Aug. 26, 1930. O. GERLACH 1,773,991

PROCESS OF PURIFYING ZINC ORE

Filed Dec. 31, 1927 4 Sheets-Sheet 1

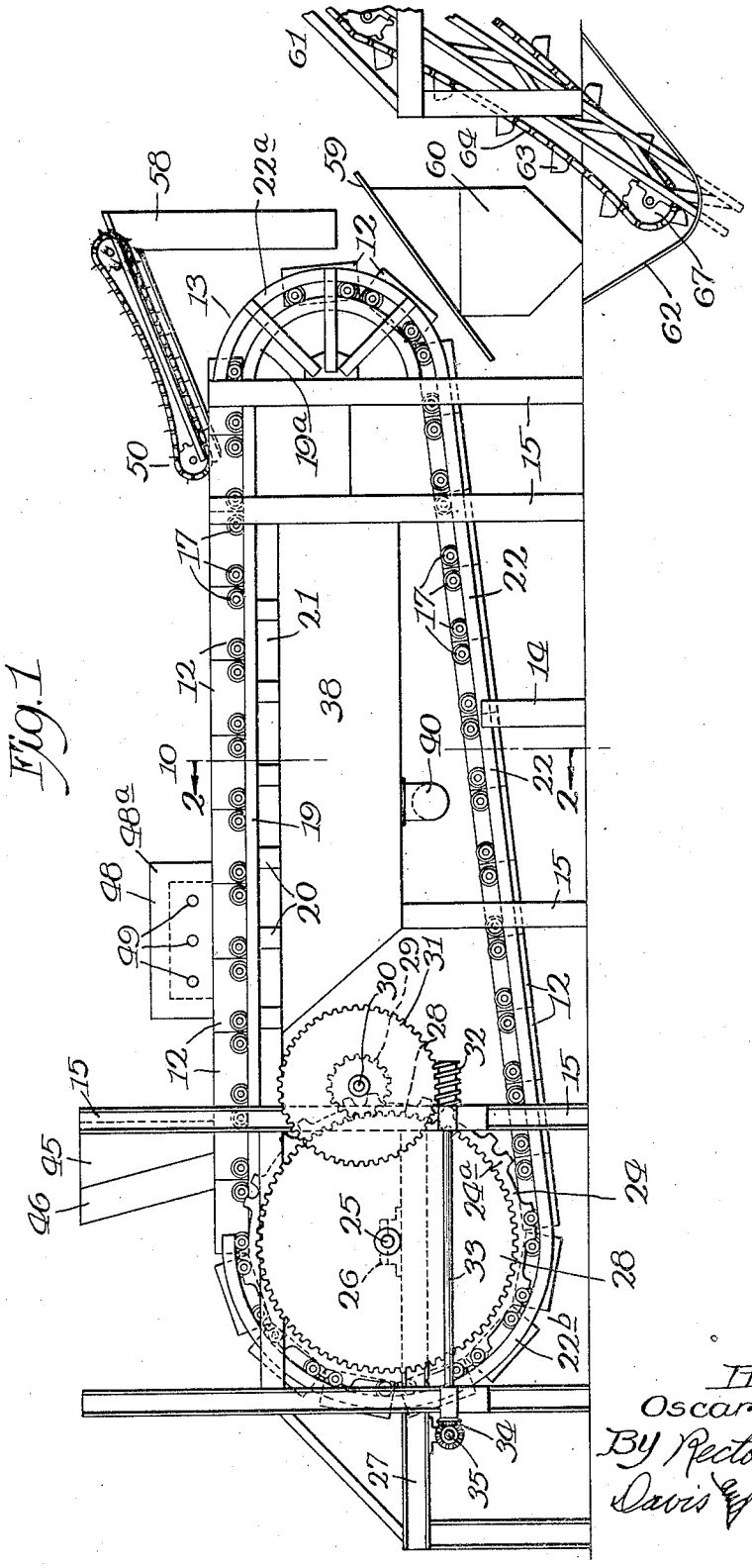


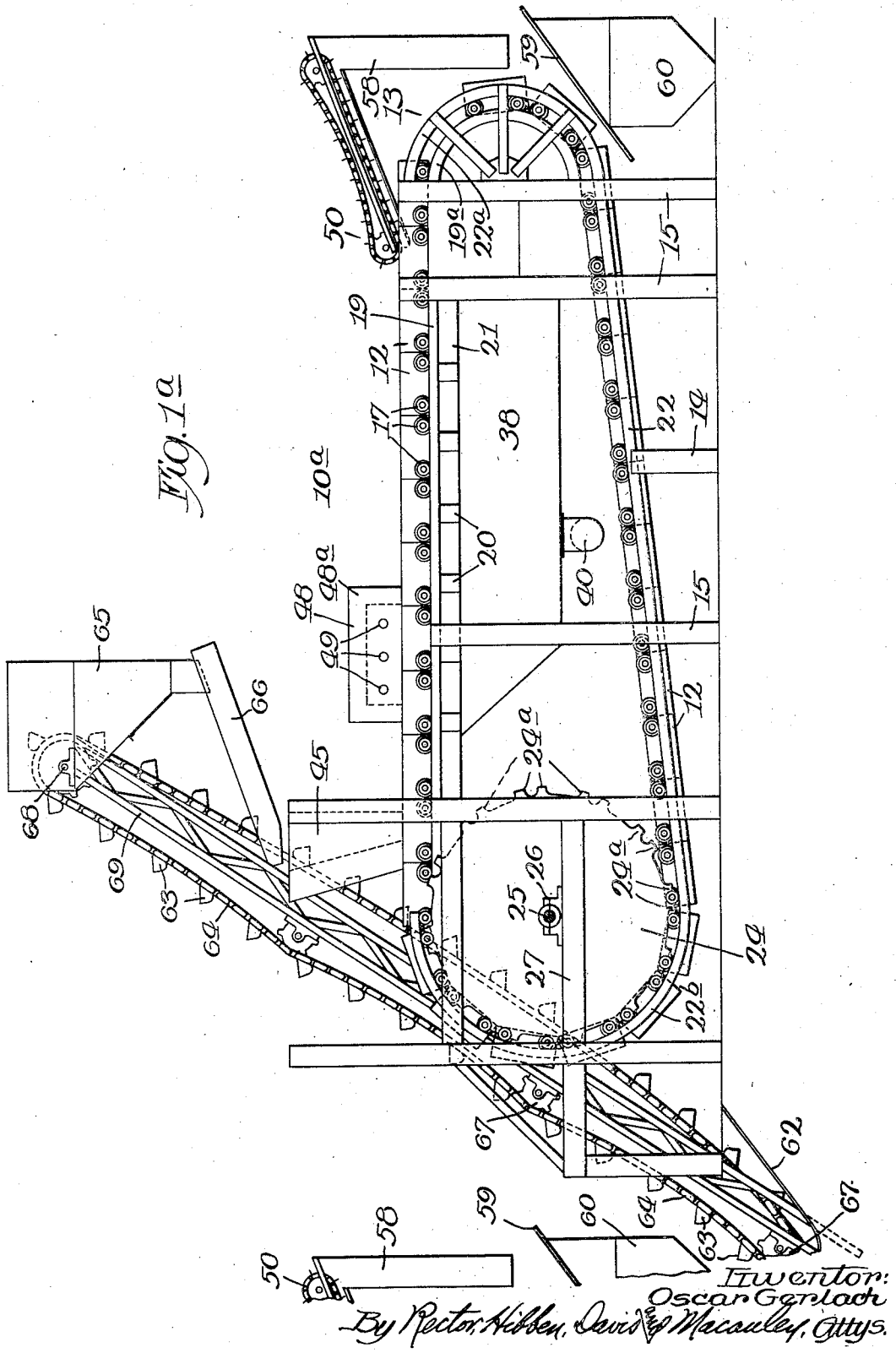
Fig. 1

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Filed Dec. 31, 1927 4 Sheets-Sheet 2

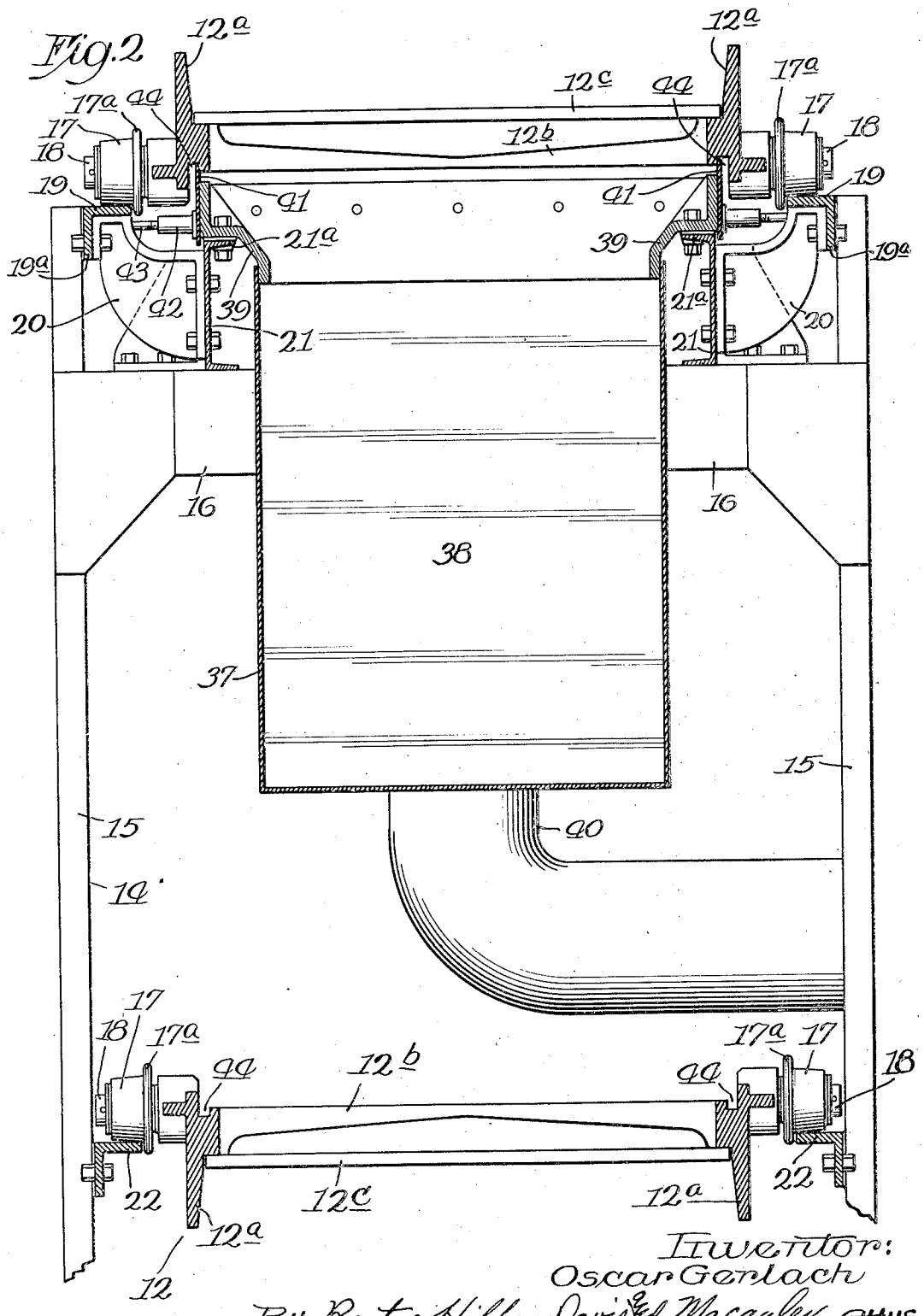


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Filed Dec. 31, 1927 4 Sheets-Sheet 3

Fig. 2



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PROCESS OF PURIFYING ZINC ORE

Filed Dec. 31, 1927 4 Sheets-Sheet 4

Fig 2

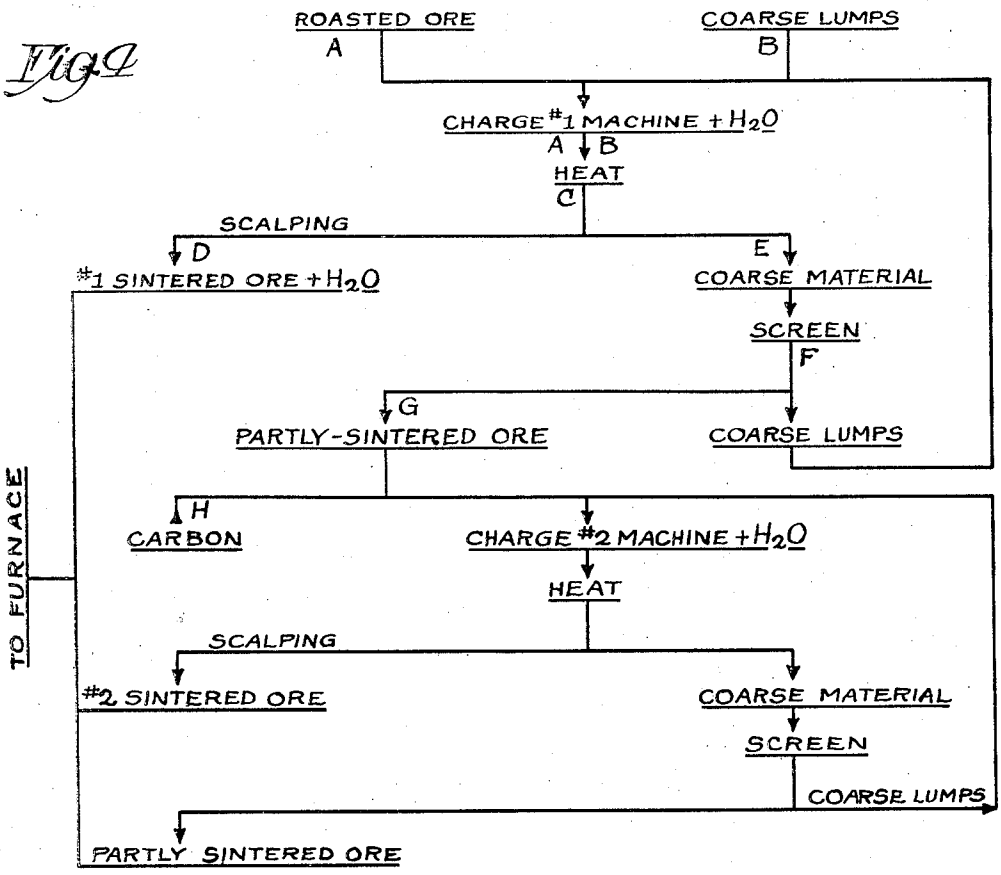
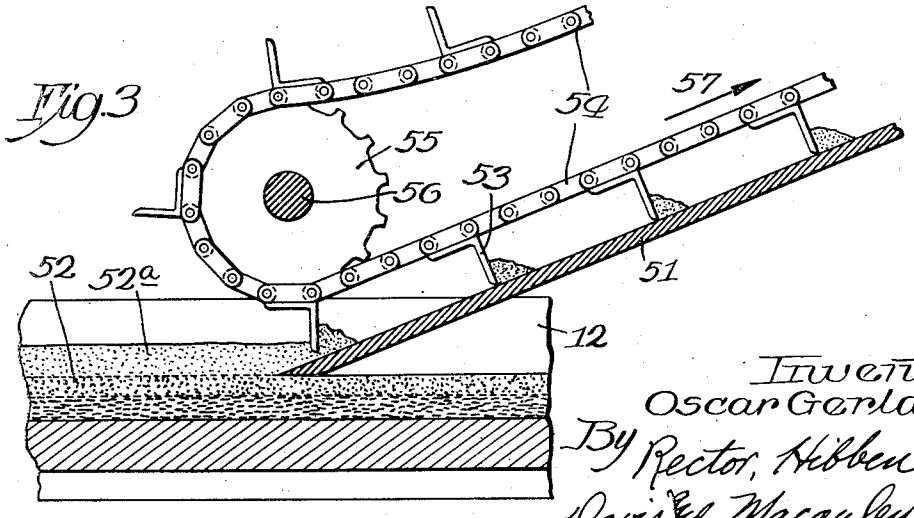


Fig 3



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UNITED STATES PATENT OFFICE

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PROCESS OF PURIFYING ZINC ORE

Application filed December 31, 1927. Serial No. 243,840.

This invention relates to an improved process of purifying zinc and other ores and to the apparatus employed in carrying on said process and its purpose is to provide improved means and an improved method for more efficiently effecting the purification which has heretofore been carried on chiefly by electrolytic means. The principal purpose of the invention is to provide a method for removing from zinc sulfide, carbonate, or other zinc ores the lead and cadmium compounds and other compounds which are frequently present and which ordinarily volatilize readily when the zinc ore is heated. A further object is to provide an improved method of purifying zinc ores by the application of heat. Another object is to provide an improved method of purifying zinc ores according to which the crushed ore is heated in the presence of a reducing agent. Still another object is to provide an improved method of purifying zinc ores by the application of heat in separate heating stages, the residue obtained from the operation of one heating stage being treated in the next heating stage of the process. An important feature of the invention is the discovery that the purification of zinc ores may be effected by a modification of the sintering apparatus which is employed with iron ores and the like. Other objects of the invention relate to various features of the process and apparatus which will appear more fully hereinafter.

Zinc ore most frequently exists in the form of zinc sulphide (ZnS) and in the practice of the present invention this ore is first crushed to a sufficiently fine condition to enable it to pass through a ten mesh screen, that is, a screen having ten divisions to the inch, and the screened ore is then roasted in the usual roasting furnace at a temperature of from 1600 degrees Fahrenheit to 1800 degrees Fahrenheit to remove therefrom the larger portion of the sulphur (about 90%), it having been found in practice that about 27% of the sulphur may be removed without much trouble by this roasting operation. The quantity of sulphur (3% to 5%) left in the ore forms part of the reducing agent needed in a later period of the process. The roasting operation converts the zinc sulphide in the ore to zinc oxide (ZnO) and liberates sulphur dioxide gas (SO_2). This sulphur dioxide gas is ordinarily taken from the roasting furnace and combined with water and oxygen to form sulphuric acid (H_2SO_4).

The zinc oxide which is produced in the roasting furnace is taken therefrom and crushed and screened after which it is put into a sintering machine through a hopper, preferably along with a quantity of previously treated ore which is taken from the discharge of the same or another sintering machine. The crushed and screened ore from the roasting furnace and the coarse materials from the discharge of the sintering machine are thoroughly wetted with water before being introduced into the pans of the sintering machine to facilitate the passage of heat through the crushed material and to aid in the reducing process. The ore which is thus placed in the pans of the sintering machine is conveyed in these pans at a relatively low rate of speed, for example, at the rate of six inches per minute, and the ore is thus brought under a sintering hood equipped with gas burners or other burners for producing a high temperature therein, preferably a temperature between 2600 degrees F. and 2800 degrees F. A number of burners are preferably provided in this hood, the first ones being fed with air and oil or gas to produce an oxidizing flame while the later ones of the series are fed with steam and oil or water gas to form a reducing flame and to cause the production of free hydrogen which is made use of in freeing the zinc ore of the cadmium oxide therein. Preferably, a two inch layer of fine zinc ore

is put on top of a one-half inch layer of coarse ore. The object of putting the coarse ore at the bottom is to prevent the clogging of the openings in the bottoms of the pans.

The flames under the sintering hood penetrate the ore in the pans of the sintering machine to a depth of an inch and a half or more with the result that the upper portions of the ore in the sintering pans are substantially freed of both lead and cadmium compounds. The lead is driven out of the layer of ore penetrated by the flames and collects partly in the ore beneath the same in the form of sulphate (while part escapes as such through the fan and stack to the air), and the cadmium likewise is driven out of the upper layer and collects partly in the lower layer in the form of sulphate and sulphide while part escapes. The zinc oxide in the upper layer is not driven out in the limited time during which the ore is exposed to the flames. It would appear that the lead and cadmium in the upper layer are reduced and then volatilized and recombine in the vaporous state with sulphur and oxygen to form the sulphates and sulphides in the lower layer. Thus, the upper portions of the crushed materials in the pans of the sintering machine are substantially freed of cadmium and lead compounds. According to the present invention, this upper portion of the ore is scraped or otherwise removed from the lower layer of ore in the pans before the pans reach the end of their upper path of travel in the machine. The zinc ore which is thus removed is subsequently distilled with carbon to obtain free zinc.

The materials remaining in the lower parts of the sintering pans are dumped out at the rear end of the sintering machine and are screened, the coarse materials being separated and returned to the inlet end of the machine as referred to above for the protection of the pans and to prevent the clogging of the openings in the bottoms of the pans, while the fine materials are introduced into a hopper along with a quantity of carbon, preferably in the form of finely divided anthracite coal. The mixture discharged from this hopper is then elevated by a conveyor, wetted with water, and fed into another similar sintering machine where the second stage of the process takes place. In this second stage likewise the upper layer of ore is freed from lead and cadmium which are reduced and driven into the lower layer or into the air in which they are found as sulphates and sulphides as in the first stage. If desired, the discharge from the second sintering machine may again be screened, after which the coarse materials are returned to the inlet end of the second machine while the fine materials are mixed with carbon and fed to a third sintering machine. By carrying on the process in a number of successive steps substantially all of the zinc in the ore may be freed of the cadmium and lead compounds and at the same time the sulphur dioxide gas which is liberated in the several machines of the series may be drawn off and made use of in the manufacture of sulphuric acid. The escaping vapors of lead and cadmium sulphates may also be saved (by a Cottrell separator) and made use of.

Although various forms of apparatus might be employed in carrying on the process described above, there is illustrated in the accompanying drawings an improved sintering machine which is adapted for that purpose.

In the drawings, Figure 1 shows a side elevation of the sintering machine;

Fig. 1[a] shows a side elevation of a second sintering machine which is arranged to receive the discharge from the first sintering machine shown in Fig. 1;

Fig. 2 is an enlarged vertical section on the line 2—2 of Fig. 1;

Fig. 3 is an enlarged section through one of the cutting and scraping devices for removing materials from the upper parts of the sintering pans, and

Fig. 4 is a diagram of the "flow" sheet of the improved process carried on by the present invention.

As illustrated in the accompanying drawings, the apparatus comprises two sintering machines 10 and 10[a] which are shown in Figs. 1 and 1[a], respectively, and which are similar in construction so that a description of one will suffice for both. Each sintering machine comprises a plurality of sintering pans 12 which are mounted to follow an endless path of travel and which form a substantially continuous series so that each pan is located closely adjacent to the next leading and following pans of the series, except at the discharge end of the machine where a gap 13 is provided to allow the pans to drop a short distance to facilitate the dumping of the contents thereof. The sintering pans 12 are supported by a frame 14 comprising a plurality of vertical frame members 15 and a number of transverse frame members 16. This frame 14 serves as a support for certain track members which are provided to coact with rollers 17 mounted to revolve on trunnions 18 projecting laterally from opposite sides of the sintering pans 12, there being two rollers 17 at each side of each pan. In the upper horizontal portion of the path of travel of the sintering pans, the rollers 17 coact with horizontal trackways 19 having depending flanges 19[a] which are secured to brackets 20 attached to the longitudinal side frame members 21, as shown in Fig. 2. At their rear ends, the track members 19 are curved downwardly in semicircular fashion as shown at 19[a] and they are arranged to cooperate with upturned semicircular ex-

tremities 22ª of the lower track members 22 which are attached to the vertical frame members 15. The lower track members 22 are inclined downwardly towards the forward end of the machine and are thence curved upwardly in a semicircle, as shown at 22ᵇ, thus guiding the sintering pans in their upward movements at the forward end of the machine. Each roller 17 has an annular flange 17ª which projects over the edge of the adjacent track members 19 and 22 so that lateral displacement of the sintering pans is prevented. The movement of the sintering pans 12 on the trackways 19 and 22 is effected by a pair of driving wheels 24 mounted on a transverse shaft 25 journaled in bearings 26 which are secured to the longitudinal frame members 27 adjacent the forward end of the machine. The driving wheels 24 are provided with teeth 24ª arranged in pairs, the teeth of one pair being spaced apart from those of the next adjacent pair in such a manner that the teeth will engage behind the rollers 17 on the sintering pans 12, as shown in Fig. 1, when the sintering pans have rolled by gravity from the rear end to the forward end of the machine, whereupon the sintering pans are elevated concentrically with the curved portions 22ᵇ of the lower trackway and are thus elevated to the forward end of the upper horizontal trackways 19 where the sintering pans are moved rearwardly by the engagement therewith of the following pans which are continuously elevated by the driving wheels 24. The driving wheels 24 are actuated by a large gear 28 fixed on the shaft 25 and arranged to mesh with a pinion 29 fixed on an auxiliary shaft 30 having bearings carried by vertical frame members 15. The shaft 30 has fixed thereon a worm wheel 31 meshing with a worm 32 attached to the rear end of a longitudinal driving shaft 33. The shaft 33 is connected at its forward end by bevel gears 34 with a transverse shaft 35 which may be driven by an electric motor or other suitable driving means. This driving mechanism serves to actuate the driving wheels 24 in such a manner that the sintering pans have relatively slow travel in a rearward direction on the upper horizontal trackways 19, as heretofore explained. When a sintering pan 12 reaches the rear ends of the horizontal portions of the trackways 19, it falls by gravity through the distance provided by the gap 13, thus discharging the materials contained therein.

The sintering pans 12 are provided with upwardly extending side walls 12ª connected by transverse bars 12ᵇ and the side walls 12ª have ledges on which are mounted the opposite sides of the grates 12ᶜ on which the crushed ore is loaded. The sintering pans are open at their ends so that when they are arranged in close spaced relation on the upper trackways 19, as shown in Fig. 1, they form a continuous trough for the reception of the crushed ore. In the region beneath the sintering pans which are mounted on the upper trackways 19, there is located a casing 37 which forms a vacuum chamber 38, the upper edges of the walls of the casing 37 being connected to a rectangular frame 39 which is seated on and secured to the inturned flanges 21ª of the side frame members and which forms a funnel for directing materials downwardly into the chamber 38. The chamber 38 has a pipe 40 leading from the lower part thereof and connected to a suction pump or other suitable apparatus adapted for maintaining a vacuum in the chamber 38 so that the sulphur dioxide and other gases which are liberated in the ore and not condensed and deposited therein are drawn downwardly into the chamber 38 and thence outwardly through the pipe 40. In order to form a seal between the vacuum chamber and the sintering pans while these pans are in the upper part of their path of travel, a sealing plate 41, of somewhat flexible construction, is mounted along each lateral edge of the frame 39, being held in position by clamping members 42 threadedly engaging studs 43. By adjusting the clamping members 42, the upper edges of the sealing plates 41 may be caused to engage in the desired manner the grooves 44 which are formed in the side members of the sintering pans on the under sides thereof, as shown in Fig. 2, in such a manner that the grooves in successive pans align accurately with each other. A seal is thus formed so that the gases from the sintering pans may be drawn downwardly into the vacuum chamber without actual loss.

The crushed and wetted materials to be treated in the sintering pans are introduced thereto through a feeding hopper 45 secured to upwardly projecting portions of frame members adjacent the forward end of the machine. The relatively coarse materials from the discharge of the sintering machine are fed to the inlet end thereof through an auxiliary hopper 46 which is mounted adjacent the hopper 45. As the sintering pans travel beneath the hoppers 45 and 46 they are filled so that the upper surface of the material therein lies flush with the upper edges of their side walls 12ª and, after being filled, the sintering pans move rearwardly on the trackways 19 and are brought successively into position beneath the sintering hood 48 the walls of which extend downwardly and terminate closely adjacent to the upper surfaces of the sintering pans. The hood 48 is lined with refractory material as shown at 48ª and is provided with a plurality of burners 49 by which the relatively high temperature before referred to is produced within the sintering hood. After emerging from the sintering hood, the pans 12 continue their travel rearwardly over the vacuum chamber 38 until,

adjacent the rear end of the machine, they reach the scraping device 50 by which the upper portion of the crushed material in each sintering pan is removed. Each scraping device 50 comprises a scraping plate 51, the lower edge of which engages in the crushed material 52 within the sintering pans as shown in Fig. 3, being mounted normally in fixed position so that its lower edge divides the material in the pans along a definite horizontal plane. If desired, the plate or chute 51 may be adjustable so that different depths of material may be scraped from the sintering pans. As the pans move rearwardly, the upper portion 52^a of the material in each pan is pushed upwardly onto the upper side of the plate or chute 51 and is conveyed upwardly thereover by means of a plurality of transverse conveying members 53 which are carried by conveying chains 54 mounted on sprocket gears 55. These gears are fixed on shafts 56, one of which is driven so that the chains 54 are actuated in the direction indicated by the arrows 57. It will be understood that the chutes 51 are inclined upwardly and rearwardly and also laterally so that the quantities of zinc oxide ore which are scraped upwardly thereover are eventually deposited from the upper end of the chute 51 into a conduit 58 which is located at one side of the machine and which conveys the zinc oxide ore away for subsequent treatment in separating the metallic zinc.

Each sintering pan, after passing the lower end of the device 50, drops by gravity through the space 13 and thus automatically discharges the remainder of its contents onto a screen 59 located over a hopper 60. The coarse materials which do not pass through the screen are taken from the lower edge of the screen and conveyed by suitable means to the feeding hopper 46 at the inlet end of the first machine while the fine materials which drop into the hopper 60 are mixed therein with a quantity of carbon, preferably in the form of anthracite coal and thoroughly wetted with water, preparatory to treatment in a subsequent sintering machine of the series.

Between each adjacent pair of sintering machines of the apparatus employed, there is located an elevating device 61 for elevating the mixture of discharged material and carbon which drops from the hopper 60 into an open vessel 62 where it is picked up by the buckets 63 of the elevating device 61. The buckets 63 are carried by endless chains 64 and are in upright position when carried by the upper stretches of these chains so that the quantities of materials picked up in the buckets are conveyed upwardly and thence dumped into the hopper 65 at the upper end of the elevating device, as shown particularly in Fig. 1^a. The hopper 65 discharges into a chute 66 which conveys the material to the feeding hopper 45 of the next sintering machine of the series. The chains 64 of the elevating device are mounted to travel on sprocket gears 67 and the sprocket gears at the upper end of the device are mounted on a shaft 68 which is driven from a suitable source of power. Bearings for the shafts on the sprocket wheel 67 are mounted on the side frame members 69 which extend upwardly in an inclined position and which may be supported by the frame 14 of the adjacent sintering machine. By this means a number of sintering machines, similar to those ordinarily employed in the sintering of iron ore, are adapted for the use of the present process by the application thereto of the modified features described above.

Although one example of the improved process of the present invention and one form of apparatus for carrying on that process have been set forth above by way of illustration, it will be understood that the improved process may be practiced in various ways and that various forms of apparatus may be employed without departing from the scope of the appended claims.

I claim:

1. A process of freeing zinc ores from lead and cadmium contained therein which comprises subjecting a portion of a body of the ore to a temperature and atmosphere at which lead and cadmium vaporize while maintaining another portion of the ore at a substantially lower temperature whereby the lead and cadmium are volatilized from the first named portion and condensed in the second named portion, and separating the two portions.

2. A process of freeing zinc ores from lead and cadmium contained therein which comprises subjecting a portion of a body of the ore to a temperature at which lead and cadmium vaporize while maintaining another portion of the ore at a substantially lower temperature whereby the lead and cadmium are volatilized from the first named portion and condensed in the second named portion, separating the two portions, and again subjecting the second named portion to the same process.

3. A process of freeing zinc ores from lead and cadmium contained therein which comprises subjecting a portion of a body of the ore to a temperature at which lead and cadmium vaporize while maintaining another portion of the ore at a substantially lower temperature whereby the lead and cadmium are volatilized from the first named portion and condensed in the second named portion, separating the two portions, mixing the second named portion with fresh material and subjecting it to the same process.

4. A process of freeing zinc ores from lead and cadmium contained therein which comprises subjecting a portion of a body of

the ore to a temperature at which lead and cadmium vaporize while maintaining another portion of the ore at a substantially lower temperature whereby the lead and cadmium are volatilized from the first named portion and condensed in the second named portion, separating the two portions, screening the second named portion and subjecting the coarser materials thereof to the same process.

5. The process of purifying zinc ore which consists in crushing and wetting the ore, heating a portion of the body of ore to vaporize certain ingredients thereof, causing said vaporized ingredients to be condensed in another portion of the same body of ore, and separating the first-mentioned portion of said ore which is thus freed of said ingredients.

6. The process of purifying zinc cre which consists in heating the ore to vaporize certain ingredients thereof, causing the vaporized ingredients to be withdrawn from a portion of said ore, separating said portion of said ore, again heating the remaining portion of said ore to vaporize certain ingredients thereof, causing said last mentioned vaporized ingredients to be withdrawn from a part of said remaining portion of said ore, and separating said part of said ore from which said vaporized ingredients are withdrawn.

7. The process of purifying zinc ore which consists in placing the ore in a conveyor, subjecting the ore to the action of heat while moving in said conveyor to vaporize certain ingredients thereof, subjecting said heated ore to the action of suction and causing the vapors to be condensed in the lower part of the moving body of ore, and continuously removing the upper portion of the moving body of ore which is freed of said vaporized ingredients.

8. The process of purifying zinc ore which consists in placing the ore in a conveyor, subjecting the ore to the action of heat while moving in said conveyor to vaporize certain ingredients thereof, subjecting said heated ore to the action of suction and causing the vapors to be condensed partly in the lower part of the moving body of ore, continuously removing the upper portion of the moving body of ore which is freed of said vaporized ingredients, and extracting the zinc from said last mentioned portion of the ore after it has been removed.

9. The process of purifying zinc ore which consists in placing the ore in a conveyor, subjecting the ore to the action of heat while moving in said conveyor to vaporize certain ingredients thereof, subjecting said heated ore to the action of suction and causing the vapors to be condensed in the lower part of the moving body of ore, continuously removing the upper portion of the moving body of ore which is freed of said vaporized ingredients, discharging the residue of said ore from said conveyor, mixing carbon with said residue, placing said mixture in another conveyor, subjecting said mixture in said last mentioned conveyor to the action of heat to vaporize certain ingredients thereof, then subjecting said mixture to the action of suction and condensing said vapors in the lower portion of the moving ore mixture, separating the upper portion of the ore mixture from which said vapors are withdrawn, and extracting the zinc from said last mentioned separated portion.

10. The process of purifying zinc which consists in crushing and wetting the zinc ore, placing said ore in a conveyor, causing said ore to pass beneath a heating means whereby certain ingredients of the ore are vaporized, then subjecting the ore to the action of suction means located beneath the moving body of ore, thereby causing the vapors to be condensed in the lower portion of the body of ore, then removing the upper layer of the body of ore from which the vaporized ingredients have been withdrawn, and separating the zinc from the upper layer of ore which is so removed.

11. The process of purifying zinc ore which comprises the steps of crushing the ore, highly heating the ore to vaporize certain ingredients thereof while retaining the zinc content of the ore in an unvaporized state, causing said vaporized ingredients to be condensed in a portion only of the body of ore, and then separating the remaining portion of the body of ore containing the zinc content freed of said ingredients.

12. The process of purifying zinc ore which consists in crushing the ore, heating the body of the ore to vaporize certain ingredients thereof while leaving certain other valuable ingredients unvaporized, causing said vaporized ingredients to be condensed in a portion of the same body of ore, and separating the portion of the ore from which the vaporized ingredients have thus been removed.

13. The process of purifying zinc ore which comprises the steps of crushing the ore, highly heating a portion of the body of ore to vaporize certain ingredients thereof while leaving certain other valuable ingredients unvaporized and retaining the remaining portion of the ore at a lower temperature, causing said vaporized ingredients to be condensed in said portion of the same body of ore retained at a lower temperature, and separating the portion of the ore from which the vaporized ingredients have been thus removed.

14. The process of purifying zinc ore which comprises the steps of crushing the ore, heating a portion of the body of the ore while it is in motion to vaporize certain ingredients thereof while leaving the zinc content

of the ore unvaporized and retaining the remaining portion of the body of the ore at a lower temperature, causing said vaporized ingredients to be condensed in said portion of said ore retained at a lower temperature, and then separating the portion of the ore from which the vaporized ingredients have been removed while the body of ore is in motion.

In testimony whereof, I have subscribed my name.

OSCAR GERLACH.