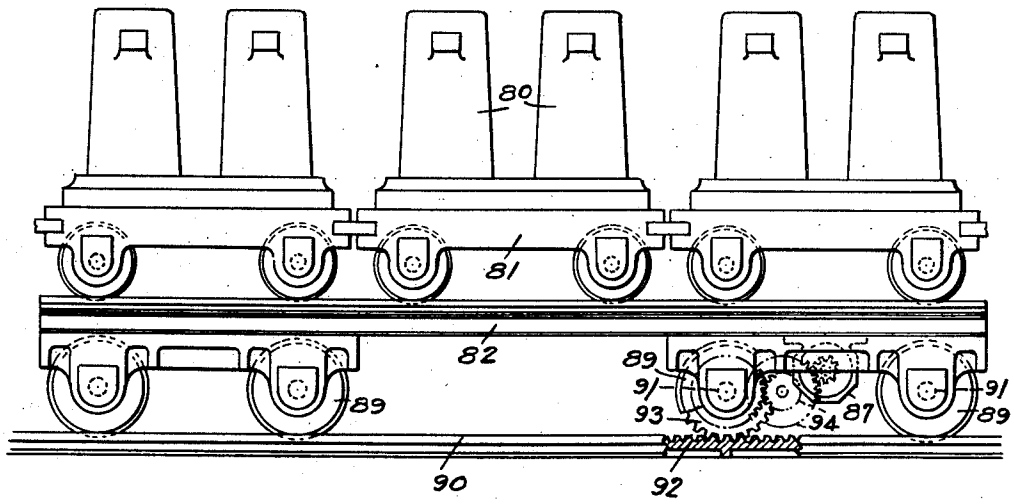


FIG. 10

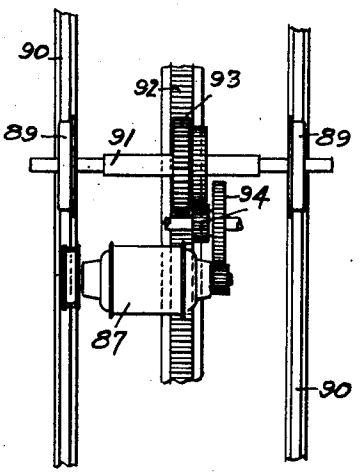
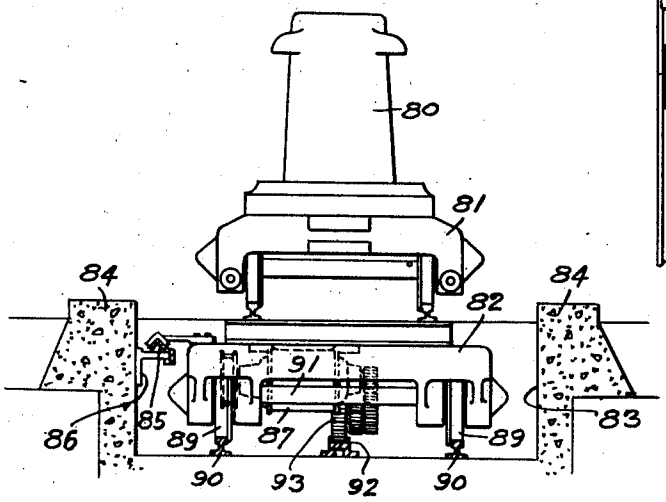


FIG. 9



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Sept. 22, 1925. 1,554,367

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PROCESS AND APPARATUS FOR MAKING STEEL

Filed Oct. 4, 1920 6 Sheets-Sheet 6

FIG. 11

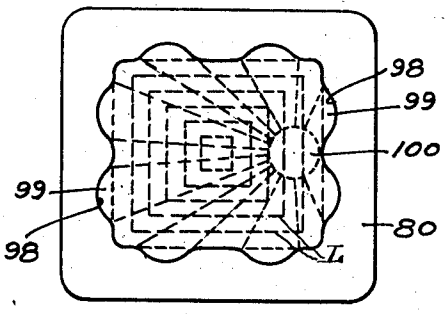
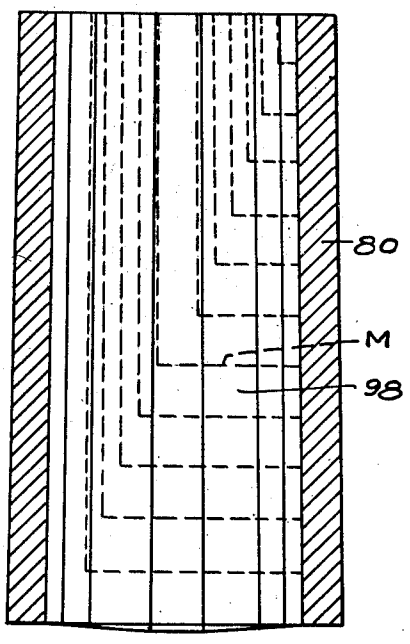


FIG. 12



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Patented Sept. 22, 1925. 1,554,367

UNITED STATES PATENT OFFICE.

ADOLPH A. RACKOFF, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR OF ONE-HALF TO JAMES LOUIS SHARKEY, OF NEW YORK, N. Y.

PROCESS AND APPARATUS FOR MAKING STEEL.

Application filed October 4, 1920. Serial No. 414,581.

To all whom it may concern:

Be it known that I, ADOLPH A. RACKOFF, a citizen of the United States, and resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Processes and Apparatus for Making Steel; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to the manufacture of steel and it has special reference to the handling of the molten metal produced in the open hearth process.

The general object of my invention is to produce steel of increased purity and uniformity, to eliminate the loss of life and injuries to workmen incident to the open hearth process as carried on at present, and to produce economies in time and labor in the handling and pouring of molten steel.

More specifically, one object of my inventeion is to provide an improved process of delivering steel from open hearth furnaces and other metallurgical furnaces, whereby the metal is received from the furnace, cleansed by removing the impurities which it always contains to a greater or less extent, and poured into ingot molds without being bodily transferred in ladles as has heretofore been customary, the metal being kept hot throughout the tapping and pouring operation with consequent reduction in wastage.

Another object of my invention is to provide an improved apparatus, in the nature of a ladle, for receiving molten metal from a furnace and for pouring the metal directly into ingot molds without being transported in the ladle, the apparatus being provided with means for straining and skimming the molten metal and for discharging the slag into a suitable receptacle.

A further object of my invention is to provide improved means for carrying ingot molds and presenting them in succession to a pouring ladle, whereby the molds, while they contain molten metal, are not subjected to shaking or jarring which impairs the solidification of the metal.

A still further object of my invention is to provide an improved ingot mold so constructed as to diminish the formation of pipe and to improve the internal structure of the ingot.

With these and other objects in view which will become evident as the description proceeds, my invention employs in one of its forms the apparatus shown in the accompanying drawings, in which Fig. 1 is a side elevational view with parts in section, showing the general arrangement of a plant constructed in accordance with my invention; Fig. 2 is a plan view with parts in section of the structure shown in Fig. 1; Fig. 3 is a horizontal sectional view taken substantially on the line 3—3, Fig. 1; Fig. 4 is a side elevational view of the ladle-carrying crane; Fig. 5 is a vertical sectional view of the apparatus of Fig. 2, through the stack 55; Fig. 6 is a vertical sectional view taken substantially on the line 6—6, Fig. 2; Fig. 7 is a plan view of the plunger-operating mechanism of one of the ladles; Fig. 8 is a side elevational view of one of my improved platforms carrying a set of cars and ingot molds; Fig. 9 is an end elevational view of the structure of Fig. 8; Fig. 10 is a plan view of the reduction gear shown in Figs. 8 and 9; Fig. 11 is a plan view of an ingot mold constructed in accordance with my invention and also illustrating my novel method of pouring; and Fig. 12 is a vertical sectional view taken centrally through the ingot mold of Fig. 11.

According to the usual method of handling steel produced by the open hearth process, the charge is fused in a suitable furnace and when the heat has been completed the entire contents of the furnace are discharged into a ladle which is carried by means of a crane to a casting floor, usually on the opposite side of the plant from the melting furnace, and the molten metal is poured from the ladle into ingot molds carried on cars which are moved along ordinary tracks by means of small locomotives.

This method of handling the molten metal has several disadvantages. In the first place, the entire contents of the furnace are discharged into the ladle and although it is expected that the impurities will rise to the top and pass off in the slag, nevertheless it is found that more or less of the impurities are entrapped with the molten metal and are not able to rise to the surface because there is substantially no stirring of the metal and because the heavy splash of the

metal prevents the particles from rising. These impurities consequently fall with the metal into the ingot molds and later appear in the rolling operation where they give rise to defects such as seams, cracks and splits which cause a considerable portion of even the best steel to be discarded as scrap. Since these defects do not appear until the rolling operation, the defective metal has undergone several expensive and useless operations.

In the second place, the transportation of the metal in the ladle from the furnace to the casting floor is in itself an expensive operation requiring powerful machinery and is also an ever-present source of danger to the workmen who, in spite of all possible precautions, are frequently burned severely and even fatally by splashes of metal and by accidents where the ladle slips from its hooks. Also, this operation requires a considerable amount of time, since the pouring operation is not begun until the ladle is completely filled and carried across the plant to the casting floor and this loss of time is not only a source of expense in itself but also a source of waste, since much of the metal in the ladle is chilled and must be broken up for remelting as scrap.

My present invention aims to overcome the disadvantages outlined above, and also to produce metal of a higher and more uniform grade than is possible under present operating conditions, by tapping the metal from the furnace and receiving it in a novel form of heated ladle or strainer, where the metal is thoroughly cleansed without stopping its onward flow. I then pour the purified metal into ingot molds directly at the furnace, the molds being carried on suitable platforms instead of on the ordinary tracks, and the platform being advanced step-by-step to bring the molds successively into pouring position without shaking or jarring the molds. In addition, I provide for pouring the metal into the molds in a vertical stream which is displaced from the center of the mold, so that any pipe which may form is formed at the side of the mold instead of in the center. The molds are provided with corrugated side walls, which produce advantages that will be more fully described below.

Referring to the drawings, the numerals 2 indicate diagrammatically two batteries of open-hearth furnaces disposed with their discharge ends parallel and facing each other. Tracks 3 are carried by suitable supports 4 in front of the furnaces, and a crane 5, provided with wheels 6 resting on the tracks 3, is adapted to travel between the batteries of furnaces and to tap off the molten metal from any pair of opposite furnaces.

The crane 5 is a rectangular structure made up of longitudinal girders 7, uprights 8 and cross beams 9, the general construction of the crane being such as is commonly found in the cranes employed in steel mills.

The crane 5 carries two devices 10 which, for convenience, are termed ladles since they replace the ladles commonly employed in transferring metal from open hearth furnaces. Their function, however, is more properly that of a strainer or funnel since they do not transport the metal but purify it and transfer it directly to the ingot molds. Each of the ladles 10 consists of an outer shell 11 suitably provided with a lining 12 of fire clay. A funnel-shaped receptacle 13 is supported on the shell 11 and the lining 12 by means of a peripheral flange 14. The receptacle 13 is perfectly constructed of sheet metal having perforations 15 and is provided with an inner and outer lining 16 of fire clay which extends through the perforations 15 and is thus held firmly to the sheet metal core. The receptacle 13 has a cover 20 which is so shaped as to provide an annular channel 21 into which extend a series of baffles 22. The channel 21 communicates with an opening 23 through which the molten metal drops into the interior of the receptacle 13 and the channel 21 also has a straight portion 24 communicating with a trough or connector 25 which is hinged at 25^a to the outer shell 11 and communicates with the usual notch of the furnace when tapped. The metal issuing from the furnace thus passes through the straight channel 24 and the circular channel 21, being guided in an indirect course by means of the baffles 22 which stir and strain the metal and cause the slag to separate thoroughly and rise to the top. In order to receive the slag, the cover 20 is provided with a central opening 26 which communicates with an inclined chute 27 that extends out through the receptacle 13 and the outer shell 11 and discharges between vertical walls 28 which guide the slag down into a slag car 29 which runs upon tracks 30 and which may be of any usual type.

In order to keep the metal perfectly molten during the straining and pouring operation, the inner receptacle 13 of the ladle is heated by means of a series of gas burners having gas inlets 35 and air inlet valves 36. Walls 37 of refractory material form passages 38 and 39 for the gas and air respectively, and also form a combustion chamber 40 above which is an annular space 41 extending around the receptacle 13, except at the slag spout 27, and a checker-work 42 which is composed, as shown in Fig. 3 of hexagonal tiles which give a large area exposed to the gases of combustion.

Each of the air valves 36 consists of a fixed sleeve 45 extending through the bottom of

the outer shell of the ladle and having at its upper end a spider 46 that supports a vertical spindle 47 which is screw-threaded and extends through a tapped opening in an outer sleeve 48 that extends around, and slightly spaced from, the inner sleeve 45 and is provided with a hand wheel 49. Fig. 1 shows one of the air inlet valves in closed position and another in slightly open position and it will be evident that the amount of air introduced in each burner can be readily regulated by raising or lowering the outer sleeve by means of the hand wheel 49.

In order to supply gas to the several gas inlets 35 a pipe 50 extends around the outside of the ladle and is tapped at intervals to admit the necessary pipe connections for the gas inlets. Since the gas pipe 50 is outside of the ladle there is no danger of overheating or explosion in the gas supply. Openings 51, having suitable covers 52, are provided above the gas inlets for convenient cleaning. When the ladle is to be repaired, the entire receptacle 13 may be lifted out of the shell 11 and access may thus be had to all of the inside and outside parts of the ladle.

The checker-work 42 is provided both for circulating the gases of combustion thoroughly around the outside of the receptacle 13 and for heating the ladle prior to use. Sometimes one ladle only may be used in tapping metal and when it is desired to employ the other ladle also, the receptacle 13 is first heated up by leading through the heating jacket of the cold ladle the gases of combustion from the hot ladle. Also, means must be provided for carrying off the gases from the ladles. For these purposes I provide a central stack or chimney 55, at the base of which is arranged a series of passages 56 and 57 controlled by valves 58, small dampers 59 and large dampers 60, as best shown in Figs. 2, 5 and 6. The valves and dampers are all arranged to close by gravity and are opened by means of chains or ropes 75. The passages 56 are disposed at a higher level than the passages 57 and the valves 58, and dampers 59, when open, permit the gases of combustion to pass freely from one ladle to the other, the large dampers 60 being closed at this time. When, however, the valves 58 and dampers 59 adjacent to one of the ladles are closed and the remaining valves and dampers left open, the gases of combustion can pass from one of the ladles through the open valves and into the stack 55 but not into the other ladle. In the normal operation, with both ladles in use, the valves 58 and the dampers 59 are left open and the chimney dampers 60 are opened sufficiently to permit part of the gases of combustion to escape through the chimney 55. The hot gases from the chimney serve to heat the furnace building.

The receptacle 13 is provided with a pouring opening 61 which is closed and opened by means of a plunger 62 consisting of a metal rod 63 covered with fire clay 64. The upper end of the rod 63 is screw threaded and is received in a correspondingly threaded opening in a sleeve 65 to the upper end of which is secured a bevel gear wheel 66 meshing with two bevel pinions 67 and 68. The sleeve 65 is rotatably mounted in a bearing bracket 65a. The bevel pinion 67 is secured to one end of a shaft 69 to the other end of which is attached a hand wheel 70, while the bevel pinion 68 is secured to one end of a similar shaft 71, to the outer end of which is secured a pulley 72 around which extends a chain or cable 73 which is conducted over guide rollers 74 to a position for convenient operation. It will thus be seen that the plunger that controls the pouring opening of the ladle may be moved up and down either by the hand wheel 70 or by means of the chain 73, as may be most convenient.

The metal issuing through the pouring opening 61 is received in ingot molds 80 which are carried on the usual cars 81, these cars, however, being mounted on platforms 82 instead of on the usual tracks. I provide the platforms 82 for supporting the ingot mold cars in order that the cars may be moved smoothly and without jarring to bring the successive ingot molds into position for pouring.

To accommodate the platforms 82 a trench 83 is provided beneath each of the ladles and this trench preferably extends the full length of the battery of furnaces. Suitable parapets 84 are provided at the sides of the trench 83 as a measure of safety, since the trench 83 contains an electric trolley rail 85 which is mounted on brackets 86 and serves to supply electric current to the electric motor 87 with which each platform 82 is provided. The platform 82 is mounted on wheels 89 which travel on tracks 90 laid in the bottom of the trench 83, the wheels 89 being loose on shafts 91. A rack 92 extends the full length of the trench 83 and the platform 82 carries a gear 93 which meshes with the rack 92 and is driven by the motor 87 through suitable reduction gearing 94. This arrangement provides that when the motor 87 is energized, the platform 82 is moved forward gently through the engagement of the gear 93 with the rack 92.

In order to control the motor 87 which operates the platform 82, a suitable set of control switches 95 is provided at a convenient point on the crane and may suitably be combined with the usual controller by means of which the crane is moved along the battery of furnaces. Since the electrical control system, and the connections between the motor 87 and the controller 95, may be of

any well known or desired arrangement and form no part of my present invention, they are not illustrated in detail.

The general arrangement of the crane and its divisions into levels for convenience in operation are best shown in Fig. 4. There are three separate main floors provided on the crane, an operator's floor A for the workman who skims the metal as it passes through the skimming channels, a girder floor B which is on the same level as the open hearth furnace floor, and an inspector's floor C. Suitable stairs D provide communication between the several floors and between the floors A and B is a trough support E for supporting the trough 25 which delivers the molten metal from the furnace into the skimming channel. Below the inspector's floor C is suspended another operator's floor F where the controller for operating the crane and the ingot platforms is preferably located and where the operator has convenient access to the chain 73 which operates the plunger of the ladle.

It will be observed on Fig. 1 that the center of the ingot mold is displaced laterally from the pouring opening of the ladle. I prefer to pour the metal into the ingot molds in this manner in order to improve the internal structure of the ingot and also to take full advantage of the special form of mold construction shown in Figs. 11 and 12. These figures show an ingot mold 80 which is of the same general proportions as ordinary ingot molds but has two or more depressions 98 formed in each of its sides so that the resulting ingot has corresponding corrugations 99.

When the metal is poured into an ingot mold with the center of the mold directly beneath the pouring spout, the metal chills symmetrically around the center, first becoming cool at the sides and then chilling gradually toward the center, the course of this cooling process being indicated by the lines L on Fig. 11. The contraction and internal stress produced in the metal on cooling result in a pipe in the center of the ingot. When, however, the metal is poured into the ingot at the side, as indicated at 100 on Fig. 11, the ingot does not cool symmetrically but first cools on the side of the mold opposite to the pouring point and gradually cools toward the pouring point. This results in a cooling process which is illustrated diagrammatically by the lines M on Fig. 12.

This unsymmetrical cooling has several advantages. In the first place, the pipe which tends to form in the end of the ingot will be located near one edge, and since ingot molds are ordinarily made slightly tapering, the pipe will be closely confined to the top portion of the ingot. Also, this unsymmetrical cooling produces advantages when the ingot is brought to the blooming mill because, instead of having an ingot with a soft center and hard sides, which cause the hard outside parts of the ingot to slip over the soft inner portion to a considerable extent without compacting the metal, in the present system, the ingot is hardest at one side and varies progressively in hardness toward the pouring side. Therefore when such an ingot is passed through the rolls of the blooming mill the metal becomes progressively harder as the rolling proceeds from the pouring side toward the center of the ingot, and therefore the ingot is rolled with regularity and is given a more uniform internal structure than where the outside layers of ordinary ingots are caused to slip over the inside layers in the rolling operation.

The corrugations 99 which I impart to the ingots by the special form of mold described above are of a somewhat softer nature than the main body of the ingot on account of the eddies set up in the recesses of the mold while the mold is being filled. Therefore, although these corrugations cool more quickly than the interior of the ingot, there is not the great difference in hardness between them and the inside of the ingot that exists between the outside and inside of an ordinary ingot at the blooming mill. Therefore, the ingot is of more uniform density than ordinary ingots even in the first blooming pass. In addition, the corrugations serve to elongate the billet since they are incorporated in the body of the billet during the rolling operation, and the first passes through the rolls, which are usually the hardest passes on account of the greater cooling on the outside of the billet, are less severe than usual because in these first passes the rolls engage only the corrugations and not the body of the ingot.

In carrying out my process with the apparatus described above, the crane is brought into position opposite to the furnace or furnaces to be tapped, the trough 25 is lowered upon the notch of the furnace and the joints around the ends of the trough are luted with fire-clay. The furnace is then tapped and the metal passes through the trough 25 into the straight channel 24, thence horizontally through the circular channel 21 and then drops vertically through the opening 23 into the interior of the receptacle 13. This flow through the channels 24 and 21 is relatively gradual and the baffles 22 serve to retard and agitate the metal and give the slag an opportunity to rise to the surface. An operator standing on the operator's floor A skims the metal by pushing the slag over the edge of the channel into the central opening 26 and the slag passes down through the chute 27 and into the slag car.

The metal which drops into the receptacle

13 through the opening 23 is free from slag and other impurities and is kept hot by the gas burners which surround the receptacle within the shell of the ladle. The platform 82, carrying a set of cars 81 and ingot molds 80, is brought into position beneath the crane, the proper number of ingot molds being preferably provided to receive the metal from one heat of the furnace. The control operator standing on the platform F advances the platform 82 step-by-step to bring the successive ingot molds beneath the spout of the ladle and the same operator may also operate the pouring plunger by means of the chain 73. When all of the ingot molds have been filled the platform is moved away from the crane and when the metal is sufficiently set in the molds so that jolting will not damage the ingots, the cars are attached to an ordinary locomotive and drawn to the usual stripper and soaking pit.

My invention produces steel of a superior quality, first by removing impurities from the steel to a greater degree than has heretofore been possible; second, by pouring the ingot in such a way as to improve its internal structure; third, by pouring the metal directly from the furnace into the ingot molds; and fourth, by allowing the metal to set in the ingot mold without jarring. A material saving in labor is also produced, since two or three workmen are sufficient to handle the entire pouring operation and in addition, the pouring operation is so carried out as to minimize the danger of accident or loss of life. The ladle is kept constantly hot and therefore no metal freezes in the ladle. An additional advantage is that the operator who controls the pouring is able to see clearly the condition of each ingot as it is poured and if any defect in the material should appear during the pouring he is able to mark the molds containing the defective ingots for remelting or other special treatment. In the usual practice, it is necessary to wait until the ingot is rolled before the defects in the metal are ascertained.

While I have herein shown and described a preferred embodiment of my invention it is to be understood that various changes in the form and arrangement of parts may be made without exceeding the limits or sacrificing the advantages of my invention. I therefore desire that no limitations be imposed upon my invention except such as are indicated in the appended claims.

I claim as my invention:

1. The metallurgical process that comprises melting a charge in a suitable furnace, drawing off the melt into a movable heated container, removing impurities from the said melt while flowing from the said furnace to the said container, and pouring said metal from the said container into suitable molds.

2. The process of making steel comprising melting a charge in a suitable furnace, causing the said melt to flow in a laterally winding path in contact with baffles for removing impurities, then causing the melt to drop into a container and pouring the molten metal from said container into molds.

3. The process of making steel that comprises melting a charge in a suitable furnace, drawing off the melt into a container, removing impurities from the melt while passing from the said furnace to the said container, heating the said container to maintain the fluidity of the said melt, and pouring the molten metal from the said container into suitable molds.

4. The process of making steel that comprises melting a charge in a suitable furnace, drawing off the melt from the said furnace, causing the said melt to flow in contact with baffles for removing impurities, then causing the melt to drop into a heated container and pouring the molten metal from the said container into suitable molds.

5. The process of making steel that comprises melting a charge in a suitable furnace, drawing off the melt from the said furnace, causing the said melt to flow down a gradual incline in contact with baffles for removing impurities, skimming the melt while flowing down the said incline, causing the melt to drop vertically into a heated container and pouring the molten metal from the said container into molds.

6. The process of making steel comprising melting a charge in a suitable furnace, drawing off the melt from the said furnace, causing the said melt to flow down an incline, agitating the said melt while flowing down the said incline and thereby separating the impurities therefrom, receiving said melt in a container and pouring the molten metal from said container into molds.

7. Metallurgical apparatus comprising a furnace, a container, means for conducting molten material from the said furnace to the said container, means for heating the said container and means for removing impurities from the molten material while flowing from the said furnace to the said container, and means for pouring the said material into molds.

8. Apparatus for making steel comprising a ladle and means for causing molten metal to flow toward said ladle in a horizontal winding path and in contact with slag-removing means, and for then causing said metal to drop vertically into the said ladle.

9. Apparatus for making steel comprising a ladle, means for causing molten metal to flow down an incline toward said ladle and then to drop vertically into said ladle, and means for agitating the molten metal while flowing down the said incline.

10. Apparatus for making steel compris-

ing a ladle, means for causing molten metal to flow in an indirect path and thence into the said ladle, and baffles extending into the path of the flowing metal from the sides thereof and adapted to remove impurities from the said metal.

11. Apparatus for making steel comprising a ladle, means for causing molten metal to flow in an indirect path and thence into the said ladle and baffles extending into the path of the flowing metal and disposed in staggered relation to each other.

12. Apparatus for making steel comprising a ladle, and means for causing molten metal to flow around the said ladle and then to drop vertically into the said ladle.

13. Apparatus for making steel comprising a ladle, a channel for causing molten metal to flow around the said ladle and then to drop vertically into the said ladle, and means adjacent to the said channel for conveying slag therefrom.

14. A steel-making plant comprising a battery of open hearth furnaces, a crane movable along the discharge side of the said furnaces, a platform disposed beneath the said crane and adapted to carry a set of ingot molds and to advance step-by-step to bring the said molds successively into pouring position, and a ladle carried by the said crane and provided with means for receiving molten metal from the said furnaces, for cleaning the said metal, and for pouring the said metal into the said molds.

15. A steel-making plant comprising two parallel batteries of open hearth furnaces, a crane movable between the said batteries of furnaces, two ladles carried by the said crane, each of the said ladles being adapted to receive molten metal from the furnaces in one of the said batteries, to clean the said metal, and to pour the said metal into ingot molds, a movable platform disposed beneath each of the said ladles, and adapted to carry a set of ingot molds, and means for imparting a step-by-step movement to the said platforms to bring the said molds successively into pouring position.

16. Apparatus for making steel comprising a ladle, a cover therefor, and a channel for causing molten metal to flow toward said ladle and through an opening in the said cover.

17. Apparatus for making steel comprising a ladle, a cover therefor, a channel for causing molten metal to flow toward said ladle and through an opening in the said cover, and baffles extending into the said channel from the sides thereof, the said baffles being in staggered relation to each other.

In testimony whereof, I the said ADOLPH A. RACKOFF, have hereunto set my hand.

ADOLPH A. RACKOFF.