Feb. 17, 1948. V. C. WILLIAMS 2,436,002

FLUX-FORMING FUEL, AND METHOD FOR THERMALLY WORKING MINERALS THEREWITH

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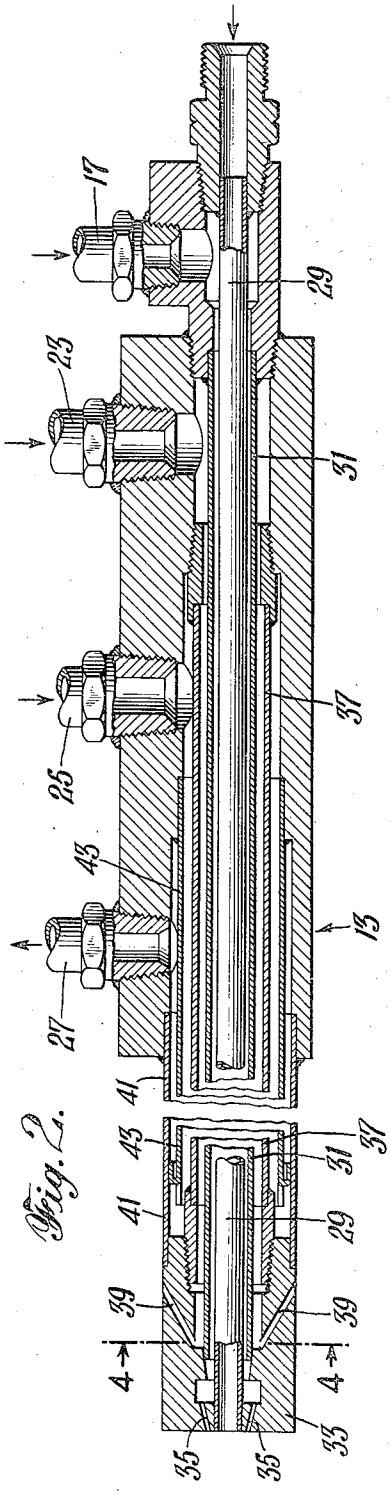

Fig. 2.

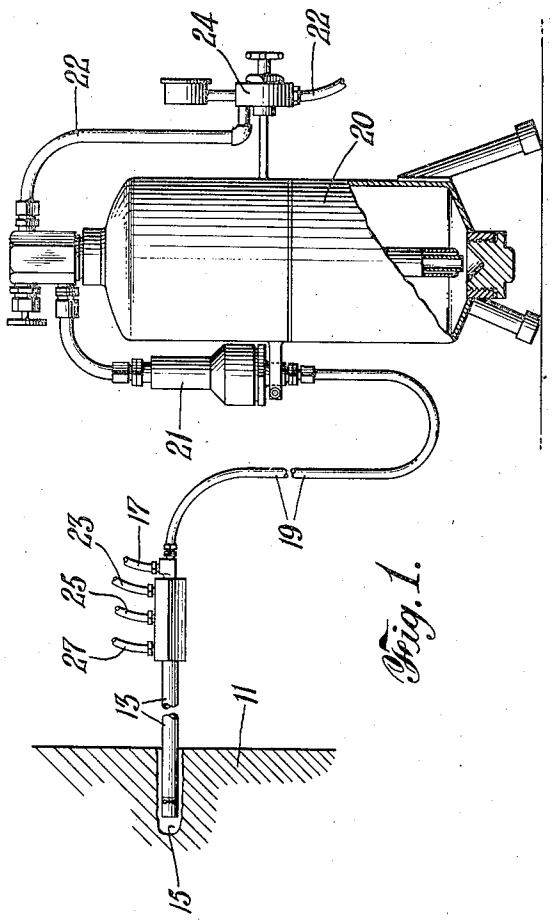

Fig. 1.

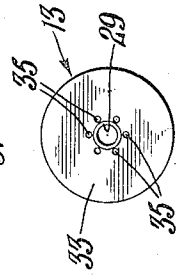

Fig. 3.

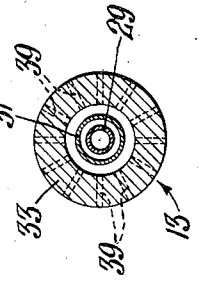

Fig. 4.

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FLUX-FORMING FUEL AND METHOD FOR THERMALLY WORKING MINERALS THEREWITH

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10 Claims. (Cl. 255—1.8)

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This invention relates to a flux-forming fuel, and to a method for thermally working mineral and like materials therewith. More particularly, the invention concerns a flux-forming fuel and a process for forming holes in such meltable mineral materials as iron ore, greenstone, and concrete. The present application is a continuation-in-part of Patent No. 2,327,482, entitled "Mineral cutting and piercing," issued August 24, 1943, to R. B. Aitchison, C. W. Swartout, and V. C. Williams.

In Patents 2,286,191 and 2,286,192 of R. B. Aitchison et al. there are disclosed novel processes and apparatus for thermally working mineral materials, as by piercing in them holes for blasting. Either a spalling procedure or a melting procedure may be followed, depending primarily upon the character of the mineral material to be worked. When forming a hole in material such as iron ore, Ely greenstone, or concrete, the melting procedure is followed by applying against the rock an intense oxy-fuel gas flame from a long blowpipe, and advancing the blowpipe into the rock as material is melted off and a hole is formed. Usually a continuous stream of an unbonded comminuted exothermically oxidizable metallic flux-forming material is carried into the flame by the fuel gas to burn and provide a large amount of heat, as well as to combine with the molten mineral material or slag and increase its fluidity. A pneumatic powder dispenser ordinarily is provided in the fuel gas supply conduit for suspending the powdered material in the gas before it enters the blowpipe.

Among the comminuted metallic flux-forming materials employed have been iron, ferrosilicon, ferromanganese, zirconium-silicon, silicomanganese, calcium-silicon, and various mixtures of these materials. Sometimes small quantities of preformed fluxes, such as oxides or salts of metals, are mixed with the metallic material for modifying the slag composition and properties. It has been found that most powdered metallic materials of this character do not ignite quickly enough and burn with sufficient rapidity to give the optimum heating and fluxing effect. Moreover, it has been found that many such powdered materials can not be pneumatically suspended in the conveying gas stream uniformly and with complete dependability because they tend to clog the passages of the powder dispenser, the conduit leading to the blowpipe, and the passages of the blowpipe.

Fuels consisting wholly of comminuted or pulverulent aluminum also have been used, but the

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resulting large quantities of aluminum oxide have been found to unite with most molten mineral materials to form a pasty viscous slag which can be removed in the fluid condition only with great difficulty.

One of the objects of the present invention is the provision of an unbonded novel comminuted flux-forming fuel characterized by its greatly improved ignitability and combustibility, and by its improved flow characteristics. Another object is the provision of such a flux-forming fuel utilizing pulverulent aluminum with other pulverulent metallic materials to impart the foregoing valuable properties. Still another object is the provision of such a fuel using such a small proportion of pulverulent aluminum that the cost of the fuel is low, yet important improvements in the foregoing properties are obtained. Other objects are the provision of a novel and improved method for thermally working mineral and like materials rapidly and continuously using a powdered fuel containing aluminum; the provision of such a method particularly adapted for the thermal piercing of holes in meltable mineral materials and the like; and the provision of such a method utilizing an oxy-fuel gas flame and a novel pulverulent flux-forming fuel containing small quantities of aluminum powder to increase the ignitability and combustibility of the chief constituent of the fuel.

The above and other objects, and the novel features of the invention, will become apparent from the following description having reference to the accompanying drawing, wherein:

Fig. 1 is a side elevational view, partly broken away and in section, showing typical apparatus for performing the process of the invention;

Fig. 2 is a longitudinal sectional view of a blowpipe for performing the process;

Fig. 3 is a view of the left end of the blowpipe shown in Fig. 2; and

Fig. 4 is a cross-sectional view taken on the line 4—4 of Fig. 2.

The flux-forming fuel of the present invention comprises a comminuted unbonded intimate mixture of pulverulent aluminum with particles of different pulverulent combustible metallic material having by itself relatively poor flowability, ignitability, and combustibility compared with the mixture. Among the metallic materials used with aluminum have been iron, and the alloys ferrosilicon, ferromanganese, zirconium-silicon, silicomanganese, calcium-silicon, and various mixtures of these materials in a pulverulent state. It has been found that pulverulent aluminum

offers important advantages in such a mixture when used in relatively small amounts ranging from 0.1% to 10% by weight of the mixture, and preferably from 0.1% to 5%, the remainder being substantially all the particles of the other metallic material.

Surprisingly, aluminum powder has been found to provide a thin adherent coating to particles of such other materials and to function as a solid or dry lubricant facilitating the free movement of the particles over and past each other and through the passages for conveying the powder mixture to the point of use. As a result, powdered metals and compounds can be conveyed by a gas stream in much more constant proportions and with much less likelihood of clogging the passages than heretofore. Moreover, the coating of aluminum has relatively good ignitability and burns rapidly, thus acting as a fuse whereby the ignition and burning of the underlying iron or other metallic particles in oxygen are facilitated. Excellent lubricating and heat promoting effects are obtained by the use in the mixture of around 1% by weight of aluminum powder based upon the total weight of the mixture.

It is noteworthy that the rate of thermally working a mineral mass by the method to be described more in detail hereinafter, using the comminuted flux-forming fuel of the invention, is considerably increased by the important properties of the novel fuel mixture. Furthermore, excellent heat promoting and powder flow characteristics are obtained more economically with small amounts of aluminum powder than where larger quantities of expensive aluminum powder are employed, because these characteristics do not increase proportionately to the increased amount of aluminum powder employed above 10% by weight.

Sometimes small amounts of preformed fluxes, such as pulverulent oxides or salts, may also be used in a minor proportion in the comminuted fuel mixture without reducing the advantages attending the presence of aluminum powder. Moreover, the novel properties of the powdered fuel of the invention are obtained even though the size of the aluminum particles be varied widely. For instance, fuels containing aluminum particles varying between 140 mesh and 300 mesh Tyler have been used successfully for performing the method of the invention. In general it is best for the aluminum to be more finely divided than the other powdered metallic material with which it is mixed.

The novel method for thermally working mineral and like masses, according to the present invention, comprises separating material from such a mass by applying an intense oxy-fuel flame to a portion of the mass while introducing continuously into the flame a comminuted unbonded flux-forming fuel of the type described previously herein. The aluminum powder is used in every case, but the nature of the other component or components of the mixture may be varied in accordance with the nature of the mass to be worked and the character of the slag desired.

The slag may be removed in either the liquid or solid condition by the gaseous products of combustion, often assisted by an auxiliary ejection fluid. Removal of the slag in the solid condition is accomplished by first quenching the slag with water, upon which it either disintegrates spontaneously or may be disintegrated mechanically. The process is particularly applicable to the piercing of deep blasting holes of circular cross-section extending straight into a mass of mineral material. However, the principles of the invention also may be applied to the production of other holes in the nature of grooves or cuts.

Typical apparatus for performing the process of the invention is shown in Fig. 1 of the drawing, as applied to the piercing of a deep blasting hole of circular cross-section in a mass of mineral material 11. A long oxy-acetylene blowpipe 13 applies an intense heating flame against the forward face of a hole 15 in the mass 11, thereby causing material to separate from the mass as a molten slag. The separated slag is removed from the hole by the gaseous products of combustion augmented by streams of ejection fluid discharged from the blowpipe 13 near its forward end. As the hole becomes deeper the blowpipe is advanced steadily to heat and separate material from each newly exposed area at the forward face of the hole. Gaseous oxygen and acetylene are supplied to the blowpipe 13 through the hoses 17 and 19, respectively, leading from suitable sources of supply.

Powdered flux-forming fuel is carried in suspension in one of the gases, preferably the acetylene. The powder is introduced into the flowing stream of acetylene by a pneumatic powder dispenser 20 connected to a suitable source of acetylene, such as a cylinder, by a hose 22 in which a pressure regulator 24 is interposed. The powder-laden acetylene from the dispenser 20 then passes to the blowpipe 13 through the conduit 19, in which is interposed a back-pressure or check valve 21.

The powder dispenser 20 may be of the type fully described in Patent No. 2,286,776, issued June 16, 1942, to V. C. Williams et al. The back pressure valve 21 may be constructed in the manner described in Patent No. 2,286,841, issued June 16, 1942, to G. H. Smith.

Auxiliary debris-ejection air or water streams for discharge from the blowpipe 13 adjacent to its forward end may be introduced into the blowpipe through a hose 23. Water for cooling the blowpipe may enter through the hose 25 and leave through the hose 27.

One type of blowpipe for performing the process of the invention is shown in detail in Figs. 2, 3, and 4. Powder-laden acetylene from the conduit 19 enters a central tube 29 and is discharged centrally at the forward end of the blowpipe. Oxygen from the conduit 17 passes forwardly through a conduit 31 surrounding the central tube 29, and is thence discharged from the tip 33 of the blowpipe through a series of discharge passages 35 arranged on an annular zone surrounding the central tube 29 and converging forwardly toward the latter and toward one another. The oxygen and powder-laden acetylene thus mix outside the blowpipe to form a flame of the diffusion type, which is peculiarly resistant to flashbacks. Oxygen is supplied in sufficient volume to burn completely both the acetylene and the powdered fuel.

An ejection fluid such as air or water, from the hose 23, passes forwardly through a conduit 37 surrounding the conduit 31 and is discharged in streams from the tip 33 toward the rear of the blowpipe through a series of annularly arranged rearwardly and outwardly inclined passages or ports 39 spaced a short distance from the front of the blowpipe.

For cooling the blowpipe, a stream of water is introduced through the hose 25 and flows forward to the rear end of the tip 33 through the outside casing 41. The water then passes around the forward end of a baffle 43 and returns to the rear of the blowpipe, from which it is discharged through the outlet hose 27.

A few examples of the method of the invention are given below.

Holes totaling 9½ ft. in depth were pierced with an oxy-acetylene flame at an average rate of 1.41 inches per minute in Soudan iron ore (a very dense iron oxide) using a comminuted flux-forming fuel mixture consisting by weight 90% of pulverulent ferromanganese and 10% of pulverulent aluminum, suspended in acetylene gas.

Holes totaling 184½ ft. in depth were pierced in Soudan iron ore using a comminuted flux consisting by weight 66.6% of pulverulent ferromanganese, 26.4% of pulverulent zirconium-silicon, and 7% of pulverulent aluminum.

A hole 43½ inches in depth was pierced in Soudan iron ore using a flux-forming comminuted fuel mixture consisting by weight 90% of pulverulent iron and 10% of pulverulent aluminum.

A hole was pierced in Soudan iron ore using a flux-forming comminuted fuel mixture consisting by weight 92% of pulverulent silicomanganese and 8% of pulverulent aluminum.

Shallow holes were pierced in Ely greenstone using a flux-forming comminuted fuel mixture consisting by weight 95% of iron powder and 5% of aluminum powder.

Deep holes were pierced in a large block of concrete using a flux-forming comminuted fuel mixture consisting by weight 99% of steel powder and 1% of aluminum powder. Deep holes also were pierced in the same material using a comminuted flux consisting by weight 90% of steel powder and 10% of aluminum powder.

It is to be understood that the comminuted or pulverulent flux-forming fuel, and the process of the invention, are capable of modification within the scope of the invention as defined by the claims attached hereto.

I claim:

1. A flux-forming fuel consisting of a comminuted unbonded intimate mixture of aluminum particles with particles of at least one different combustible metallic material having relatively poor flowability and ignitability selected from the group consisting of iron, ferrosilicon, ferromanganese, zirconium-silicon, silicomanganese, and calcium-silicon, the aluminum particles being 0.1% to 10% of the weight of said mixture and the remainder being substantially all particles of said different metallic material.

2. A flux-forming fuel consisting of a comminuted unbonded intimate mixture of aluminum particles with other combustible particles of different metallic material having relatively poor flowability and ignitability, the aluminum particles being 0.1% to 5% of the weight of said mixture and the remainder being substantially all particles of said different metallic material.

3. A flux-forming fuel consisting of a pulverulent unbonded intimate mixture of aluminum powder, with powder of different combustible metallic material having relatively poor flowability and ignitability, the aluminum powder being about 1% by weight of said mixture and the remainder being substantially all powder of said different metallic material.

4. A flux-forming fuel useful in thermally working mineral and mineral-like masses, said fuel consisting of a comminuted unbonded mixture of particles of iron and of aluminum, the aluminum particles being 0.1% to 10% of the weight of said mixture, and the remainder being substantially all iron particles.

5. In a process for thermally working mineral and like masses comprising separating and removing material from such a mass by applying an oxy-fuel flame to a portion thereof while introducing into such flame a comminuted flux-forming fuel, the improvement which consists in introducing said flux-forming fuel as a flowing stream of a comminuted unbonded intimate mixture of pulverulent aluminum, with particles of at least one combustible metallic material having relatively poor flowability and ignitability selected from the group consisting of iron, ferrosilicon, ferromanganese, zirconium-silicon, silicomanganese, and calcium-silicon, the pulverulent aluminum being 0.1% to 10% by weight of said mixture and the remainder being substantially all said particles of different metallic material, whereby a comminuted flux-forming fuel having improved flowability and ignitability is provided and the mineral working operation is expedited.

6. In a process for thermally working mineral and like masses comprising separating and removing material from such a mass by applying an oxy-fuel flame to a portion thereof while introducing into such flame a comminuted flux-forming fuel, the improvement which consists in introducing said flux-forming fuel as a flowing stream of a comminuted unbonded intimate mixture of pulverulent aluminum, with particles of different combustible metallic material having relatively poor flowability and ignitability, the pulverulent aluminum being 0.1% to 5% by weight of said mixture and the remainder being substantially all said particles of different metallic material, whereby a comminuted flux-forming fuel having improved flowability and ignitability is provided and the mineral working operation is expedited.

7. In a process for thermally working mineral and like masses comprising separating and removing material from such a mass by applying an oxy-fuel flame to a portion thereof while introducing into such flame a comminuted flux-forming fuel, the improvement which consists in introducing said flux-forming fuel as a flowing stream of a comminuted unbonded intimate mixture of aluminum powder, with particles of different combustible metallic material having relatively poor flowability and ignitability, the aluminum powder being about 1% of the weight of said mixture and the remainder being substantially all said particles of different metallic material, whereby a comminuted flux-forming fuel having improved flowability and ignitability is provided and the mineral working operation is expedited.

8. In a process for thermally working mineral and like masses comprising separating and removing material from such a mass by applying an oxy-fuel flame to a portion thereof while introducing into such flame a comminuted flux-forming fuel, the improvement which consists in introducing said flux-forming fuel as a flowing stream of a comminuted unbonded mixture of particles of iron and of aluminum, the aluminum particles being 0.1% to 10% by weight of said mixture and the remainder being substantially all particles of iron, whereby a comminuted flux-

forming fuel having improved flowability and ignitability is provided and the mineral working operation is expedited.

9. A flux-forming fuel consisting of a comminuted unbonded intimate mixture of aluminum particles with particles of different combustible metallic material having relatively poor flowability and ignitability, the aluminum particles being 0.1% to 10% of the weight of said mixture and the remainder being substantially all particles of said different metallic material.

10. In a process for thermally working mineral and like masses comprising separating and removing material from such a mass by applying an oxy-fuel flame to a portion thereof while introducing into such flame a comminuted flux-forming fuel, the improvement which consists in introducing said flux-forming fuel as a flowing stream of a comminuted unbonded intimate mixture of pulverulent aluminum with particles of different combustible metallic material having relatively poor flowability and ignitability, the pulverulent aluminum being 0.1% to 10% by weight of said mixture and the remainder being substantially all said particles of different metallic material, whereby a comminuted flux-forming fuel having improved flowability and ignitability is provided and the mineral working operation is expedited.

VIRGIL C. WILLIAMS.

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