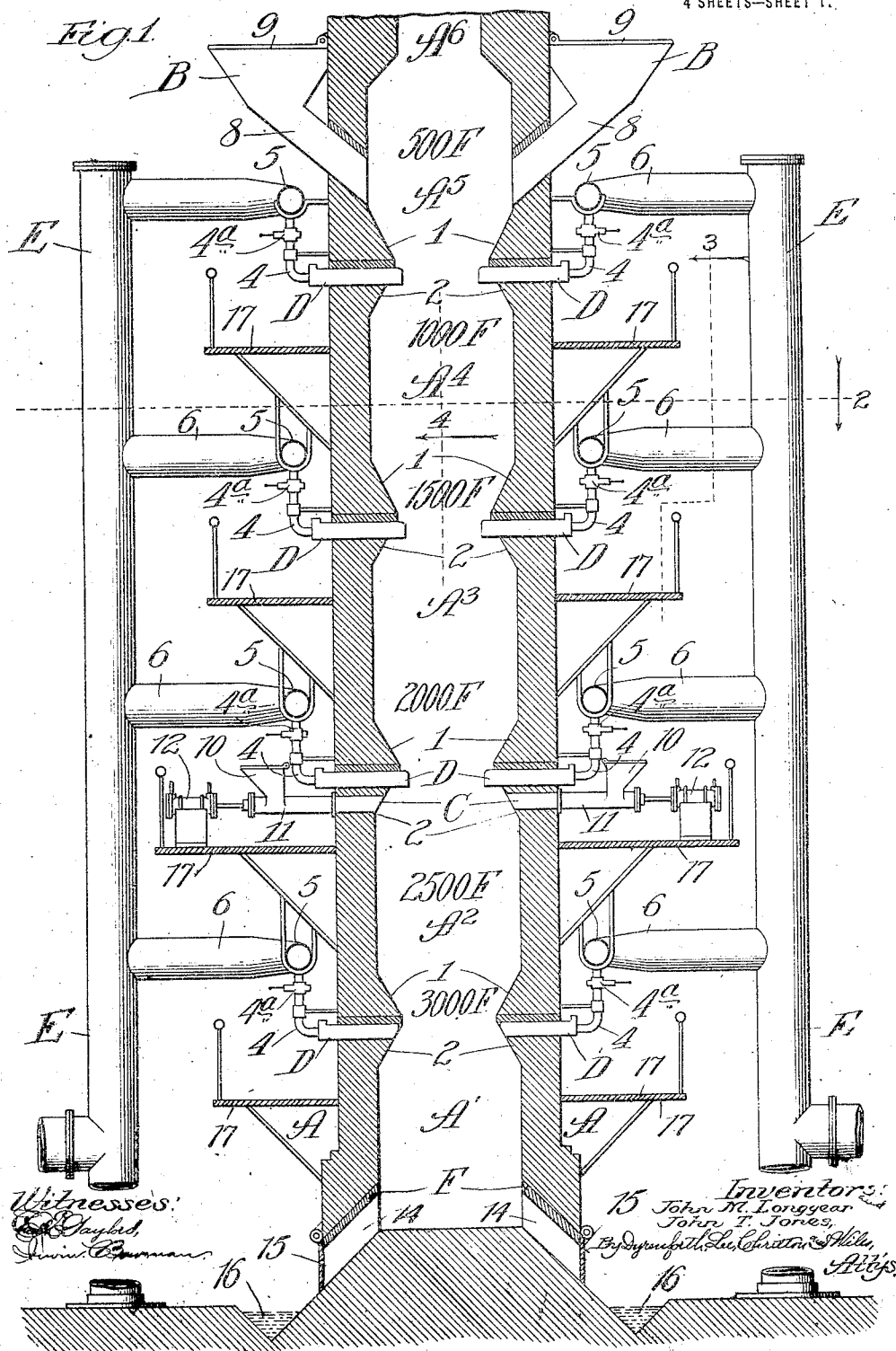


J. M. LONGYEAR & J. T. JONES.
METALLIZING PROCESS AND APPARATUS.
APPLICATION FILED FEB. 23, 1915. RENEWED NOV. 2, 1918.

1,289,834.

Patented Dec. 31, 1918.

4 SHEETS—SHEET 1.



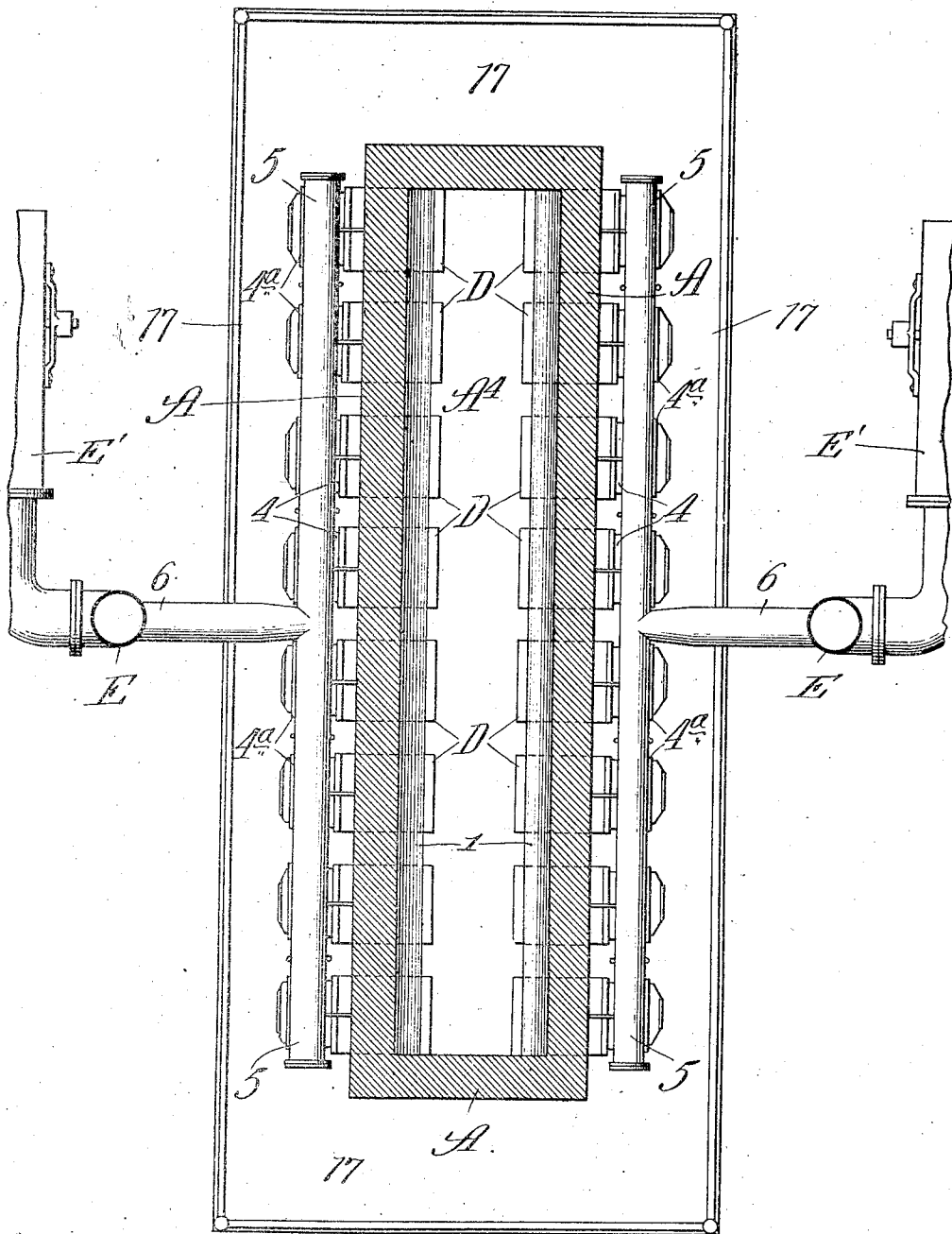
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Fig. 2.



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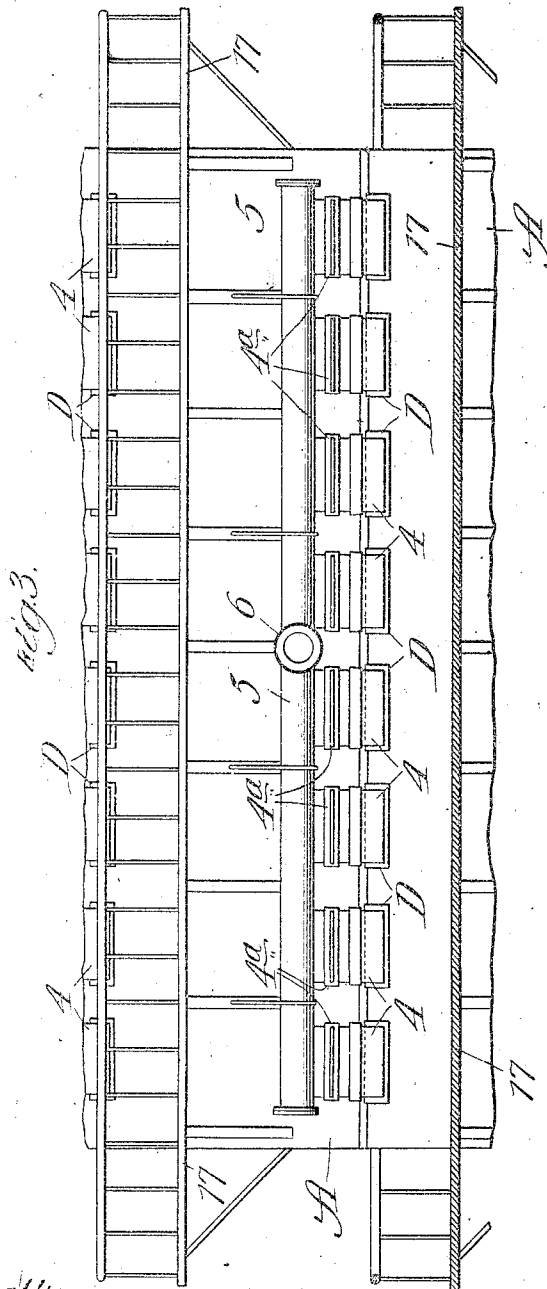
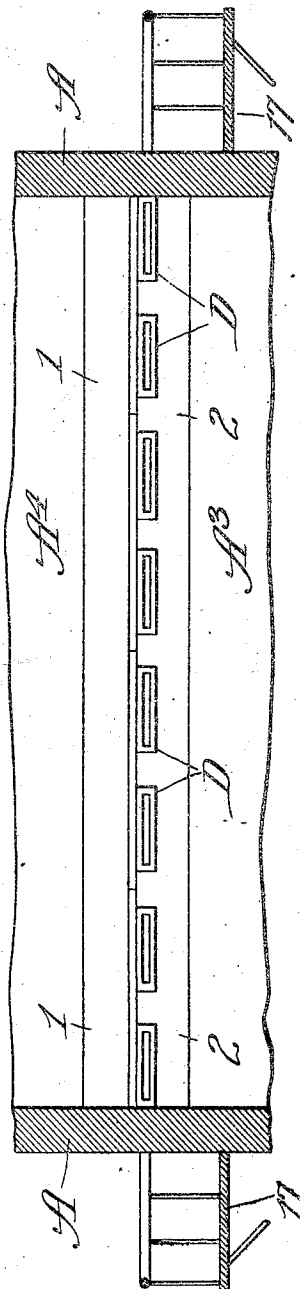


Fig. 2.



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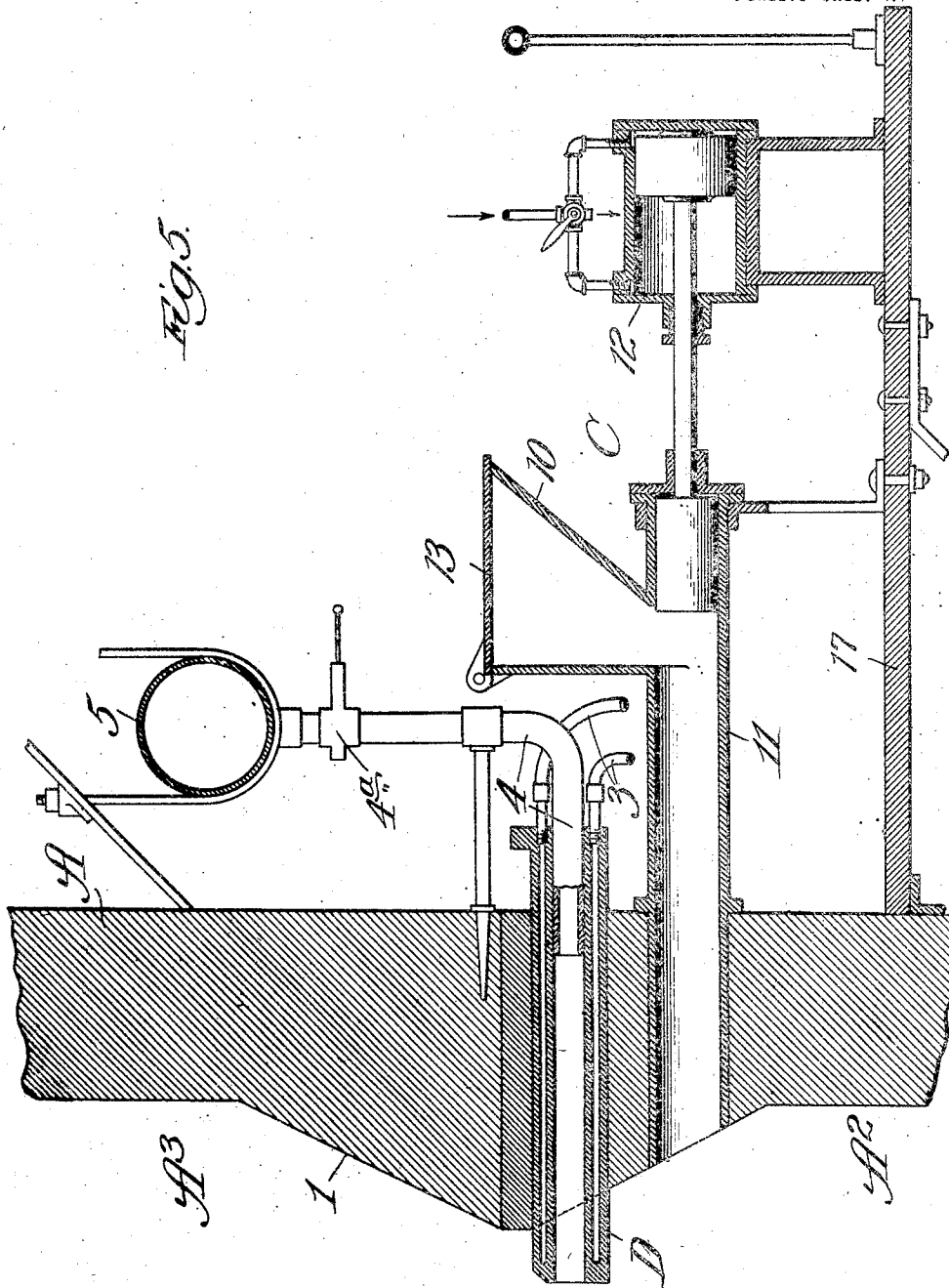
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4 SHEETS—SHEET 4.



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UNITED STATES PATENT OFFICE.

JOHN M. LONGYEAR AND JOHN T. JONES, OF MARQUETTE, MICHIGAN, ASSIGNORS TO
NEW METALS-PROCESS COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLI-
NOIS.

METALLIZING PROCESS AND APPARATUS.

1,289,834.

Specification of Letters Patent.

Patented Dec. 31, 1918.

Application filed February 23, 1915, Serial No. 9,889. Renewed November 2, 1918. Serial No. 260,914.

To all whom it may concern:

Be it known that we, JOHN M. LONGYEAR and JOHN T. JONES, citizens of the United States, residing at Marquette, in the county of Marquette and State of Michigan, have invented a new and useful Metallizing Process and Apparatus, of which the following is a specification.

This invention relates particularly to a bathless process of producing metals from metal oxides and carbonates, such as iron oxide, copper oxide, silver oxide, manganese oxide, lead oxide, zinc oxide, or carbonates of the various metals.

The process herein described constitutes an improvement on the metallizing process set forth in the application of Albert G. Jones, No. 827,358, filed March 26, 1914.

The primary object of the invention is to provide an improved metallizing process which will reduce the cost of the metallizing operation, and to provide an improved furnace of durable character, by means of which the improved process may be advantageously practised.

The improved apparatus will be described, and the improved process will be explained in connection therewith. The preferred construction of the apparatus is illustrated in the accompanying drawings, in which—

Figure 1 represents a broken, vertical, sectional view of metallizing apparatus adapted to the practice of the process herein described; Fig. 2, a horizontal section taken as indicated at line 2 of Fig. 1; Fig. 3, a broken elevational view taken as indicated at line 3 of Fig. 1; Fig. 4, a broken, vertical section taken as indicated at line 4 of Fig. 1; and Fig. 5, an enlarged broken, vertical sectional view showing a detail of a tuyere and of means for charging a relatively small amount of fresh solid fuel directly into the de-oxidizing chamber which constitutes one section of the metallizing furnace or apparatus illustrated.

In the preferred construction of the apparatus which is illustrated, A represents an upright furnace comprising a base-section or soaking-pit A', a superposed de-oxidizing chamber A², pre-heating chambers A³, A⁴ and A⁵ in successively superposed relation above the de-oxidizing chamber, and a chimney or stack A⁶ superposed above the uppermost pre-heating chamber

A⁵; B, B, means for charging a mixture of ore and distilled solid fuel (coke or charcoal) into the uppermost pre-heating chamber; C, C, means for charging fresh solid fuel containing hydrogen and carbonyl hydrates (coal or wood) directly into the de-oxidizing-chamber A²; D, a series of air-tuyers for supplying air to the de-oxidizing chamber and the pre-heating chambers at the several levels indicated; and E, E, a pair of stand-pipes connected with the several tuyers, and which may contain air under small pressure, supplied from a blower or blowers E'.

The furnace A may be of any suitable construction, and of any desired form. In the illustration given, the furnace is of rectangular form, and may conveniently have an internal width of four to eight feet. The de-oxidizing chamber A², particularly, should have its walls adapted to withstand high temperatures.

It is preferred to contract the internal dimensions of the furnace at the junctions of the sections enumerated, in order that the burden or stack of materials contained in the furnace may be supported, or partially supported, in sections, that is, at different levels. In the illustration given, the lateral walls of the furnace are provided with internal shoulders having sloping upper walls 1, and undercut lower walls 2. The sloping walls 1 at each level are preferably of such an angle and of such inward extension as to almost, but not quite, support the burden-section in the chamber for which the sloping walls form a rudimentary bottom or support. The tuyers D extend through the walls, are adjustable, and are preferably disposed in a plane below the sloping walls 1. The tuyers (except the lowermost ones) preferably project within the furnace somewhat beyond the shoulders afforded by the sloping walls 1, and thus serve as a supplemental supporting means whereby (with the shoulders 1) the burden is virtually supported in sections. A further object which is gained by this arrangement is to introduce the air far enough within the burden so that it will be diffused throughout the burden in each chamber or section of the furnace, thus avoiding the possibility of a dead core. The tuyers may be of rectangular form and arranged in horizontal series at the sides of the furnace, at the various

levels. Each twyer may be of the construction shown in d tail in Fig. 5. That is, the twyer may be of box-form and water-cooled, as by means of pipes 3. The twyers, as indicated, are adjustable through the walls of the furnace, and have slip-joint connection with air-pipes 4 which are supplied from feeders 5 arranged at different levels at the sides of the furnace and communicating with the stand-pipes E through pipes 6. The admission of air through the pipes 4 may be controlled by means of valves 4^a.

The means for supplying a mixture of ore and distilled solid fuel (coke or charcoal) to the upper portion of the furnace may be of any desired construction. The means B illustrated comprises a hopper having an inclined spout 8 leading through the furnace-wall and equipped with a lid or cover 9. This may be regarded as a conventional illustration, however, of any suitable means for introducing the charge into the upper portion of the furnace.

Any suitable means may be employed for introducing fresh solid fuel, such as coal or wood, directly into the de-oxidizing chamber. The means C comprises a hopper 10 which supplies a chute 11 in which works a plunger actuated by a piston contained in a cylinder 12. The hopper 10 is fitted with a lid 13. The fuel-introducing device C may be regarded as a conventional illustration of any suitable means for introducing fresh fuel into the de-oxidizing chamber A².

At the bottom of the chamber A' is provided discharge means F, which may be any approved device for removing the metallized ores in solid form, the gangue, and the unconsumed distilled solid fuel. In the form illustrated, the means F comprises discharge-passages 14 guarded by doors 15, through which the materials may be withdrawn or discharged into a water-bath 16.

For convenience in attending the furnace, the walls of the furnace are shown provided at the several levels with platforms 17.

While the dimensions of the chambers of the furnace may vary, within reasonable limits, it is desirable that the several chambers shall be of comparatively low height, the purpose being to avoid undue packing of the burden and any detrimental crushing of the coke or charcoal used. To this end, it is preferred to limit the height of the de-oxidizing chamber and each of the other superposed chambers to about 12 or 15 feet. The chimney A⁶ may be of any desired height. It is preferred to have the chimney of such height that little or no artificial draft or pressure will be required.

In practising the improved process in the furnace described, the ore, if hard, is preferably fed in a crushed condition, say of a size of one inch or less in dimensions, with a charge of coke (or charcoal) through the

hoppers B into the upper end of the furnace, that is, into the uppermost pre-heating chamber.

It is desirable to feed through the furnace distilled solid carbonaceous fuel (coke or charcoal) having many times the bulk or volume of the ore, and preferably having about twice the weight, or more than twice the weight, of the ore. This is particularly true in dealing with high-grade ores. It is also desirable to feed directly into the de-oxidizing chamber A², as through the charging-devices C, a relatively small amount of fresh solid fuel from which hydrogen and carbohydrates may be distilled, such as bituminous coal or wood. Such fuel not only supplies gases of high value in effecting the de-oxidation of the metal oxides, but constantly replenishes the coke or charcoal, as the case may be.

As an illustration, in dealing with a high-grade iron ore, the materials may be used in the proportion of 400 pounds of coke, 100 pounds of bituminous coal, and 250 pounds of ore, the fuel having approximately twice the weight of the ore and being approximately five times as large in volume as the ore. If wood and charcoal be used in place of coke and coal, the disparity in volume is much greater. For illustration, with 2240 pounds of ore one may use 96 cubic feet of charcoal and 32 cubic feet of wood. The proportions may be varied to gain the best and most economical results. In any case, it is preferred to use the fuel mainly in comparatively large lump or block form, although this is not indispensable. Cord or slab wood 16 inches long may be conveniently used, and where coal is used, it is preferably used mainly in large lumps. As will be explained, the coke (or charcoal) is used over and over again, being gradually reduced in size, but being constantly replenished by freshly formed coke (or charcoal) when the process is carried on in the preferred manner.

In the operation of the furnace, the burden or stack of materials, composed of a mixture of fuel and ore, the ore-portions being practically isolated in the fuel, fill the furnace to the level of the discharge-chutes 8 of the charging-devices B, the burden being virtually supported in sections, although capable of gravitating downwardly as the metals in solid form, the unconsumed portions of the solid fuel, and the gangue are removed from the bottom of the furnace. In beginning the operation, solid fuel may be introduced into the furnace and a fire lighted, and the materials in proper proportions may be introduced as the work progresses. When the process is under way, sufficient air is admitted through the lowermost twyers to provide in the lower portion of the de-oxidizing chamber A² a high

metallizing and metal-fixing temperature. Such temperature may be considerably in excess of 2000° F. for iron, but ordinarily about 3000° F., or less, will suffice. Much depends upon the character of the ore. In lean ores, containing some natural flux, it is desirable to avoid too high a temperature. It is preferred to so balance the operation that the temperature will decrease gradually from the bottom of the de-oxidizing chamber A² to the upper pre-heating chamber, somewhat as indicated by the temperature-scale shown on Fig. 1 of the drawings. Accordingly, at the upper levels, air is admitted in limited, and, if necessary, successively reduced quantities, with a view to burning the de-oxidizing gas which passes upwardly through the burden from the de-oxidizing chamber and pre-heating the ore in the pre-heating chambers. It is to be observed, however, that several zones of intensified heat occur at the inner ends of the twyers at the successive levels, each of said zones of intensified heat, however, being of successively reduced intensity as the upper portion of the furnace is approached. In the de-oxidizing chamber A² a very intense zone of heat occurs in the vicinity of the lowermost twyers, carbon-dioxid being produced. This changes to carbon-monoxid at a somewhat higher level in the chamber A², the temperature in the chamber A² being nevertheless of such a high degree of heat as to enable a rapid interchange of oxygen to occur. The carbon-dioxid, coming in contact with the highly heated fuel, changes to carbon-monoxid; and the carbon-monoxid, coming in contact with the highly heated ore, robs the ore of its oxygen, the interchange of oxygen continuing rapidly. It may happen, also, that in the lowermost pre-heating chamber A³, and even in the chamber A⁴, some of the solid fuel may still be of high enough temperature to be attacked by the oxygen entering at the twyers for said chambers, but as the upper portion of the furnace is approached, the attack upon the distilled fuel becomes less and less, owing to the reduction in temperature; and, finally, under ideal conditions, the de-oxidizing gas is alone burned in the upper portion of the furnace, and after complete combustion, the products pass upwardly through the smoke-stack. As has been indicated, the fresh fuel introduced directly into the de-oxidizing chamber A² provides hydrogen-gas and carbo-hydrates which are of great value in reducing the metal oxids, these gases operating under conditions which enable the most rapid interchange of oxygen to occur, as the process of robbing the metal-oxids of their oxygen proceeds. The fresh fuel introduced serves incidentally to replenish the supply of distilled solid fuel.

From the foregoing, it will be under-

stood that as the ore and the distilled solid fuel in which the ore-portions are practically isolated from each other settle downwardly through the pre-heating chambers, the burden in the pre-heating chambers is pre-heated under conditions which will enable much of the ore to be de-oxidized, especially in the lowermost pre-heating chamber A³, as the burden slowly settles therethrough. When the materials reach the de-oxidizing chamber A², they are at such high temperature as to enable a rapid interchange of oxygen to occur, and here the metallizing operation is mainly completed and the metals may be, by the high degree of heat in the lower portion of the de-oxidizing chamber, so fused or softened as to cause the metal particles to run together or agglomerate in globes, or masses of globular lumps; but, owing to the isolation of the ore-clusters or groups from each other and their practical envelopment by pieces, lumps or blocks of solid carbonaceous fuel while this action takes place, no molten bath is formed, and general fusing of the materials is avoided. It may happen that isolated pools of molten metal and isolated pools of molten gangue may form, which will congeal as the materials settle down into the soaking-pit A'. The formation of a general bath is avoided, however, and the contamination of the metals is largely avoided. In dealing with manganese ore, particularly, isolated pools of practically pure metal may form, which will congeal in the form of large smooth lumps.

In the passage of the ore and fuel through the de-oxidizing chamber, myriads of minute metallized particles or globules may adhere to the coke or charcoal, and when the coke or charcoal is again fed through the furnace, these minute particles become fused sufficiently to coalesce, forming globes or globular masses, or masses of globes or globules, thus putting the metal in such tangible form or size as to enable it to be separated or concentrated by any suitable method. The sizes of the metal pieces may vary greatly, but eventually, whether of very fine mesh, or of meshes of very considerable size, say of sizes ranging up to one inch or larger, the metals are nevertheless produced in lumps of such tangible size as to enable them to be readily collected, and with the metal in "set" or "fixed" condition, so that re-oxidizing will not occur. As has been indicated, it may happen, especially with rich iron or manganese ores, that isolated pools of metals will form and will congeal as the materials descend below the hottest zone; and it may happen, where the gangue contains a natural flux, that small isolated fused portions or pools of gangue will form and solidify as the charge slowly descends. In any case, the carbonaceous ore-spacing ma-

materials should be in such abundance and the air-supply should be so regulated as to avoid destroying the spacing function of the fuel. That is, a large preponderance of distilled
5 solid fuel should be carried wholly through the de-oxidizing chamber, and bathing, or general fusing of the charge is to be avoided. As the materials settle down in the soaking-pit A', the temperature decreases; and
10 inasmuch as de-oxidizing conditions are maintained in the chamber A', the de-oxidizing action will continue, especially in the hotter upper portion of the chamber A', so long as there remain any metal oxides into
15 contact with which the de-oxidizing gas can come.

It is noteworthy that because of the great preponderance of solid fuel which has a spacing function, the draft through the burden may be secured with little or no artificial pressure; and because of the fact that
20 the burden is largely supported in sections, the creation of any large crushing pressure upon the burden in the furnace is avoided, so that the air from the twyers and the gases created will pass freely through the burden. Any excessive pressure would result in crushing the coke or charcoal and in so compacting the burden as to seriously interfere with
25 the practice of the bathless metallizing process herein described. On the other hand, in the utilization of the process herein described, it is possible to use coal of inferior coke-producing quality, or wood of inferior charcoal producing quality. For instance,
30 it is possible to use coke that would not withstand the pressure of ordinary blast furnace operations.

By the practice of the improved process,
40 it is possible to produce iron of high purity, possessing about twice the value of pig iron on the market. Moreover, it is entirely feasible to obtain metals by the direct process without the use of fluxes and operating with
45 little or no artificial draft or pressure. Because of the avoidance of the production of a general bath, it is possible to prevent the great contamination of the metals which occurs when all the materials are fused,
50 as in blast practice; and large economies result from the useful application of a very high percentage of the heat units developed in the operation.

In treating iron ore, it is feasible, by the
55 improved process, to produce comparatively large masses of coalesced or agglomerated globes or globules of iron, but without producing a bath and without general fusing of the gangue, the metal being in a highly
60 pure state and capable of being removed from the furnace in solid form.

Manganese may be produced in comparatively large globular masses, as well as in smaller but still thoroughly tangible globules
65 by the same treatment as has been described

for iron ore. Copper may be produced in the same manner, and several metals, such as copper and iron, may be produced by one and the same treatment. In dealing simply with a copper ore, somewhat less fuel
70 need be used, and copper may be produced at a somewhat lower temperature than is the case with iron.

Owing to the fact that zinc and lead volatilize at a temperature of approximately
75 2200° F., they must either be treated separately from the high-fusing metals, such as iron, copper, manganese and silver, or some special provision must be made for collecting and condensing the vapors.

The present process renders it entirely feasible to metallize copper carbonates and copper oxid, for illustration, thus producing metal globules or globes ranging in size from an intangible globule to the size of a pea.
85 In such case, the ore, after subjection to the metallizing process, may be coarse-crushed and subjected to a jiggling operation to remove the large metal globules, after which the ore may be finely ground and subjected
90 to a tabling or concentrating operation; or any other preferred method of recovering the metal from the ore may be employed. It has been found, for illustration, that a copper ore, after subjection to a metallizing
95 process of this character, is amenable to treatment in accordance with the Lovett process described in U. S. Reissue Patent No. 13,517; and that concentration with a high degree of saving can be effected, even
100 where the metals are of exceedingly fine mesh.

In any given case, any suitable method for separating the distilled fuel from the gangue and metals, and for separating the metals
105 from the gangue, may be employed, and the distilled fuel may be fed again through the furnace, mixed with the proper proportion of fresh ore.

It may be added that, if desired, highly
110 refractory blocks or lumps, such as silica boulders, may be used for spacing purposes and passed with the coke or charcoal through the furnace. In such case, both the coke, or other lump fuel, and the boulders, would
115 serve as spacers adapted to practically isolate the ore-groups. In any case, however, it would be necessary to supply sufficient fuel to produce the necessary de-oxidizing gas and such high temperature as would be sufficient to enable a rapid interchange of oxygen to occur and in some cases to effect fusing or partial fusing, and thus to enable the globing or coalescing effect of the metals to take place, care being taken to preserve the
125 spacing function of the refractory pieces throughout and avoid the formation of a bath.

From the foregoing, it will be understood that preferably a limited supply of air is
130

introduced and burned at high temperature within a burden-section of pre-heated distilled solid fuel and ore-portions substantially isolated therein, together with a relatively small amount of solid fuel containing hydrogen and hydro-carbons, the air-supply being limited, however, to provide a de-oxidizing medium which, nevertheless, performs its mission largely at high temperature, or under metal-fixing conditions; that the combustible gases, after having served their de-oxidizing function in the main de-oxidizing chamber, are passed through superposed burden-sections comprising distilled solid fuel and ore-portions substantially isolated therein, and burned by the use of limited, and if necessary, successively-reduced air-supplies introduced into the burden at different levels, the solid fuel being attacked less and less as the upper part of the stack is approached; and that finally the air-supply introduced to the upper portion of the furnace is so limited and burned at such low temperature as to merely unite with the previously-formed combustible gases, without substantially attacking the solid fuel, so that the freshly introduced ore and solid fuel are merely pre-heated and the products of substantially complete combustion pass up the chimney. Thus, the preheating is accomplished by burning the combustible gases produced below within the freshly introduced portion of the burden, thereby securing intimate contact between the burning gases and all portions of the burden, so that the most economical results are obtained.

It should be noted, perhaps, that owing to the thorough pre-heating of the burden, less air will be required in the de-oxidizing chamber A² than might be supposed. In any case, the air is to be regulated to secure the best results.

In practice, the method of feeding materials to the furnace may be varied, according to conditions. If green or wet wood be used for fuel, it may be fed in at a higher level, so that the water will be driven off before the wood reaches a lower and hotter zone. In such case, the wood will be thoroughly dried and somewhat charred during the pre-heating, the volatile hydro-carbons being mainly liberated at a lower level where they can be utilized most effectively. In some cases, it may be desirable to feed all or a large portion of the fuel in at lower level than that at which the ore is fed. Much will depend upon the character of the ore and the solid fuel used. In any event, it will be necessary to maintain sufficient interstitial passages for the air and gases through the burden; and it will be necessary to maintain a large preponderance of solid fuel in the lower, hotter zone.

The foregoing detailed description has

been given for clearness of understanding only, and no unnecessary limitation should be understood therefrom, but the appended claims should be construed as broadly as permissible in view of the prior art. It is our intention to claim all of our invention as it shall appear in view of the prior art, regardless of any variations which may be practised.

What we claim as new and desire to secure by Letters Patent is—

1. The bathless process of recovering metals, which consists in burning air in limited regulated quantities at a plurality of levels in a stack of superposed burden-sections comprising solid fuel and ore-portions substantially isolated therein, without producing a bath, regulating the combustion in such manner as to produce generally a de-oxidizing medium throughout the lower portion of said stack and to provide a high-temperature metal-fixing zone near the bottom of said stack, and to pre-heat, without substantially attacking, the solid fuel in the upper portion of said stack.

2. The bathless process of recovering metals, which consists in passing through a sectionally-supported burden comprising solid fuel undergoing combustion and ore-portions substantially isolated therein, said burden arranged in a stack of superposed sections, air introduced at a plurality of levels and regulated to produce a high de-oxidizing and metal-fixing zone near the lower end of the stack, and to attack the solid fuel in successively reduced degree as the upper end of the stack is approached.

3. The bathless process of recovering metals, which consists in passing through a sectionally supported burden of distilled solid fuel undergoing combustion, and ore-portions substantially isolated therein, air so regulated as to produce in one zone in said stack a temperature exceeding 2000° F. and in another zone de-oxidizing gases, thereby effecting metallization and fixing of the metals without producing a bath; then passing the de-oxidizing gases through superposed sections of such a burden and supplying air to burn the de-oxidizing gases therein under such conditions as to substantially preserve the solid fuel in the upper portion of the burden.

4. The bathless process of recovering metals, which consists in passing through a burden-section of distilled solid fuel undergoing combustion, and ore-portions substantially isolated therein, air so regulated as to produce in one zone in the stack a temperature exceeding 2000° F. and in another zone de-oxidizing gases, thereby effecting metallization and fixing of the metals without producing a bath; then passing the de-oxidizing gases through superposed sections of such a burden and introducing limited

supplies of air at a plurality of levels into said superposed sections of said burden to burn the de-oxidizing gases therein at successively reduced temperatures as the upper
5 end of the stack or burden is approached.

5. The bathless process of recovering metals, which consists in burning air in limited, but relatively large, quantity, in a lower section of a stack of superposed burden-sections, comprising solid fuel and ore-
10 portions substantially isolated therein, without producing a bath, introducing a relatively small amount of fresh solid fuel into the lower section, so regulating the combustion in the lower section as to produce a
15 high-temperature de-oxidizing medium, and a metal-fixing zone; and introducing and burning air in limited regulated quantities at different levels within the superposed burden-sections, and so regulating the
20 combustion as to attack the solid fuel less and less as the upper end of the stack is approached.

6. The bathless process of recovering
25 metals, which consists in giving substantial independent support to a series of superposed burden-sections composed of solid fuel and ore-portions substantially isolated therein, so as to prevent compacting of the
30 stack of materials and crushing of the fuel, while permitting the stack, as a whole, to settle slowly as materials are withdrawn from the bottom of the stack; burning a limited amount of air in a lower burden-
35 section and producing therein a high-temperature de-oxidizing medium and a metal-fixing zone; and introducing and burning at different levels within the superposed burden-sections limited air-supplies, so regulated that the solid fuel will be substantially
40 preserved at the upper portion of the stack and the combustible gases produced below will be burned in intimate contact with the solid fuel and ore in that zone.

7. The bathless process of recovering
45 metals, which consists in confining a stack comprising superposed burden-sections composed of solid fuel and ore-portions substantially isolated therein, between walls
50 which serve to contract the stack of materials at a plurality of levels and thus provide independent support for the burden-sections, introducing and burning a limited air-supply within a lower burden-section to
55 produce therein a high-temperature de-oxidizing medium and a metal-fixing zone, and introducing and burning within the burden-sections at a plurality of higher levels limited air-supplies, regulated to avoid attacking the solid fuel at the upper portion of the
60 stack, while burning in contact with the ore and fuel at that point the combustible gases produced below and passing to such point.

8. An ore-reducing furnace comprising a
65 plurality of superposed chambers having

means at their junction-planes adapted to afford supports for a plurality of superposed burden-sections but permitting continuous settling of the burden therethrough; and means for introducing such limited air-
70 supplies into the burden-sections at a plurality of levels in said furnace as to produce a general de-oxidizing medium in the furnace.

9. The bathless process of recovering
75 metals, which consists in burning a limited air supply in a lower burden-section comprising a mixture of ore and excess solid fuel, passing the de-oxidizing gases through superposed burden-sections containing ore,
80 and introducing and burning air therewith at a higher level in the stack, the operation being carried on without producing a bath.

10. An ore-reducing furnace comprising
85 a plurality of superposed chambers with contracted internal areas at their junction-points adapted to afford independent support to a plurality of superposed burden-sections contained in the furnace, supplemental burden-supporting means at the
90 junction-points, and means for supplying air in limited quantities to the furnace at a plurality of levels.

11. A furnace comprising a plurality of
95 superposed chambers with contracted internal areas at their junction-planes adapted to afford supports for burden-sections contained within the furnace, adjustable supplemental burden-supporting means at said
100 junction-planes, and means for supplying air to the burden-sections in limited quantities at a plurality of levels.

12. An ore-reducing furnace comprising
105 a plurality of superposed chambers with contracted internal areas at their junction-planes adapted to afford support to burden-sections contained in the furnace, adjustable twyers extending through the walls of the furnace at or near the junction-planes
110 and adapted to afford supplemental support to the burden-sections, and means for regulating the introduction of air to said twyers.

13. An ore-reducing furnace comprising
115 a plurality of superposed sections with sloping internal walls at the junction-planes adapted to afford support for a series of superposed burden-sections within the furnace, and means for supplying air at different levels, having associated therewith adjustable supplemental supporting means for
120 the burden-sections.

14. An ore-reducing furnace comprising
125 a plurality of superposed sections with sloping internal walls at the junction-planes adapted to afford support for a series of superposed burden-sections within the furnace, adjustable twyers extending through the furnace-walls and associated with the sloping portions of the walls, and means for regulating
130 the supply of air to said twyers.

15. An ore-reducing furnace comprising a lower de-oxidizing chamber and a series of superposed pre-heating chambers, means at the junctions of the chambers for affording support to a series of superposed burden-sections contained in said chambers, said means permitting continuous feed past them of the materials of the burden-sections, means for supplying a limited amount of air to the de-oxidizing chamber, and means for supplying air in limited quantities at different levels to the pre-heating chambers.

16. An ore-reducing furnace comprising a plurality of superposed sections, means at the junctions of said sections for affording support to superposed burden-sections contained in the furnace, means for introducing fresh solid fuel into a lower section, means for introducing distilled solid fuel and ore into the upper section, means for supplying air in limited quantities at a plurality of levels, and means for removing unconsumed fuel, gangue and metals in solid form from the lower portion of the furnace.

17. An ore-reducing furnace comprising a soaking-pit provided at its base with means for removing unconsumed fuel, gangue and metal in solid form, a superposed de-oxidizing chamber, a plurality of superposed pre-heating chambers, means for introducing ore and fuel into the upper portion of the furnace, and means for supplying air in regulable quantities at a plurality of levels.

18. An ore-reducing furnace comprising a soaking-chamber provided at its base with means for removing unconsumed fuel, gangue and metal in solid form, a superposed de-oxidizing chamber, twyers at the junction of said chambers, a plurality of superposed pre-heating chambers, twyers at a series of levels adapted to supply air in regulable quantities to the pre-heating chambers, means for supplying fresh solid fuel to the de-oxidizing chamber, and means for supplying distilled solid fuel and ore to the upper pre-heating chamber.

19. An ore-reducing furnace comprising a de-oxidizing chamber and a series of superposed pre-heating chambers, supporting means at the junctures of said chambers af-

fording independent supports for the burden-sections and permitting continuous passage of the materials of the burden-sections, twyers for supplying air in limited quantities at a plurality of levels to the de-oxidizing chamber and the pre-heating chambers, means for supplying ore and fuel to the upper portion of the furnace, and means for supplying air under pressure to the twyers.

20. An ore-reducing furnace for the purpose set forth, comprising a de-oxidizing chamber of substantially rectangular form and relatively narrow width, a series of superposed pre-heating chambers of similar form, means at the junctions of said chambers for affording independent support to a series of superposed burden-sections contained in the furnace, and means for introducing into the burden-sections at a plurality of levels limited air-supplies.

21. An ore-reducing furnace comprising substantially parallel side walls and end walls, said side walls having internal projections dividing the furnace into a main de-oxidizing chamber and a series of superposed pre-heating chambers, a plurality of series of twyers extending through the side walls of the furnace at a plurality of levels and associated with the inward projections of the side walls, and means for supplying air in limited quantities to the several series of twyers.

22. An ore-reducing furnace comprising a pair of side walls spaced a comparatively short distance apart and provided with internal projections dividing the furnace into a main de-oxidizing chamber, and a series of superposed pre-heating chambers, end walls for the furnace, a plurality of series of adjustable twyers extending through the side walls of the furnace at a plurality of levels and associated with said inward projections of the furnace walls, and means for supplying air in regulable quantities to the several series of twyers.

JOHN M. LONGYEAR.
JOHN T. JONES.

In the presence of—
ALBERT G. JONES,
E. W. JONES.