

May 10, 1927.

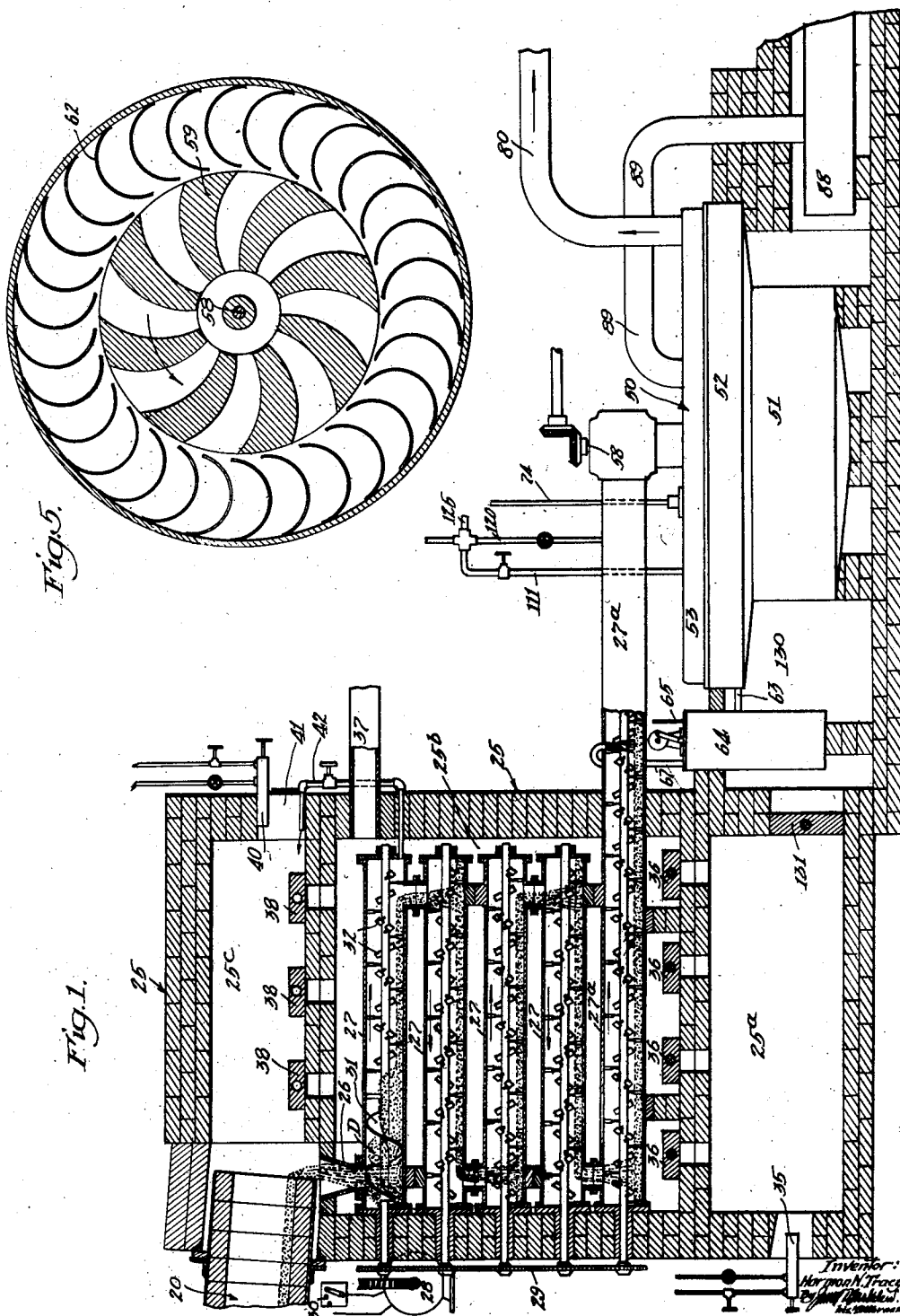
H. N. TRACY

1,628,012

PROCESS AND APPARATUS FOR METALLIZING ORES

Filed May 29, 1923

3 Sheets-Sheet 1



May 10, 1927.

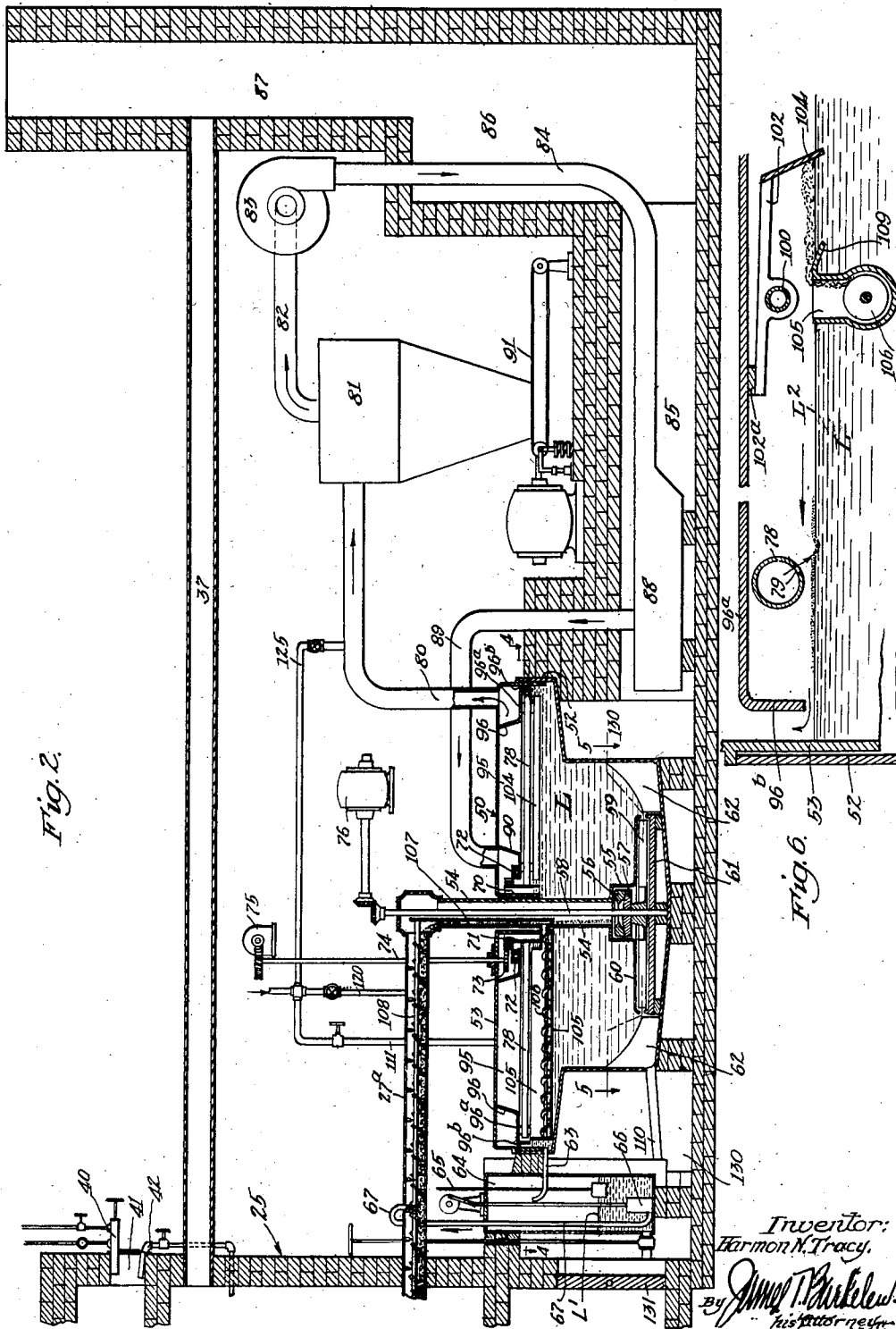
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PROCESS AND APPARATUS FOR METALLIZING ORES

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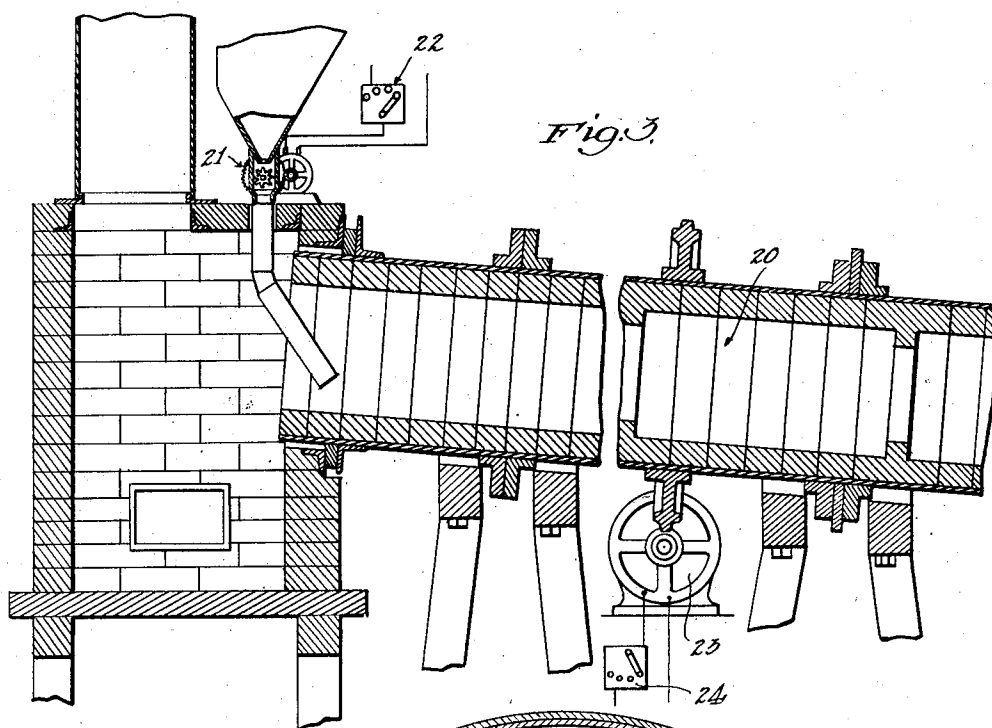
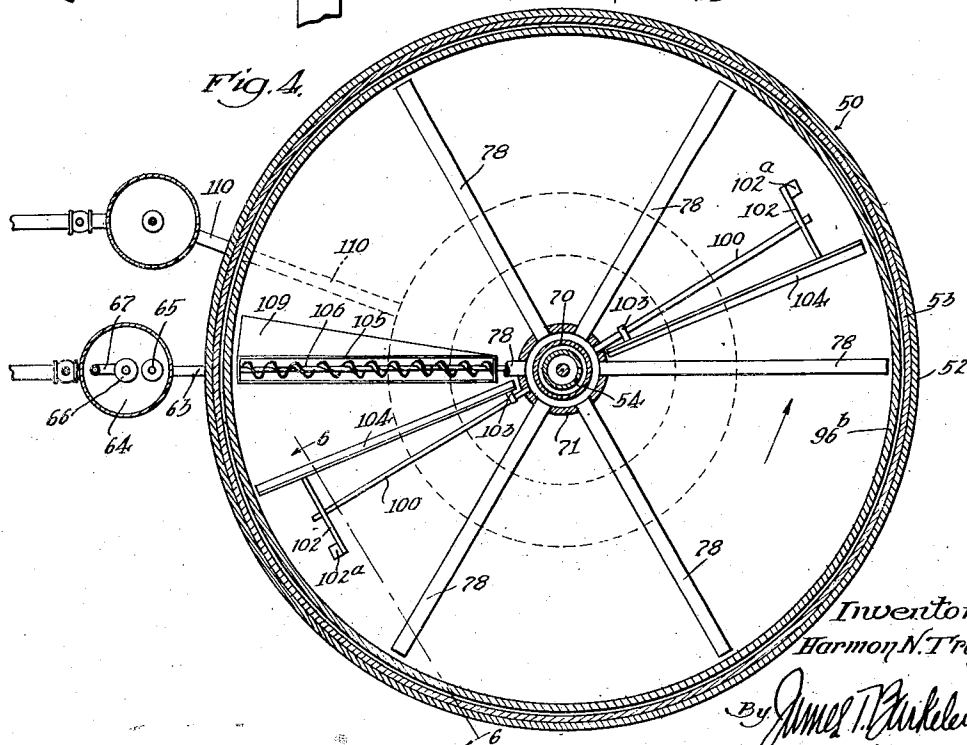
1,628,012

H. N. TRACY

PROCESS AND APPARATUS FOR METALLIZING ORES

Filed May 29, 1923

3 Sheets-Sheet 3



Inventor:
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By *James T. Minkew.*
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Patented May 10, 1927.

1,628,012

UNITED STATES PATENT OFFICE.

HARMON N. TRACY, OF LOS ANGELES, CALIFORNIA.

PROCESS AND APPARATUS FOR METALLIZING ORES.

Application filed May 29, 1923. Serial No. 642,164.

This invention relates to the general type of process that is set out in my application Serial No. 349,408 filed January 5th, 1920, on process and apparatus for metallizing ores. The present process, like that of the prior application, extracts metal from the ores by bringing the metal carrying ore into contact with a bath of liquid and preferably molten metal, such as lead; and maintains on the ore and on the liquid metal bath an atmosphere of non-oxidizing gas. This process, again like the process described in the prior application, also preferably first reduces the metal in the ores to metallic state; the reduction action being preferably carried on simultaneously and continuously with the metal extracting action, and an atmosphere, preferably the same atmosphere, of non-oxidizing gas being maintained on the ore during its reduction. For purposes of reduction the superimposed atmosphere is maintained with a reducing gas; and so, in the practical operation of my process I use a reducing gas throughout as that gas serves both as a reducing agent and serves to supply a non-oxidizing atmosphere during the metal extracting operations.

The improvements that are concerned particularly in this present application relate most to improvements in the operations of extracting the metal from the ore after the metal has been reduced to metallic state; and, although there are many objects attained by the present improvements, both in process and in apparatus, and while the majority if not all of the objects and corresponding features and advantages of the invention, will be best and most fully understood from the following detailed description, I will here merely say in a preliminary way that it is generally an object to provide a process and apparatus in which there is no tendency for the ore to gather together in sticky masses—to ball up; and thus to keep the ore in finely divided condition at all times during its treatment and thus increase the efficiency of metal absorption by the molten bath; and to provide a process and apparatus which attains a high percentage of metal extraction, and in which the gangue is easily and cleanly separated from the bath metal so that a very small amount of the bath metal, and therefore of the extracted metal, is carried away with

the gangue. These and other objects and corresponding accomplishments of the invention will be best understood from the following detailed description of a preferred form of apparatus and process embodying the invention, reference for this purpose being had to the accompanying drawings in which:

Fig. 1 is a longitudinal vertical section showing the major portion of the apparatus, parts being shown in elevation;

Fig. 2 is a longitudinal vertical section of those parts of the apparatus shown in elevation in Fig. 1 and also of the remaining gangue handling portion of the apparatus;

Fig. 3 is a longitudinal vertical section of a preheating or roasting apparatus as may be used with my system;

Fig. 4 is a somewhat enlarged horizontal section on line 4—4 of Fig. 2;

Fig. 5 is a similar section on line 5—5 of Fig. 2; and

Fig. 6 is a section taken as indicated by line 6—6 on Fig. 4.

In the drawings I show at 20 a preheating or roasting drum that needs no special description except to say that it is fed by feeder 21 which may be controlled, for instance, by rheostat 22, to control the amount of ore fed into it. The speed of rotation of the drum, which is operated by a motor 23, may be controlled by a rheostat 24. The lower end of the drum discharges into a furnace structure 25 and discharges directly into a chute or inlet 26 that carries the ore into the uppermost one of a series of deoxidizing elements 27. These elements are preferably in the form of pipes or tubes within which there are spiral conveyers, operated by motor 28 and gearing 29, the speed being controlled by a rheostat or controller 30. The spiral conveyers within the tubes may be in the form of a continuous spiral as illustrated at 31, or may be in the form of a broken or discontinuous spiral as illustrated at 32; the function of the last mentioned form being not only to feed the ore through the tubes 27 but also to keep it well agitated and thus cause it to come into thorough intimate contact with the deoxidizing atmosphere and at the same time prevent it from balling up. The ore, after having been carried back and forth in the deoxidizing tubes, is finally carried out through the final tube 27* to the metal ex-

tracting device. Tubes 27 are set in furnace structure 25 which is heated from below by a burner 35 to maintain a proper deoxidizing temperature. The initial combustion in this furnace takes place in the lower chamber 25^a; and the amount of heat that passes into and through the chamber 25^b in which the deoxidizing tubes are located may be controlled by dampers 36. From the upper end of chamber 25^b there may be a discharge pipe or stack 37; and the gases of combustion from chamber 25^b may pass out through 37 or may wholly or partially pass, under the control of dampers 38 into the uppermost furnace chamber 25^c, hence they may pass through drum 20 to aid in heating the ore in the drum. The flame from burner 35 may of course be maintained in reducing, neutral or oxidizing state as may be desired. There is also, a burner provided at 40 for the sole purpose of heating the ore in the drum, and for roasting it if necessary; and for this purpose air is admitted at 41 in proper quantities. Also any excess reducing gas that has not been completely used up in the reducing operations in tubes 27, may be passed through pipe 42 into combustion chamber 25^c.

With some ores, as oxides, it is only necessary or desirable to preheat them; while with others, as sulphides, it is desirable to both preheat and roast, in preparation for the deoxidizing step. The ore thus reaches the deoxidizing tubes as oxides, or in such form as may be reduced by reaction with a reducing gas. The action in reducing tube 27 then becomes simply to reduce the metal to metallic state; and in this form the ore, still finely divided, is discharged through the last tube 27^a into the device that I term the lead pot 50. I may say here, that for the purposes of the process I explain I preliminarily grind or otherwise finely divide the ore to a comparatively fine size; preferably to what may ordinarily be termed dust.

In order to maintain a slight pressure above atmosphere in the deoxidizing tubes (to exclude atmospheric air) a dam of ore may be formed at D at the ore inlet hopper 26. The gas pressure is then regulatable by the gas feed at 120 and by the surplus gas take-off at 42.

The lead pot, in the specific form to which I have now developed it, has a circular casing with a lower part 51 of smaller diameter and an upper part 52 of larger diameter. For convenience in construction and inspection or repair the pot is provided with a removable cover 53. A vertical ore feed pipe 54 extends down through the center of the cover to a point near the bottom of the pot and there it is expanded to form a chamber 55 that encloses the mulling disks 56 and 57. Disk 56 is stationary while disk 57 rotates, being mounted on shaft 58 on which is also

mounted the runner 59 of a centrifugal ore throwing device. These runners are formed substantially the same as the centrifugal runners of a pump of what is known as the shrouded type. A cover plate 60 covers the upper surface of the runners and is supported on casing 55; and a bottom plate 61 encloses the runners below. Outside these centrifugal runners I provide reaction vanes 62, of proper form to absorb and stop any circular motion of the materials and of the molten lead in the pot, so that the body of lead is relatively quiescent and maintains a relatively quiet and smooth upper surface. The spaces between the reaction vanes 62 are open upwardly so that the materials thrown out into them may freely float up through the lead bath L. The level of the lead bath is maintained constantly at the point illustrated in the drawings by the expedient of having an overflow pipe 63 which discharges a small amount of lead into a small reservoir 64. This reservoir has a level indicator 65 for the purpose of enabling the operator to keep the lead level L in reservoir 64 below the level of discharge pipe 63. From this reservoir the lead is pumped at a suitable rate by a small pump 66 through pipe 67 back into tube 27^a where it is carried along with the ore passing through that pipe. Thus the lead level in the pot is constantly maintained at the same point. At the same time this constant passage of a small portion of the bath metal, and with it of course any metal that it has absorbed, into tube 27^a, assists in the thorough admixture which I desired to attain between the ore and the bath metal. This is perhaps of small or no consequence as long as the operation in the lead pot itself is not carried beyond the efficient capacity of the lead pot; but if the capacity of the lead pot is "pushed" so to speak, then I find I can still maintain the maximum efficiency by passing a suitable small portion of the bath metal continuously into the tube 27^a.

Of course, the lead level in the pot may be maintained without passing the lead into tube 27^a; and in that case it is only ore, carrying metal in metallic state, that is thrown out into lead bath by the centrifugal runners; but I prefer to do as I have described, and so the centrifugal runners throw out into the lead bath also a small quantity of the bath metal itself. The centrifugal runners are so shaped, and are operated at such speed, as to overcome the liquid pressure of the bath metal and as to throw the ore outwardly, against that pressure, and forcibly into the bath metal. When the device is in full operation, there is of course no bath metal (except the small amount intermingled with and thrown out with the ore) present in the centrifugal vanes; the ore in fact coming into contact with the metal bath as it leaves the vanes. The ore is forcibly thrown

into the metal bath; in finely divided state; and, considering any one instant or a short period of time, in an amount comparatively small in relation to the mass of the metal bath. The ore rises upwardly through the metal bath, and due to its finely divided state and to the relatively wide separation of its particles, each particle is intimately and completely surrounded by the bath metal and its carried metal is quickly and effectively absorbed. The remaining gangue floats on up to the surface and is there removed as I will now describe.

Surrounding the ore feed pipe 54, cover 53 has a sleeve 70 that extends down far enough to project into the liquid and thus form a liquid seal. Around that sleeve, and spaced from it, is another rotating sleeve 71, mounted on bearings 72, and slowly rotated (say about 3 R. P. M.) by means of gearing 73 from a shaft 74 that is driven by some suitable means, as a motor 75. The centrifugal runner shaft 58 is also driven by some suitable means, as a motor 76. By controlling the speeds of these motors, the speeds of the various driven parts may be independently controlled. The rotating sleeve 71 carries a plurality of pipes 78 provided with perforations 79 through which the gas is directed downwardly and angularly rearwardly (that is, opposite to the direction of rotation of the parts) onto the surface L^2 of liquid L . The gangue that comes to the surface in finely divided particles is blown up as dust into the space above the liquid level, and from this space the dust is carried in a gas current out through pipe 80 into a dust collector 81 that may be of any suitable kind. From this dust collector the clean gas passes out through pipe 82 to a blower 83. The gas is then forced by blower 83 to pipe 84. This pipe 84 passes through the horizontal flue 85 and the lower portion of chamber 86 of a stack 87 for the purpose of maintaining the gas at such a temperature that it will not cool the surface of the molten metal in the lead pot. For this purpose the pipe 84 may discharge into a somewhat enlarged chamber 88 in flue 85; and from this heating chamber a pipe 89 leads again to the upper part of the lead pot, discharging into the lead pot at a point inside the circular wall 90 that keeps this gas from immediately passing into the open space over the liquid and forces it to pass into the sleeve 71 and thus into pipe 78.

The pressures used on the gas are not very high, so that the jets at 79 are just strong enough to blow up the gangue dust and not to blow up any lead or metal dust that may be entrapped with the gangue dust. And by putting the perforations 79 on the back side of pipes 78 there is less tendency of the jets to blow the material along the lead surface; in fact, the action on the

heavier metal particles is to blow them down—depress them—into the lead bath. This is somewhat indicated in Fig. 6.

The circular wall 90, in effect, forms an annular chamber around the upper end of sleeve 71. Outside the circular wall 90 there is another but wider annular chamber 95; whose outer wall is formed by another annular wall 96 near the outer edge of cover 53. This outer wall 96 is conveniently formed with a downwardly extending portion that extends down from the top of the cover and then with a horizontal portion 96^a that forms a convenient support for the outer ends of pipes 78 then a downwardly extending flange 96^b that terminates just above the liquid level. The dust that is blown up by the gas jets or streams from pipes 78 is blown up into the space 95 and then it is blown under the lower edge of flange 96^b and into the annular space outside wall 96 and with which space pipe 80 connects. Not a very high pressure is required for these operations. The gas in this system is used over and over again and fresh gas only needs to be supplied to make up for casual losses. The gangue dust may be removed from dust collector 81 in any suitable manner that does not allow escape of the gas. For instance, under the lower end of the collector I may arrange a travelling conveyor belt 91 that will carry off the dust, while the accumulated dust in the lower part of the collector prevents the gas from reaching the lower outlet of the dust collector.

Now, in order to keep the lead surface clean and free of any scum, so that the gangue dust may freely reach the surface and float on the liquid in such state as to be removable as described, I provide a skimming device preferably in the form shown in the drawings, and there may be one or more of them. I show two for instance. A supporting rod 100 is mounted on rotating sleeve 71, and this rod carries a pair of arms 102 and 103 that carry at their outer ends a skimmer bar 104. One end of arm 102 has a stop or bumper 102^a that comes up against part 96^a to limit the downward movement of skimmer bar 104 to a position where it either just touches the liquid surface or just extends below it far enough to skim off the scummy matter that accumulates. These skimmer bars by their revolution carry the surface scum around to a small trough 105 that has a small spiral conveyor 106 in its bottom. This trough is mounted at its inner end, and also communicates at its inner end with the stationary ore feed pipe 54, and the spiral conveyor 106 is rotated by any suitable means. Merely for purposes of illustration here I show a sprocket chain connection 107 from the conveyor shaft 108 in reducing tube 27^a driving the spiral in such

a direction as to feed the accumulated scum and other matter into pipe 54. This trough 105 preferably has an apron 109 projecting from its edge in such a direction that the revolving gathered scum is picked up by the 5 apron and then carried over the apron surface into the trough. The upper edge of the trough stands just above the liquid level, and the apron surface may stand substantially 10 at the liquid level or just above it, so that it will pick up only the scum accumulation that is being moved forward by the skimmer bars. It will be apparent from what I have said that the skimmer bars can rise to pass 15 over the apron and trough.

By this arrangement the liquid surface is not only kept free of a surface scum or other thick or tenacious film, but also the collection from the surface is put back through 20 the muller and the centrifugal runners. The surface is kept clean enough so that the finely divided gangue particles can freely pass upwardly through the surface and float on the surface. At the same time, any ore 25 particles that may happen to have coalesced into larger bodies during the passage upwardly through the liquid lead, and which may be so large as not to be removable by the gas current, are gathered up in the scum and fed back to the muller where they are 30 finely divided and put through the lead again. Thus, any metal that may have escaped extraction on the first lead passage is again put back through the molten bath in 35 finely divided form; and any metallic particles that may have been caught in the scum are also kept in the bath. I have found that during the time it takes to charge the metal bath up to its maximum capacity with absorbed metal, the scum does not accumulate 40 beyond the amount that can be handled in the manner herein described. That statement is made on the assumption that the lead pot may be operated on the batch principle 45 and the lead with its absorbed metal entirely removed and replaced with fresh lead from time to time. However, the lead pot may be operated continuously by the continuous withdrawal of lead amalgam and continuous 50 introduction of fresh lead; and in that case the accumulation of scum is kept down because the scum forming materials will be withdrawn proportionately with the withdrawal of the lead amalgam.

55 The function of mullers 56 and 57 is not to grind the ore, but is merely to disintegrate any accumulations of the small particles into which the ore is initially ground. The positioning of the mullers directly adjacent the centrifugal runners and so that 60 the ore passes directly from the muller to the centrifugal runners, insures the ore reaching the lead bath in finely divided state and without any substantial opportunity of balling up. For this purpose the capacity

of the muller is designed to be considerably greater than the normal ore feed and the capacity of the centrifugal runners is also much greater than the normal ore feed. Consequently, the mulled ore is dropped 70 from the muller into the centrifugal runners in the form of finely divided particles comparatively widely separated (rather than in a solid stream). Also the runners throw out into the lead bath, along with the ore, 75 a certain quantity of the reducing, or at least non-oxidizing gas. It is preferred not to design and operate the runners at such speed that they will throw a body of gas out into the lead bath; but they do throw such 80 gas out into the lead bath as is entrained with the particles. This gas serves, to some extent at least, to make up for such loss of gas as may occur by gas entrainment with the dust that is removed from dust collector 85 81.

The gaseous atmosphere for the deoxidizing operations in tubes 27 is fed in initially under pressure at a point such as illustrated by pipe 120, so that the deoxidizing gas 90 passes through the tubes oppositely to the passage of ore. This deoxidizing gas also passes down through pipe 54 and around the mullers and thus maintains an atmosphere of deoxidizing (or at least non-oxidiz- 95 ing) gas in the centrifugal runner. Thus, the ore has a constantly non-oxidizing atmosphere maintained upon it up to the instant it enters the bath; and the surface of the molten metal around the centrifugal runners (the surface that the ore particles 100 enter) also has this non-oxidizing atmosphere maintained upon it. Likewise, in the manner I have hereinbefore described, the upper surface of the molten metal has a 105 non-oxidizing atmosphere maintained upon it. This upper non-oxidizing atmosphere, formed by the gas that carries off the gangue, may conveniently be the same gas that is used for reducing purposes. Gas 110 to supply any loss in the metal absorbing system may be fed in at 111 or at 125 under the same pressure as the gas is fed into the deoxidizing tubes. The suction side of the gas circulating system is thus maintained, 115 like the gas in the deoxidizing tubes, above atmospheric pressure. In fact, there is a gas communication through spiral conveyor 106, between the space over the lead and the deoxidizing tubes; and thus a single point 120 of gas introduction may suffice for the whole apparatus.

The liquid metal bath is maintained at proper temperature by being set in a chamber 130 that is heated from furnace chamber 125 25* through the control of damper 131. This chamber communicates with flue 85 and stack 87. Reservoir 64 is also set in chamber 130.

The lead amalgam withdrawn may be 130

treated in any suitable manner to recover the valuable material and the lead then returned to the pot for reuse. The process is applicable to any metal that is amalgamable
 5 with a liquid. That liquid may be of any suitable substance for the particular metal being treated. I do not limit myself necessarily to liquid metal, nor to a metal that is kept liquid by heat; although I have found
 10 that molten lead very efficiently extracts many of the metals, among which are gold and silver.

Having described a preferred form of my invention, I claim:

15 1. A process for extracting metal from ores that includes forcibly throwing metal carrying ore in finely divided form, and with its particles relatively widely dispersed, into a body of metal absorbing liquid at a point
 20 below its surface, and maintaining a non-oxidizing atmosphere on the ore and on the liquid surface at the place of entry of the ore into the liquid.

2. A process for extracting metal from
 25 ores that includes forcibly throwing metal carrying ore in finely divided form, and with its particles relatively widely dispersed, into a body of molten metal at a point below its upper surface, and maintaining a non-oxi-
 30 dizing atmosphere on the ore and on the liquid surface at the place of entry of the ore into the liquid.

3. A process for extracting metal from
 35 ores that includes forcibly introducing metal carrying ore into a body of molten metal heavier than the ore at a point below its upper surface; removing from the molten
 40 metal surface any scum accumulation together with ore that may be caught in such scum, returning the removed accumulation to the ore being introduced into the body
 of molten metal, and removing the spent ore from the surface of the molten metal.

4. A process for extracting metal from
 45 ores that includes forcibly introducing metal carrying ore into a body of metal absorbing liquid heavier than the ore at a point below its surface, and removing from the upper
 50 surface of the liquid body the spent ore that floats on the surface by blowing off the spent ore with a current of gas.

5. A process for extracting metal from
 55 ores that includes forcibly introducing metal carrying ore into a body of molten metal heavier than the ore at a point below its upper surface, removing from the molten metal
 60 surface any scum accumulation together with ore that may be caught in such scum, returning the removed accumulation to the ore being introduced into the body of molten
 metal, and removing the spent ore from the surface of the molten metal, the spent ore
 65 being removed from the surface of the molten metal by blowing it off with a current of gas.

6. A process for extracting metal from
 ores that includes forcibly introducing metal carrying ore into a body of molten metal heavier than the ore at a point below its
 70 upper surface, removing from the molten metal surface any scum accumulation together with ore that may be caught in such scum, returning the removed accumulation to the ore being introduced into the body
 75 of molten metal, and removing the spent ore from the surface of the molten metal; maintaining on the ore and on the upper surface of the molten metal and its surface at the
 place of introduction of the ore, an atmosphere of non-oxidizing fluid. 80

7. A process for extracting metal from
 ores that includes forcibly introducing metal carrying ore into a body of molten metal heavier than the ore at a point below its
 85 upper surface, removing from the molten metal surface any scum accumulation together with ore that may be caught in such scum, returning the removed accumulation to the ore being introduced into the body of
 90 molten metal, and removing the spent ore from the surface of the molten metal, maintaining on the ore and on the upper surface of the molten metal and its surface at the
 place of introduction of the ore, an atmosphere of non-oxidizing fluid; the spent ore
 95 being removed from the surface of the molten metal by being blown with a current of non-oxidizing fluid.

8. A process for extracting metal from ores
 100 that includes reducing the metallic content of an ore to metallic state; then forcibly injecting such ore with its metallic content in finely divided form, and with its particles
 105 relatively widely dispersed, into a body of metal absorbing liquid at a point below the upper surface of the liquid; and maintaining on the ore during the step of reduction and up to the point of introduction into the
 liquid, and also on the liquid at the place of such introduction, a non-oxidizing at-
 110 mosphere.

9. A process for extracting metal from
 ores that includes reducing an ore to reduce its metallic content to metallic state; then
 115 forcibly introducing such reduced ore in finely divided form and with its particles relatively widely dispersed into a body of molten metal at a point below its upper surface; and maintaining on the upper surface
 120 of the molten metal, and on the ore during the operations stated, and on the surface of the metal at the point of introduction, a non-oxidizing atmosphere.

10. A process for extracting metal from
 125 ores that includes reducing an ore to reduce its metal content to metallic state; then forcibly injecting such reduced ore in finely divided and relatively widely dispersed state into a body of molten metal heavier
 130 than the ore at a point below the upper sur-

face of such body; maintaining on the ore throughout the operations stated and on the surface of the molten metal at the point of injection, a non-oxidizing atmosphere; and removing spent ore from the molten metal surface to which it has floated by blowing it off with a current of non-oxidizing gas, and thereby at the same time maintaining a non-oxidizing atmosphere on the upper surface of the molten metal.

11. Apparatus for such a process as herein described, including a chamber adapted to hold a body of metal absorbing liquid; means to introduce finely divided ore into the body of liquid; and means to remove spent ore from the surface of the liquid comprising a gas circulating system provided with means to create a current of gas over the surface of the liquid.

12. Apparatus for such a process as herein described, including a chamber adapted to hold a body of metal absorbing liquid; means to introduce finely divided ore into the body of liquid; and means to remove spent ore from the surface of the liquid, comprising a moving gas jet pipe movable over the surface of the liquid, means to supply the pipe with gas under pressure, and means to exhaust from the upper part of the chamber the dust raised by these jets.

13. Apparatus for a process such as herein described, embodying a chamber adapted to hold a body of molten metal of greater specific gravity than the ore being treated; means to introduce ore into the body of molten metal; means to remove any scum from the surface of the molten metal thereby to keep the surface clean and allow spent ore to rise through the surface and float thereon; and means to blow the ore from the surface of the molten metal.

14. Apparatus for a process such as herein described, embodying a chamber adapted to hold a body of molten metal, of greater specific gravity than the ore being treated; means to introduce ore into the body of molten metal; means to remove any scum from the surface of the molten metal thereby to keep the surface clean and allow spent ore to rise through the surface and float thereon; comprising a rotating skimmer moving over the surface of the molten metal, and a conveyor to take away the accumulation gathered by the skimmer; and means to blow the spent ore from the surface of the molten metal, comprising a rotating jet pipe above the molten metal surface, means to feed gas under pressure to the jet pipe, and an outlet means from the container above the molten metal level.

15. Apparatus for a process such as herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated, means to introduce ore in finely divided form into the

liquid body, and means to remove spent ore from the liquid surface, comprising a blower having its intake connected to the container above the liquid level, and a jet pipe arranged in the container above the liquid level, connected to the outlet of the blower, and adapted to direct a gas jet downwardly onto the liquid surface.

16. Apparatus for a process such as herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated, means to introduce ore in finely divided form into the liquid body, and means to remove spent ore from the liquid surface, comprising a blower having its intake connected to the container above the liquid level, and a jet pipe arranged in the container above the liquid level, connected to the outlet of the blower, and adapted to direct a gas jet downwardly onto the liquid surface, and a dust collector in the connection between the container and the blower intake.

17. Apparatus for a process of the kind herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated; an ore feed pipe leading down through the center of the container to a point near its bottom, a centrifugal runner located in a horizontal plane at the bottom of the container and fed from the ore feed pipe; an outlet opening in the upper part of the container above the liquid level, and a plurality of gas jet pipes rotatable in a horizontal plane above the liquid level and having jet orifices directed downwardly onto the liquid.

18. Apparatus for a process of the kind herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated; an ore feed pipe leading down through the center of the container to a point near its bottom, a centrifugal runner located in a horizontal plane at the bottom of the container and fed from the ore feed pipe; a revolving skimmer adapted to remove any scum from the surface of the liquid body and to remove with it any ore entrapped and a feeder delivering the accumulation of the skimmer into the central ore feed pipe.

19. Apparatus for a process of the kind herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated; an ore feed pipe leading down through the center of the container to a point near its bottom, a centrifugal runner located in a horizontal plane at the bottom of the container and fed from the ore feed pipe; a revolving skimmer adapted to remove any scum from the surface of the liquid body and to remove with it any ore entrapped therein, and a feeder delivering the accumulation of the skimmer into the central ore

feed pipe; a plurality of jet pipes revoluble in a horizontal plane over the surface of the liquid body, means to feed gas under pressure to the jet pipes, and an outlet from the container above the level of the liquid body.

5 20. Apparatus for a process of the kind herein described, embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated; 10 an ore feed pipe leading down through the center of the container to a point near its bottom, a centrifugal runner located in a horizontal plane at the bottom of the container and fed from the ore feed pipe; a 15 revolving skimmer adapted to remove any scum from the surface of the liquid body and to remove with it any ore entrapped and a feeder delivering the accumulation of the skimmer into the central ore feed pipe and 20 a muller at the lower end of the ore feed pipe.

21. Apparatus for a process of the kind herein described embodying a container adapted to hold a body of metal absorbing 25 liquid heavier than the ore being treated, an ore feed pipe leading down into the container to a point near its bottom; a muller in said feed pipe; means located below the muller and near the bottom of the container 30 to eject ore into the body of liquid; an ore

disturbing and feeding device feeding into the upper end of the ore feed pipe, and means to circulate the liquid from the container into the ore raising and feeding device at a point somewhat removed from its 35 discharge into the ore feed pipe.

22. Apparatus for a process of the kind herein described embodying a container adapted to hold a body of metal absorbing liquid heavier than the ore being treated, 40 an ore feed pipe leading down into the container to a point near its bottom; a muller in said feed pipe; means located below the muller and near the bottom of the container to eject ore into the body of liquid; an ore 45 disturbing and feeding device feeding into the upper end of the ore feed pipe, and means to circulate the liquid from the container into the ore raising and feeding device at a point somewhat removed from its dis- 50 charge into the ore feed pipe; means to skim the surface of the liquid body and to return the skimmed matter into the ore feed pipe; and means to blow spent ore from the surface of the liquid body.

55 In witness that I claim the foregoing I have hereunto subscribed my name this 17th day of May 1923.

HARMON N. TRACY.