March 7, 1944. C. E. AGNEW 2,343,270

PREPARATION OF RETURN MATERIAL

Filed Aug. 23, 1941 2 Sheets-Sheet 1

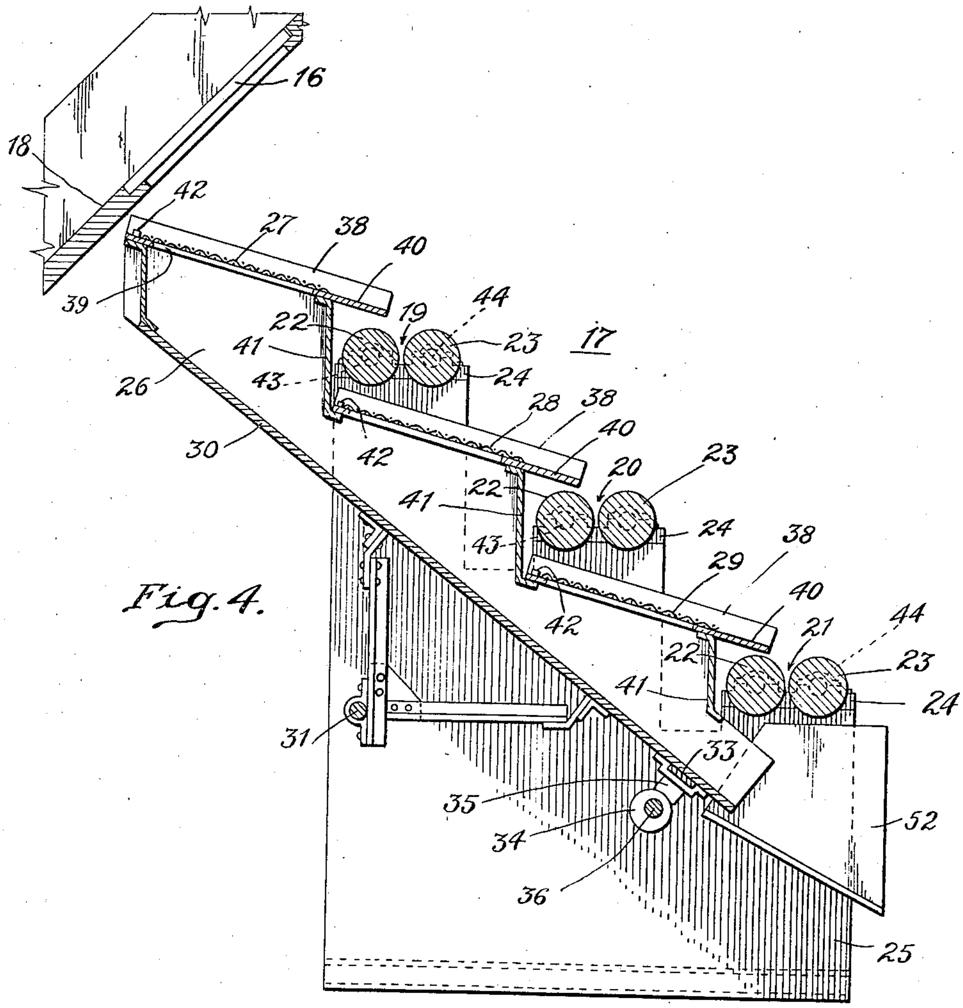

Fig. 4.

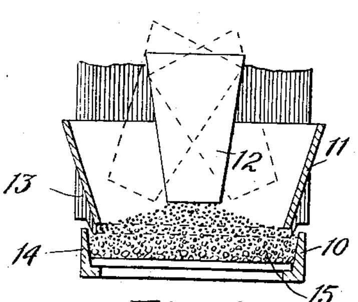

Fig 1.

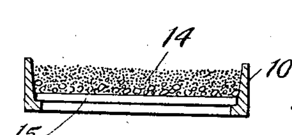

Fig. 2.

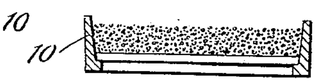

Fig. 3.

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BY [signature]

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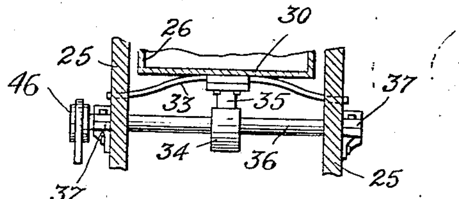

Fig. 6.

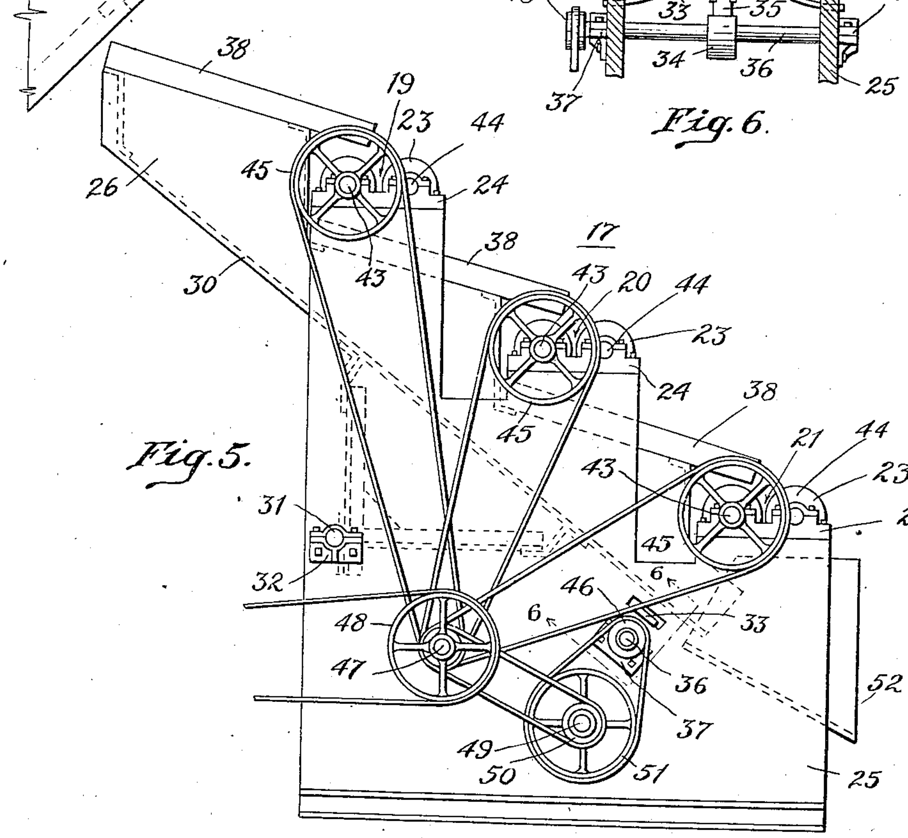

Fig. 5.

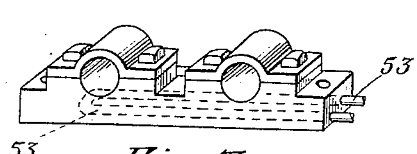

Fig. 7.

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UNITED STATES PATENT OFFICE

2,343,270

PREPARATION OF RETURN MATERIAL

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Application August 23, 1941, Serial No. 408,113

2 Claims. (Cl. 75—5)

In the sintering of ores or other metal bearing material, there is used in general some form of pallet with a grate-bottom for supporting the charge of ore over a wind box in which latter a partial vacuum is maintained to draw air through the charge to support combustion for the sintering.

The resulting sinter cake is discharged from the pallet onto an inclined grating of grizzly bars forming part of a discharge chute which bars serve to break up the cake into briquetts of a size suitable for further processing and by-pass the debris of smaller pieces and fines. This debris is usually returned to and mixed with the raw material, and as so used is referred to as return material.

Most usually the process is a continuous one, known generally as the Dwight-Lloyd process, in which the grate-bar pallets are carried in an endless train around over the opening of the wind box from a point of charge where the mixture to be sintered is fed onto the pallets, to a point of discharge where the sinter cake is dumped from the pallets onto the grizzly bars. There are also intermittent processes in which a stationary pan with a bottom of grate bars is set over a wind box. The pan is charged with material which is ignited and sintered, and the resulting sinter cake dumped from the pan onto a grating of grizzly bars which break up the cake into briquetts, and by-pass smaller size particles and fines to be used as return material. The present invention is applicable to both the continuous and intermittent processes.

Ores or other metal bearing material which require sintering, consist in great part of material of extremely small particle size known as fines which because of their fineness have a tendency to pack and to unduly retard the flow of air drawn through the charge or bed of material on the pallet, with the result that the intensity of the sintering fire is reduced and the sintering rate greatly retarded.

It is common practice to offset this tendency to packing by mixing with the raw material a quantity of the above mentioned return material to open up the mixture to be sintered. However, it is axiomatic in the sintering industry that an increased percentage of return material in the mixture to be sintered does not increase tonnage. This is so with the use of return material as heretofore practiced because while an increase in sintering rate is effected by permitting a more rapid rate of passage of the sintering fire down through the bed of material being sintered, such increase is offset by the fact that the more return material there is used, the more raw or fresh material is displaced, with the result that the net output tonnage is not materially changed.

The main object of the present invention is the provision of a method of and means for beneficiating the return material to increase its efficiency in opening up the charge, whereby to obtain maximum practical benefit from a small percentage of return material and whereby the increase in sintering rate will be greater for a given amount of return material, with improvement in quality of product and increase in tonnage for a sintering machine of given cubical capacity.

This object of the invention is obtained in general by a treatment of the return material resulting in substantial elimination of particles above an optimum size while increasing the proportion of particles of optimum size over that heretofore normally obtained.

In the case of a continuous processing machine of the type above mentioned, even with the use of return material as ordinarily practiced, consisting as it does, in large proportion, of extreme fines and relatively coarse particles, there is still a tendency to pack in the upper layers of the charge due to the fact that the raw material is fed vertically onto the grate bars by gravity from a swinging spout or feed chute, and the fact that in the distribution by gravity of solid materials of mixed particle size, there is a tendency for the coarse and fines to collect in different zones with the fines mostly on top and the coarse mostly at the bottom. Such segregation is more pronounced the greater the difference in particle size.

There is also the disadvantage that the oversize particles necessarily present in large amount in order to afford the use of a large amount of return material, are very much less effective in opening up the mixture than would be the same volume or weight of material of a particle size smaller than such oversize material, but substantially larger than the fine raw material. While no definite theory is advanced for this fact, it is believed that the opening up effect is proportional to the extent of the area over which the particles of the fine raw material can make contact with a coarser particle instead of with other fines, which area is of course greater the smaller the particle size of the relatively coarse return material, for a given volume or weight.

These disadvantages now may be overcome in large measure through the use of return material beneficiated in accordance with my invention wherein the difference in particle size is greatly reduced, with an increase in the proportion of an optimum size substantially coarser than the fine raw material, but sufficiently small to avoid objectionable segregation and to afford a more efficient opening up of the charge on the grate of the sintering machine.

Although the production of sinter is rendered more difficult the finer the predominating particle size of the raw material, it is sometimes necessary to grind the raw material still finer to facilitate elimination of gangue elements such as silica where the latter is present in an undesirable amount. With such finer grinding the tendency to pack is of course increased with consequent loss in economy of production. In such cases the present invention finds great usefulness in its provision of a return material having an increased proportion of particles of a size which is optimum for maximum efficiency in opening up or increasing the porosity of such a finer raw mixture.

Various other objects and advantages of my invention will become apparent as the description proceeds with reference to the accompanying drawings.

In the drawings:

Figure 1 is a diagrammatic transverse sectional view through a sintering machine pallet illustrating a typical method of charging.

Fig. 2 is a diagram illustrating a form of natural segregation of particle sizes.

Figure 3 is a diagram illustrating a substantially uniform distribution of particles of different sizes.

Figure 4 is a vertical, longitudinal section through the center of a preferred form of machine for processing the return material.

Figure 5 is a side elevation of the machine.

Figure 6 is a fragmentary transverse section on the line 6—6 of Figure 5.

Figure 7 is a detailed perspective view of one of the fluid-cooled bearing blocks.

According to the present practice, the grizzly bars are spaced at from one-fourth inch to three-fourths inch, thus permitting the return of material of a size in some cases as large as three-fourths of an inch, together with fines and intermediate sizes. It has been explained above how with this great difference in particle size that exists in the return material as heretofore used, there is a tendency to segregation with consequent accumulation of the coarser material in one zone and the fines in another. In further explanation of this, reference is to be had to Figures 1 and 2. Here is shown in diagrammatic form a typical sintering-machine pallet 10. In Figure 1 the pallet is shown in the charging position under the charging hopper 11 and swinging spout 12, and about to pass under the usual gate plate 13 for leveling the charge 14. Because the grate bars 15 lie in a horizontal plane in the charging position, as is typical of all sintering-plant grate bars, the material must be delivered to them in a vertical stream. Under such condition the material obeys the natural laws governing the flow of loose solids of different particle size which is that the fines on the one hand and the coarser particles on the other, tend to collect in different zones with the fines mostly on top and the coarse mostly on the bottom, intermediate sizes assuming intermediate positions. Also, as the pallets 10 move under the gate plate 13, the feed material heaps up and rolls over ahead of the gate plate, the coarse particles gravitating mostly to the bottom of the pallets coming into the filling position, the fines remaining mostly at the top. These effects are the more pronounced the greater the difference in particle size. The result is that after the pallet is charged and ready for the sintering fire as shown in Figure 2, the coarser material will lie near the bottom of the bed and the fines on top, thus rendering the bed considerably less permeable near the top than near the bottom and largely nullifying the benefits sought to be derived from the usual preliminary pugging of the fine raw material with the return material. Under such conditions it is possible to maintain a fair average permeability of the bed through different vertical sections, but since the sintering fire operates in a horizontal plane passing down through the bed in a substantially horizontal stratum, the desired condition is not simply such an average permeability as shown in Figure 2, but an effective opening up of the charge with substantially uniform permeability or porosity of the bed throughout its depth, or throughout a vertical plane.

To attain this desired condition I depart from the usual practice of using the return material directly as it comes from the grizzly bars by treating the return material to eliminate the presence of substantially all such relatively large particles as tend to settle to the bottom of the charge, and to increase the proportion of particles of that optimum size which is sufficiently large to effectively open up the charge without accumulating mainly at the bottom.

For naturally fine material such as flue dust or for material which has been quite finely ground, for concentration and removal of gangue elements, to a particle size of approximately one tenth of an inch in large proportion, and with a substantial proportion of fines of 100 mesh and finer, this optimum size is in the neighborhood of one eighth of an inch, and may be expanded in range from one sixteenth to slightly over one eighth of an inch. This gives a ratio, between the optimum size of the predominant size of the raw material, of one-eighth inch to one-tenth inch or an optimum particle size of five-fourths of the predominant particle size of the raw material. With return material having an upper limit of substantially this particle size and containing particles of substantially this size in larger proportion than in the usual untreated return material, the charge on the sintering grate ready for ignition will closely approach the desired condition of substantially uniform distribution and substantially uniform permeability throughout as indicated in Figure 3. Because that portion of the return material originally of a size too large for even distribution in the charge has been reduced in particle size to the optimum, the proportion of this latter size has been increased without increase in the total amount of return material and with resultant increase in efficiency. Thus the sintering rate of a given machine may be increased without sufficient increase in the amount of raw material displaced by return material to materially off-set the increased rate, resulting in an increased net output.

The ideal condition to be approached is a production of return material comprised substantially, wholly of particles of a size between one sixteenth and one eighth of an inch but this is unattainable because of the naturally occuring unsintered and other fines in the return material which must be recirculated for economical operation. The greater the percentage of particles of the optimum size range, the more efficient will be the return material, and great improvement in efficiency is attained by reduction of the naturally occuring, ineffective, oversize particles to particles of the optimum size range as herein disclosed.

By way of example illustrative of the relation between the particle-size composition of a raw material and a return material not treated according to my invention, assuming a raw material of a size ranging from that remaining on a 10 mesh screen after passing a one eighth inch screen, to fines of a size passing a 100 mesh screen, and the use of grizzly bars with openings set at three quarters of an inch, a representative screen test would be approximately as indicated in the following table.

	Raw material	Return material
	Per cent	*Per cent*
Retained on .5 inch screen		30.0
Retained on .25 inch screen		20.0
Retained on .125 inch screen		19.0
Retained on screen of 10 mesh	35.0	10.0
Retained on screen of 20 mesh	10.0	9.0
Retained on screen of 40 mesh	10.0	5.0
Retained on screen of 60 mesh	10.0	3.5
Retained on screen of 80 mesh	10.0	1.5
Retained on screen of 100 mesh	10.0	.5
Through screen of 100 mesh	15.0	1.5
	100.0	100.0

From the above table it will be noted that 31 percent of the untreated return material is of substantially the same particle-size composition as the ore to be sintered and therefore of little or no benefit in increasing the permeability of the bed, and that 50 per cent is well above the optimum size of one eighth inch, thus making it possible in accordance with my invention to increase the proportion of material of optimum particle size by substantially the latter large amount while eliminating those oversize particles which have a pronounced tendency to segregation. This nearly fifty percent of the optimum size plus the nineteen percent naturally occurring in the return material as exemplified in the above table makes it possible to obtain nearly sixty-nine percent of the optimum size in the entire body of returns.

This beneficiation of return material may be carried out with various forms of apparatus, a preferred form being that illustrated in Figures 4 to 7. It will be understood that while certain specific dimensions of the apparatus and of the product or parts of the product in its finished or intermediate stages are given for the sake of example, such dimensions may necessarily vary, according to the physical nature of the material to be sintered.

The apparatus comprises in general, two main cooperating portions, the screen of grizzly bars 16 set to break the sinter cake delivered from a sintering machine into large chunks or briquetts and permit the debris to pass down through for use as return material, and the sizing apparatus 17 for reducing the oversize particles of the return material to particles of a predetermined optimum size.

For the sake of affording a definite example not intended as a limitation of the scope of the invention, certain definite dimensions and other characteristics of the apparatus and certain characteristics and changes in character of the material are given for the processing of a typical Eastern magnetite ore which is usually concentrated and after concentration, sintered to give it a particle size and other characteristics suitable for charging into a furnace.

The grizzly bars 16 may be those of any known or other suitable form of continuous sintering machine, which in known manner form a grating in the bottom of a discharge chute 18 onto which the sinter cake falls in its discharge from the sintering machine to be broken up into briquetts suitable for the blast furnace. For the purpose of the present invention the grizzly bars are of such length and so spaced as to by-pass the desired amount of return material of limited maximum particle size. The amount of return material may constitute from 10 to 45 percent by volume of the mixture being sintered according to the nature of such material. In the example chosen, this quantity would be in the neighborhood of 30 per cent by volume of the mixture of raw material and returns fed to the sintering machine, while the spacing of the grizzly bars would be about three quarters of an inch so as to limit the maximum particle size in the return material to about three quarters of an inch. For softer ores such as the Lake hematites, the quantity of return material would be about half this amount. The sizing apparatus 17 is situated to receive the crude return material passing down through the grizzly bars, and comprises a series of roller crushers 19, 20 and 21, each formed of a air of rollers 22—23, journaled in bearing blocks 24 mounted on side frame members 25 of the main supporting frame. The use of crushers of the roller type or jaw type is preferable as being less productive of fines than other types of crushers. A vibrating gang, screen-support 26 mounted between the side frame members 25, carries a series of screen elements 27, 28 and 29, one each above one of the series of roller crushers and positioned to discharge retained material into the crusher next below. The screen support 26 is provided with a bottom wall 30 to serve as a chute to receive the material passing through the screens, and is pivotally mounted between the main side frame members 25 on a shaft 31 journaled in bearing blocks 32 mounted on the side frame members. The screen support 26 is supported near its lower end upon a cross, leaf spring 33 secured at its central portion to the screen support and bearing at its ends upon the side frame members 25 as shown in Figure 6. Vibration or jigging of the several screens is effected by vibrating the gang screen support as a whole, in an oscillatory movement about its pivotal support, motion being imparted to the support by a jigging eccentric or cam 34 through a cam block 35 at the bottom of the screen support, the cam being fast to a driving cam shaft 36 journaled in bearing blocks 37 mounted on the side frame members 25.

Each screen element such as 27 is mounted in an individual screen frame 38 having an opening 39 covered by the screen, and a discharge apron 40 terminating above the space between the rollers of the crusher next below, the frame being mounted on an incline toward the crusher so as to feed material from the top of the apron to the crusher. Vertical partition member 41 extending transversely across the common screen support 26 divide it into stepped vertical chambers or chutes, one for each screen, through which material passing through the screens is conducted down to the common discharge chute formed by the bottom 30 of the screen support. These partition members also serve to support the individual screen frames secured in any suitable manner as by bolts 42, and being rigidly secured to the sides of the screen support 26 as by welding or other suitable joining, serve also as reinforcing cross-members or sheer plates to form a substantially rigid structure.

The crushing rolls 22—23 have bearing in the bearing blocks 24 through shafts 43 and 44. As only one of the rolls of each pair need be driven, the shaft 43 of the roll 22 of each pair is extended through its bearing block at one side of the machine where it carries a driving pulley 45 as shown in Figure 5. Similarly the cam shaft 36 extends through the same side of the machine where it carries a driving pulley 46. These various driving pulleys may be driven in any known or other suitable manner as from a common jack shaft 47 driven through a pulley 48 from a suitable source of power not shown, the driving pulley 46 of the jigging cam preferably being connected through a counter-shaft 49 and intermediate pulleys 50 and 51 for increased speed. A stationary extension chute 52 provides an extension from the lower end of the screen support 26 under the last or lowermost crusher 21 to a point beyond the outer end of the machine for convenient discharge of the processed return material for return to the mixture to be sintered through any known or other suitable means not shown. To prevent over-heating of the crusher bearings by conduction from the crusher rolls, the bearing blocks 24 are arranged to be cooled with water or other coolant as shown more in detail in Figure 7, by the provision of a pipe 53 cast in the bearing block, for conduction of the coolant through the block in heat-interchange relation therewith. The pipe is arranged preferably in the form of a loop although it may as well extend through the block. It will also be understood that in lieu of the pipe a suitable fluid conducting channel may be formed in the block by coring or drilling.

As previously indicated, in the sintering of an ore of the kind here selected by way of example, the grizzly bars 16 are set at about three fourths of an inch apart, thus by-passing particles of a size from extreme fines up to about three fourths of an inch, to be deposited on the uppermost screen element 27. The screens 27, 28 and 29 are chosen with a mesh of approximately one eighth of an inch, while the rolls of the crushers 19, 20 and 21 are set at progressively narrowing gaps of one half, one fourth and one eighth of an inch respectively. Thus in operation, with the driving rolls 22 of the crushers being rotated and the jigging cam 34 rotating at relatively high speed to vibrate the screen frame 26 in oscillatory motion about its pivotal shaft, the crude return material delivered to the uppermost screen 27 is jigged down along the screen, the fines and other particles of a size up to substantially one eighth of an inch passing through the screen into the common chute formed by the bottom and sides of the screen holder while the oversize particles, of over one eighth to three fourths of an inch pass on over the apron 40 into the crusher 19 set at about one half inch, where they are reduced in the main to a slightly smaller size not to exceed one half of an inch with a minimum of fines, and a predominant proportion of relatively coarse particles. The material leaving the crusher 19 falls onto the screen 28 next below where the jigging motion of the screen permits substantially all particles of a size up to substantially one eighth of an inch to pass into the screen holder and causes the oversized particles now of over one eighth and not over one half inch to pass on over the apron 40 of the screen 28 into the crusher 20 set at about one fourth inch where the particles of over one fourth inch are reduced to a size not to exceed one fourth inch with a minimum of fines. Similarly, the material leaving the crusher 20 and falling upon the screen 29 has that portion containing what small additional fines have been produced and all coarser particles up to about one eighth inch by-passed through the screen into the screen holder, while the remaining portion containing all the oversize particles now of over one eighth and not over one fourth inch is moved on over the apron into the last crusher 21. This crusher being set at one eighth inch, reduces the remaining oversize material now not in excess of one fourth inch to smaller particles not in excess of one eighth inch which leaving the crusher 21 fall into the chute 52 from whence it, with the material from the screen holder 26, is discharged as beneficiated return material containing a minimum proportion of fines, substantially no oversize particles, and particles in the neighborhood of one eighth inch, the predetermined optimum size, in larger proportion than that of the crude untreated material by-passed by the grizzly bars.

While I have herein described a specific example of my method and a preferred embodiment of means for carrying out such method, particularly as applied to metal bearing material, it is to be understood that the invention is applicable to the treatment of any material where a process similar to sintering is to be applied, and is not limited to the specific example of method or means above described for the sake of disclosure, but contemplates all such variants and modifications thereof as fall fairly within the scope of the appended claims.

What I claim is:

1. In the art of sintering iron ore of a particle size range from fines of 100 mesh and smaller to a maximum of between one tenth and one eighth inch, with over fifty percent composed of particles less than one tenth of an inch, to form a sinter cake and wherein the sinter cake is broken up on grizzly bars to reduce it to a size suitable for use in a blast furnace and the fines and coarse rubble resulting from the breaking up is screened through the grizzly bars and returned to the mixture forming a charge to be sintered; the improvement which comprises establishing a substantially uniform porosity throughout the depth of the charge by adjusting the grizzly bars to by-pass for use as return material an amount of material of not less than ten percent nor more than 45 percent of the mixture of material being sintered, sizing those particles of the by passed material which are over one-eighth of an inch, down to substantially one-eighth of an inch with a minimum production of additional fines, and mixing the whole of the by-passed material thus treated, with the raw material to form a charge to be sintered.

2. In the sintering of iron ore which has been finely ground for the removal of a gangue element to a particle size of near one-tenth of an inch in large proportion with substantially no particles of over one-tenth of an inch, and a substantial proportion of fines of 100 mesh and finer, and in which the sintered product is broken up into pieces of a particle size suitable for reduction in a blast furnace and screened to bypass the debris of smaller size particles and fines to provide a return material to be mixed with the

raw material to form a charge to be sintered; the improvement which comprises treating the entire body of return material including both said smaller particles and fines by separating therefrom all material of a particle size of approximately one-eighth of an inch and less, sizing down the residue consisting of larger particles to give a predominance of particles of approximately one-eighth of an inch with a minimum of additional smaller particles and fines, and mixing the entire body of return material thus treated, including all the fines and the reduced coarse residue, with the raw material to form the charge, the entire amount of return material being not in excess of 45 percent of the raw material and predominating in a particle size of approximately one-eighth of an inch with none larger, whereby the proportion of particles of approximately one-eighth inch in the entire body of bypassed material is increased to form with the raw material a charge having a high degree of uniformity of porosity throughout a vertical section of the charge and without discarding smaller sizes and fines.

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