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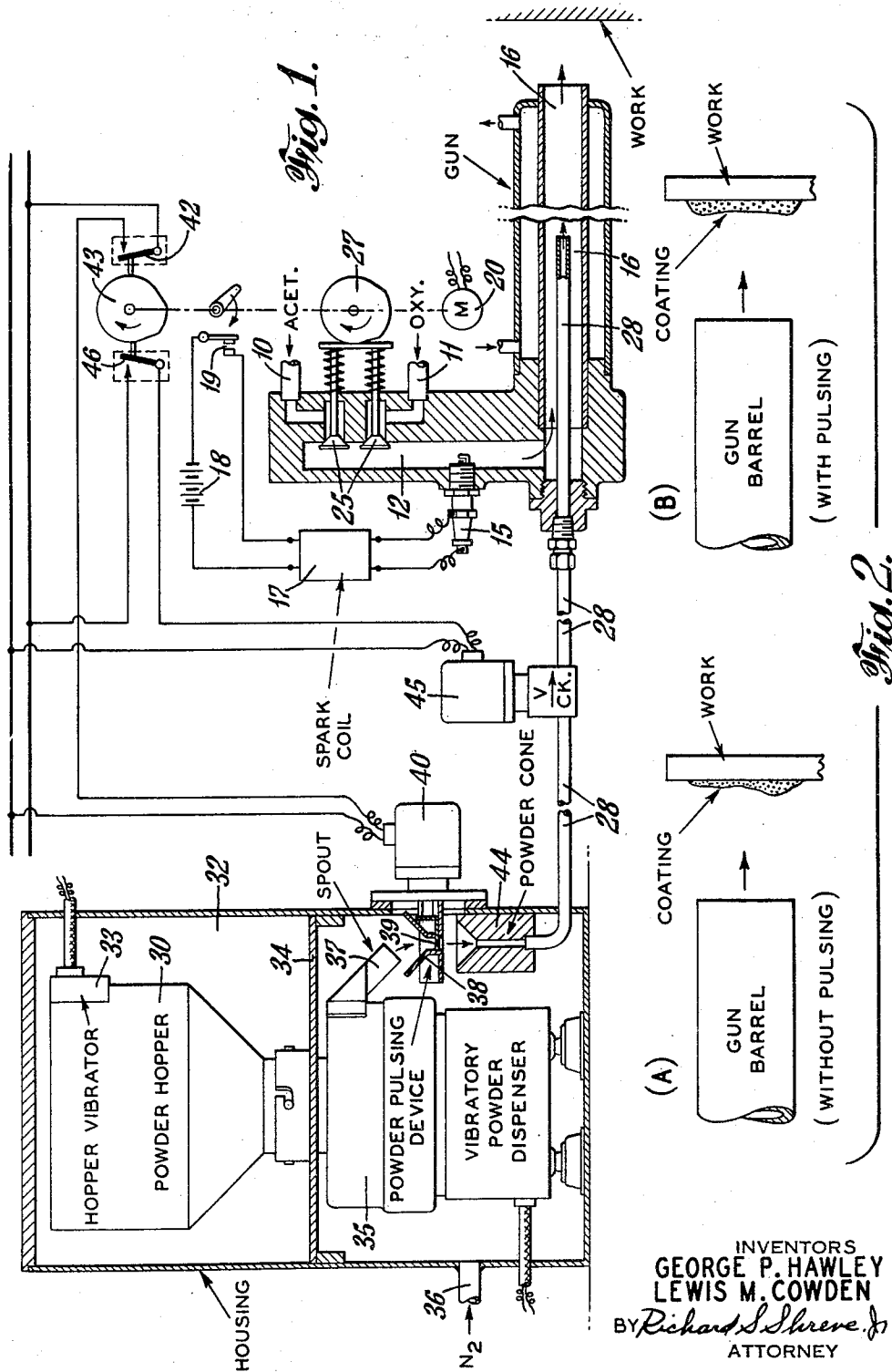
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2 Sheets-Sheet 1



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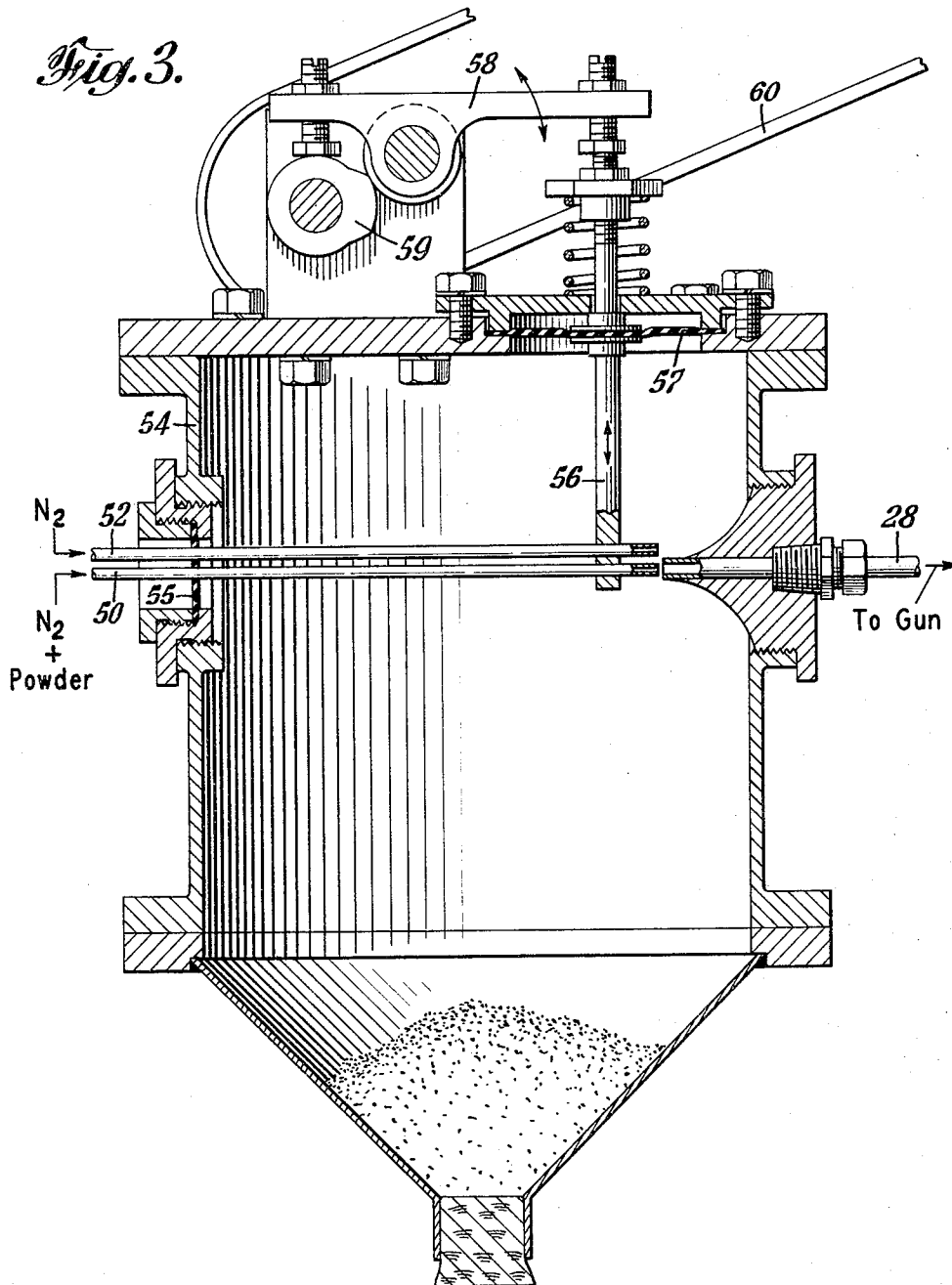
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PULSE POWDER FEED FOR DETONATION WAVES

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9 Claims. (Cl. 239—13)

This invention relates to pulse powder feed for detonation waves, and constitutes an improvement upon the subject of Poorman et al. Patent No. 2,714,563, the entire disclosure of which by this reference is hereby incorporated into this application.

The main object of the present invention is to provide method and apparatus for conveying powdered coating material from a dispenser to the barrel of the detonation gun in the form of pulses timed with the cycle of operation.

With this pulse powder feed less powder is wasted, and the position of the powder in the barrel of the gun at the time of the detonation is controlled, thus giving greater control over the coating process. This pulse powder feed also makes possible the application of other coating materials with different melting temperatures by changing the position of the powder in the barrel at the time of the detonation. This changes both the length of time heat is applied to the particles and the velocity with which the particles strike the base metal.

The accurate metering and injection of powder in substantially equal pulses at the same point in each successive cycle eliminates some variables encountered in the detonation gun process and results in greater control over the process.

In the drawings:

Fig. 1 is a vertical sectional diagram of a modified form of apparatus according to, and for carrying out the method of, the present invention;

Fig. 2 is a diagrammatic comparison of the effect of pulsing on the coating; and

Fig. 3 is a vertical sectional diagram of the preferred form of method and apparatus for supplying the pulsed powder to the system shown in Fig. 1.

As shown in Fig. 1, a combustible gas such as acetylene is supplied through a pipe 10, and an oxidizing gas such as air is supplied through a pipe 11, to a mixing chamber 12 where they form a detonatable gaseous charge mixture. The chamber 12 also constitutes an ignition chamber, provided with a spark plug 15. Sparking of the plug 15 ignites the charge, leading to the formation of a detonation wave which travels through a barrel 16 of the gun and out its open end. The firing of the spark plug 15 is accomplished by a spark coil 17, battery 18, and cam operated switch 19. The frequency of firing is regulated by a variable speed motor 20 which drives the cam of the switch 19.

To provide positive closure between the ignition chamber and the gas supply, poppet valves 25 are operated by the motor 20 and cam 27 to obtain the desired frequency of opening and closing the valves. A powder tube 28 is shown between the ignition chamber 12 and the open end of the gun barrel 16. The powder is supplied from a powder hopper 30 mounted in a housing 32 and provided with a hopper vibrator 33. The hopper 30 delivers the powder through a partition 34 to a vibratory dispenser 35 in the lower chamber of the housing 32 which is supplied with an inert gas such as nitrogen through an inlet

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36. The dispenser 35 delivers the powder through a spout 37 to the powder pulsing device.

The powder pulsing device consists of a small trough 38, the bottom of which is a sliding trap door 39. The door 39 is actuated by an electric solenoid 40, which in turn is energized through a cam operated microswitch 42. For operating this switch, a cam 43 is mounted on the same shafts as cam 27 and the cam for switch 19. Once each cycle the trap door 39 slides open and closed, dropping the powder that has collected into the powder cone 44, which delivers it into the powder tube 28, where it is carried to the open barrel by the carrier gas.

In this form of powder pulsing apparatus, rather violent pressure attained in the detonation gun at time of ignition can travel back through the powder feed tube and blow the powder from the pulser, thus destroying all effects gained by the pulse.

To prevent the back surge from reaching the dispenser, an electric solenoid valve 45 is mounted in the powder tube between the housing 32 and the gun. This valve is actuated by a microswitch 46 operated by the same cam 43 as the microswitch 42. Switch 46 is coordinated with the cam to close the valve 45 just prior to the spark, and to open it soon after the detonation has occurred.

As disclosed in the above-mentioned Patent 2,714,563, the preferred method of operating a detonation gun is to purge the barrel with gas such as nitrogen after each detonation and prior to the introduction of the detonatable fuel-oxidant mixture for the next detonation. The powder pulsing device 39 is thus timed to inject powder into tube 28 in such fashion that the powder arrives in the barrel 16 subsequent to the purging portion of the cycle and prior to the firing of spark-plug 15. Any powder introduced subsequent to the ignition will not be desirably heated and propelled by the detonation wave and accompanying hot gases against a workpiece to form a coating. This powder will simply pass through the barrel along with the purge gas stream and be wasted.

The preferred method and apparatus for pulse powder feed to a detonation gas is shown in Fig. 3. The powder is entrained in a stream of carrier gas such as nitrogen and supplied at constant velocity through a tube 50. A stream of nitrogen at substantially the same velocity is supplied through a parallel tube 52. The entrance ends of these tubes are mounted pivotally and gas tightly in a housing 54 by means of a support 55. The outlet ends of these tubes are carried by a connecting rod 56 reciprocably and gas tightly supported by a diaphragm 57 in the top of the housing 54. The connecting rod 56 is actuated by a follower 58 engaging cam 59 driven by a belt 60 from the shaft of motor 20.

The cam 59 moves the connecting rod 56 at regular intervals. The open ends of the tubes 50 and 52 alternately register with the inlet end of the powder introduction pipe 28. Thus the flow of powder in substantially equal pulses into the gun barrel 16 is controlled in regularly spaced intervals. The device is so timed that the powder flows into the gun barrel only during the time or a portion of the time when fuel gas is also flowing into the gun barrel. When the barrel is being purged with nitrogen, the continuing powder flow is collected in the hopper bottom of the housing 54.

The fraction of the operating cycle during which the powder enters the gun barrel is called the length of the pulse. This pulse length is conveniently expressed in degrees of operating cam angle, the total angle from one ignition to the next being 360°. Fuel gas is usually introduced to the barrel for 270° of the operating cycle and the powder pulse is introduced during the fuel injection portion of the cycle. It has been found that the powder pulse length should be a maximum of 200° or $\frac{5}{6}$ of the operating cycle. It has also been found that the length

of the powder pulse tends to increase as it passes through the powder tube 28. This powder feed tube must therefore be of relatively short length in order to maintain the desired pulse lengths.

EXAMPLE

Detonation gun plating employing powder pulsing

A powder pulsing feed apparatus of the type shown in Fig. 3 was operated in the following manner. Finely divided (mostly 10 to 40 microns particle size) cast tungsten carbide composition containing, apart from the tungsten, about 9% cobalt and 4% carbon, was fed at a rate of about 8½ lbs. per hour into a nitrogen gas stream of 0.2 c.f.m. and then passed continuously into powder tube 50. Nitrogen gas at 0.4 c.f.m. was also passed continuously into tube 52. Tubes 50 and 52 were alternately passed into axial alignment with feed tube 28 connected to a detonation gun so as to provide about four powder feed pulses per second. The powder which flowed through tube 50 during the non-plating part of the cycle was collected and amounted to 40% of the total powder dispensed. This raised the efficiency of the resulting plating operation by 40%. The accompanying detonation gun was operated at acetylene and oxygen feed rates of about 2¾ c.f.m. each. The ignition rate of the gun was about four times per second. A smooth, dense, adherent layer of tungsten carbide composition about 0.06 inch thick was deposited at a rate of about one square inch per minute on a steel surface placed about three inches from the open end of the gun.

This application is a continuation in part of application Serial No. 602,582, filed August 7, 1956, now abandoned.

What is claimed is:

1. In a method for utilizing detonation waves to act upon a comminuted solid material which comprises introducing a detonatable mixture of combustible gas and oxidizing gas to an elongated confined path having an open end; introducing a comminuted solid material to the detonatable mixture in said barrel, igniting said detonatable mixture to produce a detonation therein and thereby transmit to said comminuted material some of the energy of said detonation to eject said comminuted material at high velocity from the open end of said path; and repeating these process steps in cyclical operation; the improvement which comprises introducing the comminuted solid material under pressure to the detonatable mixture in a controlled pulse timed with the cycle of operation, such comminuted material pulse being completely introduced prior to ignition of such detonatable mixture, whereby less comminuted material is wasted and greater control over the process is obtained.

2. In a method for utilizing detonation waves to act upon a comminuted solid material which comprises introducing a detonatable mixture of combustible gas and oxidizing gas to an elongated confined path having an open end; introducing a comminuted solid material under pressure to the detonatable mixture in said path; igniting said detonatable mixture to produce a detonation therein and thereby transmit to said comminuted material some of the energy of said detonation to eject said comminuted material at high velocity from the open end of said path; and repeating these process steps in cyclical operation; the improvement which comprises introducing the comminuted solid material by a stream of inert carrier gas to the detonatable mixture under pressure in a controlled pulse timed with the cycle of operation, such comminuted material pulse being completely introduced prior to ignition of such detonatable mixture and continuing for a maximum of ⅓ of the total operating cycle, whereby less comminuted material is wasted and greater control over the process is obtained.

3. In a method for utilizing detonation waves to act upon a comminuted solid material which comprises introducing a detonatable mixture of combustible gas and

oxidizing gas to an elongated confined path having an open end; introducing a comminuted solid material to the detonatable mixture in said path; igniting said detonatable mixture to produce a detonation therein and thereby transmit to said comminuted material some of the energy of said detonation to eject said comminuted material at high velocity from the open end of said path; purging the barrel of combustion gases with a stream of inert gas; and then repeating these process steps in cyclical operation; the improvement which comprises introducing the comminuted solid material by a stream of nitrogen gas under pressure to the detonatable mixture in a controlled pulse timed with the cycle of operation, such comminuted material pulse being completely introduced subsequent to the purging portion of the previous cycle and prior to the ignition of the detonatable mixture, whereby less comminuted material is wasted and greater control over the process is obtained.

4. In a method for intermittently utilizing detonation waves to act upon a comminuted solid material which comprises introducing a detonatable mixture of combustible gas and oxidizing gas to a detonation zone in an elongated cylindrical path having an open end; introducing a comminuted solid material to the detonatable mixture in said barrel; igniting said detonatable mixture to produce a detonation therein and thereby transmit to said comminuted material some of the energy of said detonation to eject said comminuted material at high velocity from the open end of said path; and repeating these process steps in cyclical operation; the improvement which comprises introducing the comminuted solid material to the detonatable mixture contained within a detonation zone in a controlled pulse timed with the cycle of operation, such comminuted material pulse being formed and completely introduced prior to ignition of the detonatable mixture by passing a pressurized stream of said comminuted material entrained in an inert gas axially into said cylindrical path containing a detonatable mixture and then periodically and controllably deflecting the comminuted material stream for collection of the unused comminuted material subsequent to the ignition of the detonatable mixture while continuing to introduce inert gas into said detonation zone.

5. Apparatus for supplying comminuted solid material in controlled pulses to an elongated barrel for utilizing detonation waves to act upon the comminuted material, which comprises in combination an inlet conduit to the detonation barrel; a first conduit for supplying purge gas to the inlet conduit; a second conduit for supplying comminuted solid material suspended in a carrier gas to the inlet conduit; and means connected to the first and second conduits for alternately registering these conduits with the inlet conduit so as to produce alternate controlled pulses of purge gas and suspended comminuted solid material in the inlet conduit, such pulses being in timed sequential relation to the operating cycle of the detonation device.

6. Apparatus for supplying comminuted solid material in controlled pulses to a barrel for utilizing detonation waves to act upon the comminuted material, which comprises in combination a comminuted material collecting chamber with an outlet for removing comminuted material therefrom; an inlet conduit to the detonation barrel, such inlet conduit gas-tightly communicating with the chamber; a first conduit gas-tightly passing into the chamber for supplying purge gas to the inlet conduit; a second conduit gas-tightly passing into the chamber for supplying comminuted solid material suspended in a carrier gas to the inlet conduit; and means gas-tightly passing into the chamber and connected to the first and second conduits for alternately registering these conduits with the inlet conduit so as to produce alternate controlled pulses of purge gas and suspended comminuted solid material in the inlet conduit while the chamber collects the unused comminuted material, such pulses being in

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timed sequential relation to the operating cycle of the detonation barrel.

7. Apparatus for supplying comminuted solid material in controlled pulses to a barrel for utilizing detonation waves to act upon the comminuted material, which comprises in combination a comminuted material collecting chamber with an outlet for removing comminuted material therefrom; an inlet conduit to the detonation barrel, such inlet conduit gas-tightly communicating with the chamber; a first conduit gas-tightly passing into the chamber for supplying purge gas to the inlet conduit; a second conduit gas-tightly passing into the chamber for supplying comminuted solid material suspended in a carrier gas to the inlet conduit; and reciprocating means gas-tightly passing into the chamber and connected to the first and second conduits for alternately registering these conduits with the inlet conduit so as to produce alternate controlled pulses of purge gas and suspended comminuted solid material in the inlet conduit while the chamber collects the unused comminuted material, such pulses being in timed sequential relation to the operating cycle of the detonation barrel.

8. Apparatus for supplying comminuted solid material in controlled pulses to a barrel for utilizing detonation waves to act upon the comminuted material, which comprises in combination a comminuted material collecting chamber with an outlet for removing comminuted material therefrom; an inlet conduit to the detonation barrel, such inlet conduit gas-tightly communicating with the chamber; a first conduit passing into the chamber for supplying purge gas to the inlet conduit; a second conduit passing into the chamber for supplying comminuted solid material suspended in a carrier gas to the inlet conduit, such first and second conduits being parallel and pivotally and gas-tightly supported at the chamber wall; and a cam-operated reciprocating connecting rod gas-tightly passing into the chamber and connected to the first and second conduits for alternately registering these conduits with the inlet conduit so as to produce alternate controlled pulses of purge gas and suspended com-

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minuted solid material in the inlet conduit, while the chamber collects the unused comminuted material, such pulses being in timed sequential relation to the operating cycle of the detonation barrel.

9. In a method for utilizing detonation waves to act upon a comminuted solid body which comprises introducing a detonatable mixture of combustible gas and oxidizing gas to a detonation zone in an elongated cylindrical path having an open end, introducing a comminuted solid material to the detonatable mixture in said barrel, igniting said detonatable mixture to produce a detonation therein and thereby transmit to said comminuted material some of the energy of said detonation to eject said comminuted material at high velocity from the open end of said elongated cylindrical path, and repeating these process steps in cyclical operation, the improvement which comprises continuous and uniform feed and delivery of powder in inert gas through an inlet conduit at constant velocity to storage, intermittent and equal delivery of powder to said cylindrical path when said inlet conduit is in register therewith, this occurring after purging and before detonation, but only during fuel delivery, delivering purging nitrogen through another inlet conduit with alternate registration of the exit thereof, thus phasing the nitrogen feed, preventing back surge of powder through said other inlet conduit by disregistration thereof during a detonation and storage of the powder during periods of non-registration of the powder tube.

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