

A. V. M. KROLL.
 PROCESS OF AGGLOMERATING FINELY DIVIDED GRANULAR OR FRIABLE MATERIALS.
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Fig. 1.

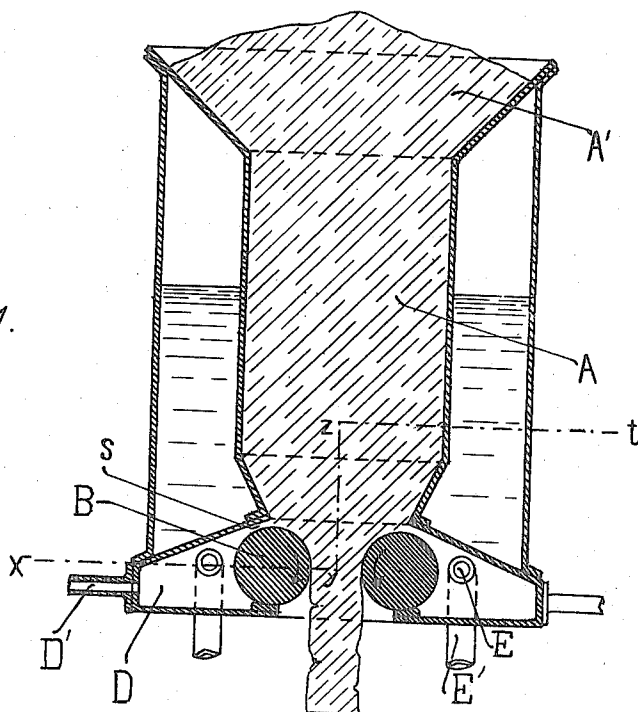
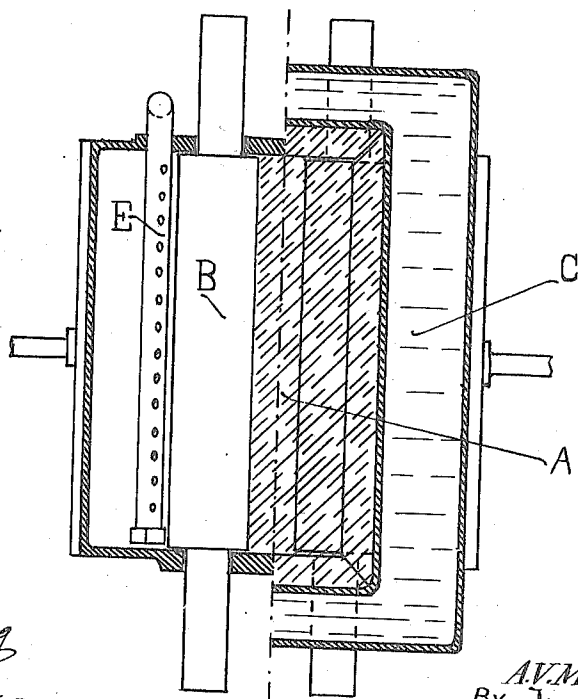


Fig. 2.



Witnesses:
 John H. Hoving
 Frank H. Logan

INVENTOR:
 A. V. M. Kroll
 By *Wm. S. Deane*
 ATTORNEY

UNITED STATES PATENT OFFICE.

ADOLPHE VICTOR MARIE KROLL, OF LUXEMBURG.

PROCESS OF AGGLOMERATING FINELY-DIVIDED GRANULAR OR FRIABLE MATERIALS.

1,196,705.

Specification of Letters Patent.

Patented Aug. 29, 1916.

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To all whom it may concern:

Be it known that I, ADOLPHE VICTOR MARIE KROLL, a subject of the Grand Duchess of Luxemburg, and residing at Luxemburg, (Grand Duchy,) have invented certain new and useful Improvements in Processes of Agglomerating Finely-Divided Granular or Friable Materials, of which the following is a specification.

My present process based upon numerous practical experiments permits of realizing in a simple and perfect way unknown heretofore, the agglomeration of finely divided ores of any kind, and particularly flue dust, residues of pyrites or washing operations or any other origin, and in a general way the agglomeration of metals, oxids or other compounds such as phosphates, or even the manufacture of cement or fritted magnesia, provided that the initial materials are granular or non-sufficiently compact before the treatment.

In order to enable the novel feature of the invention and its unusual efficiency to be easily and perfectly understood, I will first proceed to give some scientific explanations.

Broadly stated the new process consists in its purest form, in introducing by suction or pressure air and a combustible gas into the interior of the granular or porous mass to be agglomerated. These gases will be mixed and lighted within the incandescent mass and perfectly burnt without finding free spaces to produce flames proper. Therefore and assuming the case of the perfect process, the gaseous mixture which is introduced into the interstices of the mass, is in an explosive state, while the gaseous mixture which is discharged from the mass, is completely burnt, the combustion taking place without flame in the interior of the powdery mass. If this process is carried out exactly or at least partially, particularly favorable agglomerating effects will be produced, whether a complete fusion or a simple sintering of the mass is produced, or whether the coherence or compactness is produced by any suitable manipulation of the glowing mass.

The favorable effect is first due to the fact that a freely developed flame is avoided, which wastes its energy over a long space instead of disengaging its calorics where they are wanted, that is, in the interior of the mass within the interstices and porosities between the particles. In fact in my

new process the flame is forced back into the interior and produced merely within the pores of the mass. However the possibility of the combustion in the interior of a powdery mass was unknown heretofore and mineral dust such as fine sand, is even used as a very efficacious extinguisher of flames of burning gases, especially in the coal-mines, where the sprinkling-holes containing the cartouches of dynamite are covered with a large layer of sand to extinguish the burning gases escaping through the cartouche-holes at the moment of the discharge. A cold mineral dust or sand has therefore the property of extinguishing any combustion of gases in its interior, but on the contrary the same dust or sand previously heated to a red-hot state, favors the combustion of gases within its pores. The best theoretic explanation for that remarkable difference between the behavior of the cold and the previously heated mineral dust, is probably the hypothesis of an effect of contact exerted by the hot dust upon the combustible mixture of gases. In that case the combustion is entertained through the contact with the heated mass and not through the development of a free flame. Such a contact combustion in hot dust is necessarily most active and may be compared to the following phenomena: Humphrey Davy discovered 100 years ago the phenomenon which he called "the flameless combustion" of gases. In order to produce this phenomenon, all that is necessary is to expose a mixture formed of air and combustible gas to the action of certain contact masses, formed preferably of porous incandescent bodies. Moreover it is well-known that in ordinary metallurgical furnaces the combustion of gases becomes more active where it meets with projecting parts of the brick-work or hot walls. Davy's contact masses produce the remarkable effect of facilitating and especially accelerating the chemical reaction of the combustion of gases, so that the flame, which is as much longer as the combustion is slower and vice versa, is completely avoided. Therefore this is the reverse of the principle suggested by Siemens of the freely produced long flame, which principle was alone consciously applied to the construction of metallurgical furnaces of any kind. However the acceleration of the combustion by the effect of contact masses is of absolutely positive technical importance,

as it enables more concentrated thermic actions to be produced, with the result, that not only a better produce of the combustion is obtained, but also that the temperature of the combustion is much higher, upon which
5 fact the attention of the industry was especially drawn heretofore. Very recently Davy's discovery has been taken up again and thoroughly studied by Professor Bone,
10 who discovered what he called, "flameless incandescent surface combustion," which he carried into practical effect by inventing heating plates and crucible furnaces. In these apparatuses he utilizes the very intense
15 radiation of the surface of a contact mass, as refractory or fireproof as possible and preferably formed of hazelnut-shaped fragments, (English Patents: 29430 of 1909; 4362
20 and 4364 of 1910; 27524 of 1910), or a pervious plate of ordinary terra cotta one surface of which is only slightly heated (English Patents: 25808 of 1909; 10149 and 10150 of
25 1910). In these patent specifications are disclosed the principles of combustion described in the English Patent 18388 of 1903 to Justice. But Professor Bone succeeded in concentrating the reaction of combustion in
such a way that the temperature in the small crucible furnace was raised to 2000° C.,
30 without making use of hot air.

Instead of using a special contact mass formed of highly refractory hazelnut-shaped fragments, I cause the ore-dust to operate itself as a contact-mass, although it is easily
35 fusible and generally of extremely fine grain, which prevents the gases from being moved at a velocity comparable to the other, so that it was believed heretofore that any kind of gaseous combustion would be immediately
40 extinguished by dust. Therefore the chemical reaction of the combustion takes place in a still more limited space, but the particularly practical effect resides in the fact that the calorics are immediately consumed by
45 the mass within which they are produced, for the purpose of soldering the particles together. Therefore these calorics do not serve an external purpose as in Bone's devices, wherein the strong radiation of heating
50 plates acts on the surrounding space, or wherein through the agency of incandescent refractory fragments, either water of a tubular boiler or a crucible containing the material to be treated (and which is therefore
55 heated in third instance), is secondarily heated. The different method of using the flameless combustion results in the necessity of renewing the contact mass at each operation in my agglomerating process, because
60 said contact-mass, instead of being fireproof, will be softened, sintered or even completely melted, which is the result to be attained by my new process.

Practical experiments proved that iron
65 oxid already used by Davy is an excellent

contact mass, and for this reason it has been utilized in numerous chemical processes; my experiments proved moreover and particularly that ordinary residues of ores and flue dust have this quality in spite of the impurities contained therein. The combustible gas
70 introduced into the incandescent mass together with air, will be burnt within this mass and produces such a concentrated and intense heat that any fine ore, dust or other
75 material will be baked or sintered or even completely melted, although the complete fusion will be preferably effected in a furnace which is specially arranged or combined for this purpose. Owing to the intense heat
80 of the combustion, the new process brings the materials easily to the point of fusion, while other processes of agglomerating materials require to this end complicated furnaces and large quantities of fuel and handi-
85 work especially if dust of low specific weight is to be treated. As fine ores are generally easily fusible, the high temperature produced by the combustion may be raised beyond the point of softening of said ores,
90 which point is still attained in powders which are usually fireproof, such as fine dolomite and magnesia. In any case my process requires less gas than any other process, whether high or low temperatures are to be
95 produced, and owing to the utmost intensity of the internal flameless combustion I preferably use poor gases, the combustion zone of which is longer. These gases may be easily
100 produced by gasifying waste coke, residues of coal-washing, lignite, turf and other inexpensive fuel, but especially by collecting the gases from furnace-tops, particularly blast-furnaces, which gases need not be purified. On the other hand if it is desired to push on
105 the combustion or accelerate the process for economical purpose, rich gases, hot air or any other well known active and economical means may be used.

The new process is not a simple application of the mode of combustion used by
110 E. A. F. Schultze (U. S. P. No. 578271), to the new purpose of agglomerating fine ores by substituting gaseous fuel to solid fuel in the known agglomerating processes. Solid
115 fuel is used in the process of Heberlein (U. S. P. No. 844,355 and Robinson No. 926,289) disclosing a previous careful mixing and the burning out of solid fuel in the ore mass. Schultze introduces air and
120 gas which is burnt in the interstices of the ore mass; however the mass is not of fine grain but of large and rocky lumps ("pieces weighing one hundred pounds or more") and the combustion is ceased at the moment where the ore is disintegrated to a
125 pulverulent state by a chemical action of the gases upon the special ores. Schultze claims thereby only the new furnace, the process of burning gases between large ore
130

lumps being a common expedient in the practical metallurgy, even if a certain percentage of fragments or earthy constituents, such as fall during the mining operations, will be added to the large pieces of the charge. This process of distintegrating large ore lumps, "without crushing or stamping by the usual mechanical means", contains not any anteriority to the internal combustion of gases within fine ores, but it is on the contrary an example of a combustion extinguished or ceased at the moment of the formation of fine ore, this moment being even that of the accomplishment of the said process of Schultze. If nevertheless the internal combustion of gases within fine ores could be considered as a known expedient, its application to the special purpose of agglomerating these ores by repairing the solid fuel of the known processes through combustible gases, would be an invention producing an unexpected progress in the art, because of the following reasons: In the said processes the solid fuel is thoroughly mixed through the whole fine ore mass, and this mixing is a most important part of the process of Heberlein and others, creating thereby a perfect regularity in the softening through the whole mass. Against this in my process the introduction of gas-like fuel at the same time as the air, produces necessarily a great inequality in the distribution of the combustible matters and of the heat through the charge, so that in most cases a part of the mass is exposed to a complete softening and flowing away, while the other part is scarcely brought to a glowing state. The impossibility of mixing the gaseous fuel with the fine ore is therefore a serious impediment not existing in the process of Schultze, which remains always under the softening point of the ore, and not more in the process of Heberlein and Robinson, mixing the solid fuel previously through the whole mass of fine ore. Further, the presence in the mass of large quantities of solid fuel, which is gradually burnt out, and the continuous escapement of waste gases from the combustible part of the mixed mass, both create artificial free spaces assuring a great porosity and permitting the entrance of the large quantities of air in the mass, through which alone the heat will be sufficiently intensified for attaining the softening point of the ores. This capability of attaining the agglomeration with solid intermixed fuel, could therefore not decide, whether the pores of the fine ores, without artificial means of enlargement, would permit of the introduction of sufficient quantities of gaseous fuel and air for attaining the agglomeration of the ore, the process of Schultze not being more conclusive on this point. On that account the last step of my process

based upon the internal combustion of gases, namely the fact of attaining the agglomeration, is rightly represented in my claims as a most important part of my invention.

In carrying my process into practical effect, I may use any kind of furnace, especially owing to the fact that the existing types of furnaces and apparatuses may be easily adapted to the requirements of the new method. However the new process is not limited in its practical execution to the adaptation of known apparatuses and furnaces. I will now proceed to describe a simple apparatus given only by way of example:

I may use a vertical furnace provided with lateral air and gas passages arranged for example at its bottom part. In order to permit the passage of gases without excessive pressure, the vertical furnace proper will be properly very low, and in order to facilitate the entrance of gases into the mass, said furnace will be preferably made of elongated rectangular section. It will be seen that the part of the vertical furnace wherein the internal combustion takes place, must be filled with the finely divided mass, in order to avoid the formation of the long free flame of other agglomerating processes (for instance U. S. P. No. 865,659 of 1907 to J. Scott), wherein a completely empty and necessarily very high furnace is utilized. In said patent, the finely divided ore is caused to drop in a shower through an enormous free flame, instead of making the reverse by suffocating this flame within the pores of the dust, whereby it would be changed to internal combustion as in the present process. The new furnace will be preferably made of sheet copper without inner lining and water-cooled or of the water-jacket type, in order to prevent the sintered mass from adhering to the walls. In its incandescent state the mass to be agglomerated may be treated in any suitable compressing device, for the purpose of producing or increasing coherence.

The proportion of gas with relation to the air introduced into the furnace or apparatus, is generally such as is required for producing a complete combustion. However I may also use either an excess of air for the purpose of oxidizing the mass, or an excess of gas for the purpose of reducing the same, in accordance with the special effect to be produced together with the agglomeration. Owing to the easy control, the mass may be reduced and oxidized successively and even repeatedly by means of pure or diluted gases, whereby the agglomeration is facilitated and for instance arsenic easily removed.

In certain cases it may be desirable to use air and gas after they are thoroughly mixed,

but it is always possible and generally easier to separate the gas-inlet from the air-inlet and even to retard the mixture in the interior of the mass, whereby a longer zone of combustion is produced while the too intense effect of rich gases will be lessened. In certain cases the gases may be diluted by means of steam or by burnt gases. By introducing directly water into the furnace, the zone of combustion may be directed and reduced to the desired place, whereby a very short and too intense zone of combustion may be conveyed through a very long or high mass, for instance, in a converter. In order to permit of the internal combustion, the mass must be made capable of burning the gases by contact. This point is highly important as cold dust would suffocate the combustion. It will be sufficient to heat a portion of the mass to incandescence. If the furnace is in operation the incandescent mass will itself light the gaseous mixture passed through the same, at the same time heating the adjacent layers. However, the furnace operates more securely if the gaseous mixture is continuously lighted prior to its introduction into the mass, especially in the case of a sintering furnace or machine wherein the combustion gases are not passed through the fresh mass. The flame which is formed draws away the necessary heat for heating the first layers of the mass through which it passes and within which it will be extinguished. But if the mass is heated sufficiently, the combustion takes place without free flame within it and causes the materials to be agglomerated. The previous lighting of the gas may be maintained by any well known device, but the observance of the present process requires that the combustible matters are yet combustible and not already combusted at the moment where they reach the mass. I may also produce a special free flame for first heating the fresh mass as in other agglomerating or roasting processes. There is moreover a plurality of good devices for previously heating the dust, and it will be sufficient to mention as an example specially the heating by means of hot gases of any nature and origin, passed through or around the compact or divided mass, for instance, combustion gases from other furnaces or the agglomerating furnace itself, superheated steam, hot air or gas, and in this latter case the use of hot air and gas in the internal combustion itself. In cases where special heating is used, the furnace may be very easily brought into operation. Otherwise it is necessary to previously light or heat, or use solid fuel, until the mass is sufficiently heated to maintain the lighting, or the furnace must be charged bit by bit by covering the flame. In order to avoid as much as possible the formation of channels or passages through

which the gases would escape and produce a flame, it will be desirable, in all these cases to moisten thoroughly the dust prior to its introduction into the furnace, as it is a well known and simple means used since long for similar cases. If the gaseous current draws away the dust at its discharge from the furnace, the objection may be avoided by causing water to drop into the furnace, or by means of any other retaining device. The dust may be treated still more easily, if molasses, solutions of salts, tar or any other solution known as means for preventing the drawing away of dust rather than as agglomerating means, are added to the same. But as my new process is a general method of combustion for agglomerating processes, the processes may be easily combined and I may use for instance agglomerating substances proper, which produce the coherence of the dust by means of heat either alone or by reaction in the heat.

The gaseous fuel which is necessary for the production of flameless combustion, may be of any nature and origin. Besides the rich gases and gases from furnace-tops there are gases produced by the partial combustion of any solid or liquid fuel, which gases are known as poor gases, or vaporized solids or liquids, carbureted air, or pulverized liquids or solids introduced by special devices in a finely divided state into the pores of the glowing mass. By using liquid fuel, particularly petroleum, (kerosene), oil, tar, residues of naphtha, all that is necessary is to cause these liquids to flow into the hot zone of the furnace, where they are rapidly gasified either by partial combustion or by vaporization, especially if they are introduced directly in a liquid state into the hot mass itself.

The use of solid fuel previously mixed with the mass permits of obtaining combinations with various known processes unless it concerns dust of coke or anthracite contained in dust from blast-furnaces. In fact, the solid fuel may directly assist the agglomeration by its combustion heat, provided that a large excess of air is used with the gases introduced and the solid fuel is burnt sufficiently. Otherwise the solid fuel may be used simply to assist the preparation and improvement of the mass, for instance, by reducing the same or by remaining incorporated in the state of coke within the agglomerated mass, so that fine ore and wastes of coke or any other fuel will be agglomerated simultaneously.

As an example of a useful combination of my process I may still mention the following important modification: The mass to be agglomerated, is brought to a glowing state and treated by the new process of heating by means of the combustion of gas-like matters with air in the pores of the

mass itself. During this heating period a part at least of the metallic oxides of the mass will be deoxidized either by means of solid carbon previously mixed in the mass, or rather by using a combustible mixture of gases having reducing properties by the presence of an excess of combustible gas, or in any other way. A part of the heat developed by the internal combustion of gases, is absorbed by the reduction of the oxides. Then the mass will be reoxidized preferably suddenly by means of pure air or of a mixture (combustible or not) of gases, having oxidizing properties. It is well known that the reoxidation of partly reduced ores, liberates the calorics absorbed during the reduction period and produces or completes the agglomeration of the particles. In this case also, the flameless combustion is a very practical means for producing the agglomeration.

My invention does not relate to any particular form or construction of apparatus, but it relates to a new process of agglomerating finely divided materials and the like, in any desired suitable apparatus or furnace and I claim as new and heretofore unknown the agglomerating by internal combustion of gas-like matters within the pores of the mass of dust or other material. For this reason the following description of a furnace (shown in the accompanying drawing) serves merely the purpose of more clearly showing one means for carrying my invention into practice.

Figure 1 is a section of a continuously operating vertical furnace, for the agglomeration of dust and finely divided ore or other like purpose; Fig. 2 is a horizontal section of said furnace on line $x y z t$ of Fig. 1.

A indicates the low and narrow furnace room having a wide rectangular cross-sectional area. The inner space is filled with dust to be agglomerated, introduced in a thoroughly moistened state through the funnel A', while the bottom is closed by two rolls B to complete by their compression the coherence of the softened mass of dust. The body of the furnace is surrounded by a water-jacket C. The current of air is introduced through the pipes D' into the mixing chamber D, while the current of combustible gas is supplied by the pipe E'—E provided with numerous perforations (in its part which is inclosed in the chamber D), so that the gas will be distributed upon the whole length of the furnace. The chamber D communicates through the slit S with the proper furnace room A.

I will now explain the means of working of the furnace.

The operation is continuous and very simple: The fresh and moistened dust is continuously filled into the hopper A', and

agglomerated mass removed through the rolls B. In the device shown in Fig. 1, the currents of gas and air are joined in the chamber D and more or less completely burnt in the lower part of the mass of finely divided dust A, the combustion softening and agglomerating the dust, while in the upper parts the moisture is eliminated and the dust heated to incandescence by the already burnt and hot gases escaping through the fresh mass to the top of the furnace. The rolls B are preferably rotated at a low speed and continuously, in the direction pointed out by arrows in the drawing, the sintered product will be thereby discharged by degrees between the revolving rolls, which grasp, compress and remove the agglomerated mass. Rolls for a similar purpose are already used by J. Scott (U. S. P. No. 865,659). Care must be taken that the incandescent zone is not too rapidly lowered in the furnace, in order that the dust reaching the level of the slit S is sufficiently heated for enabling the internal combustion of gases to take place. Moreover the presence of these rolls or of any other compressing or discharging device is optional in the construction of the furnace.

These nearly are the simplest means for carrying my process into practice. Good results are also obtained in the case of the important modification given in a former paragraph as an example of a useful combination of my process. For realizing at least one manner of working in accordance with this modified process, it may be sufficient to intermittently change the amount of combustible gas relatively to that of the air in the introduced gaseous mixture. I have already mentioned that this proportion may be varied in accordance with the oxidizing or on the contrary with the reducing effect to be produced upon the ore. The simplest means whereby the mass may be reduced and oxidized successively, as required in the combined process, is that of providing the air inlets (D' in the figure) and the gas inlets (E') each with a simple cock controlling the passage of more or less quantities of either of the ingredients of the gas mixture entering the furnace.

I will now describe how the modified process may be applied to a normally working furnace such as before presented but provided with cocks at each of the air and gas inlets.

Without changing the absolute quantity of combustible gas blown into the furnace, I diminish something, for example about the third or the half part, the amount of air in the gaseous mixture, by partially shutting the cocks of the air inlets (D'). The resulting combustible mixture contains an excess of combustible gas and has therefore reducing properties producing a sensible effect of

reduction upon the heavy oxids in the ore, which will be deprived of a part of its oxygen. After a few minutes (for example five or ten) I partially shut the cocks of the combustible gas inlets (E') (for example about the half part) and at the same time I completely reopen the cocks of the air inlets (D'). The resulting combustible mixture presently contains an excess of air, naturally producing a sensible oxidation upon the formerly more or less reduced heavy oxids of the ore and consequently, in accordance with the experience of the metallurgists, a completion in the agglomeration. After the expiration of this oxidation period (performed during five minutes for example) a normal heating with a neutral combustible mixture of gases may again take place by completely reopening the cocks of the combustible gas, or the reducing period may immediately reënter in action with a reducing mixture of gases as firstly described. Although the rolls B may be rotated in a continuous manner during the reducing and the oxidizing period, it is preferable to intermit their action and for example only revolve them during the period of the neutral heating.

Having fully described my invention, what I claim and desire to secure by Letters Patent is:

1. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of combustible matters into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

2. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the moistened mass to be agglomerated, introducing a current of air and at the same time a current of combustible matters into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

3. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the

same time a current of combustible matters, both currents previously mixed together, into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

4. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of combustible matters in a lighted and burning (but not already combusted) state, into the pores of the mass, producing an internal combustion between the not consumed part of the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

5. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of combustible matters in a lighted and burning (but not already combusted) state, both currents thoroughly mixed together, into the pores of the mass, producing an internal combustion between the not consumed part of the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

6. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of fuel in a condition of mixibility with gases into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

7. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of atomized solid or liquid fuel into the pores of the mass,

producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

5 8. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine
10 ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, the heating being effected by hot gases traversing the same, introducing a current of air and at the same time a current
15 of combustible matters into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, thereby increasing the temperature in the interior
20 of the mass, and attaining the agglomeration of the said mass, substantially as set forth.

25 9. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of combustible mat-

ters into the pores of the mass, producing 30 an internal combustion between the said combustible matters and the air within the pores of the mass, increasing the temperature in the interior of the mass, reducing by suitable agents a part of the oxids in the 35 mass, and attaining the agglomeration of the said mass, substantially as set forth.

10. The herein described process of agglomerating finely divided granular or friable materials other than sulfids, especially 40 fine ore or flue dust, which consists in heating at least a portion of the mass to be agglomerated, introducing a current of air and at the same time a current of combustible
45 matters into the pores of the mass, producing an internal combustion between the said combustible matters and the air within the pores of the mass, increasing the temperature in the interior of the mass, reducing by suitable agents a part of the oxids in the 50 mass, oxidizing subsequently with a gaseous agent, and thereby attaining the agglomeration of the said mass, substantially as set forth.

In testimony whereof I affix my signature 55 in presence of two witnesses.

ADOLPHE VICTOR MARIE KROLL.