United States Patent [19]

Melton, Jr. et al.

[11] **3,893,578**

[45] **July 8, 1975**

[54] **SYSTEM FOR INJECTING PARTICULATE MATERIAL INTO THE COMBUSTION CHAMBER OF A REPETITIVE COMBUSTION COATING APPARATUS**

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[73] Assignee: **Southwest Research Institute**, San Antonio, Tex.

[22] Filed: **Apr. 8, 1974**

[21] Appl. No.: **458,884**

[52] **U.S. Cl.** **214/305**; 214/310; 221/74; 222/94

[51] **Int. Cl.** **B65g 65/04**

[58] **Field of Search** ..... 214/300, 152, 309, 310, 214/304, 305; 221/74; 222/94; 53/381 R

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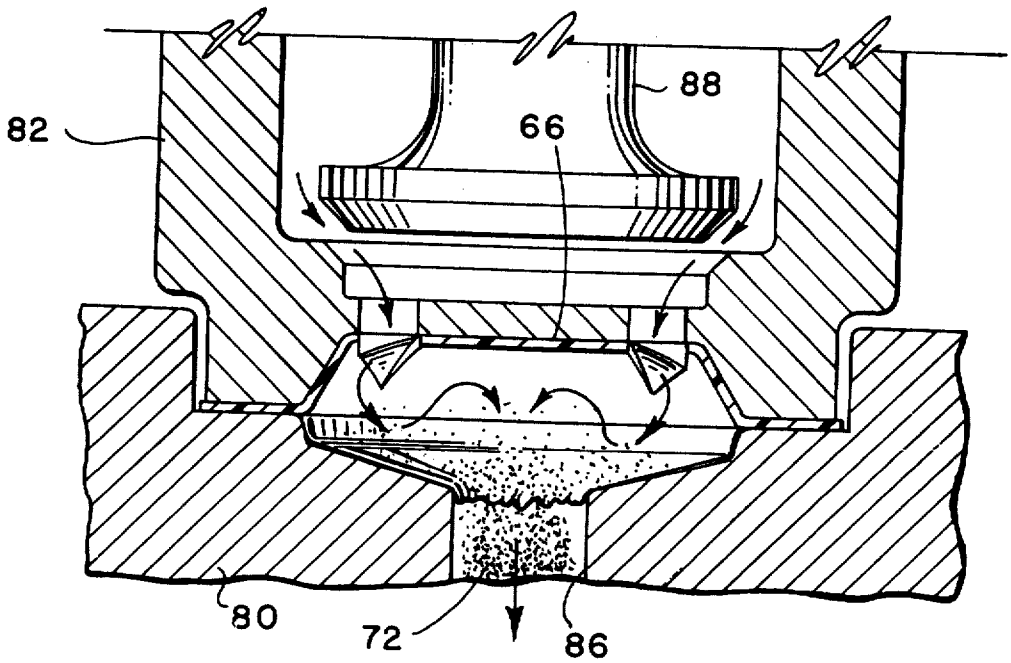
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Primary Examiner—Robert J. Spar
Assistant Examiner—Lawrence J. Oresky
Attorney, Agent, or Firm—Hubbard, Thurman, Turner & Tucker

[57] **ABSTRACT**

A repetitive combustion system for coating a work piece with particulate material is disclosed which utilizes an encapsulating tape having a plurality of discrete capsules each containing a predetermined quantity of the particulate coating material. The capsules are sequentially fed into a stripping chamber where the tape is clamped between inlet and outlet manifolds which provide a circumferential seal around the respective capsules so that pressure can be applied to an inlet face of the capsule. The inlet face is so configured as to admit air into the interior of the capsule which then swells and bursts the outlet face or otherwise passes through the outlet faces. The air pressure then injects the particulate material into the combustion chamber while the pressure in the combustion chamber is near the peak produced by combustion. A number of different tape configurations are disclosed and also a number of different stripping stations designed to enhance scavenging of all of the particulate material from the capsules without entraining any of the material forming the capsules and to position the capsules to the station at a high rate. The coating apparatus includes a sequencing means which feeds the tape at a continuous rate through the stripping station and initiates introduction of a fuel-air mixture to the combustion chamber, ignition of the fuel-air mixture, and injection of the particulate material from the stripping station in the proper sequence. High speed rotary manifold systems for positioning these capsules at the stripping station are also disclosed.

9 Claims, 29 Drawing Figures



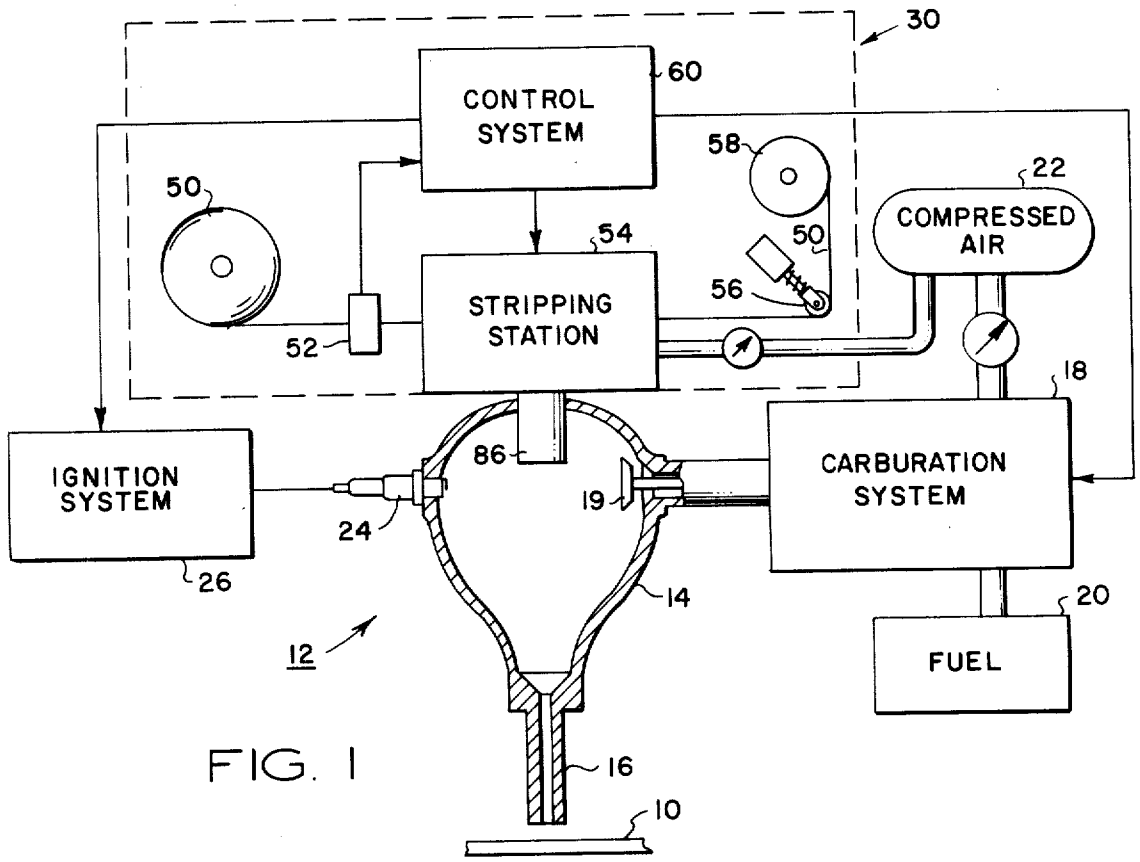

30
CONTROL SYSTEM
60
58
22
COMPRESSED AIR
50
54
50
STRIPPING STATION
56
52
18
IGNITION SYSTEM
86
CARBURATION SYSTEM
19
24
26
14
20
12
FUEL
16
10

FIG. 1

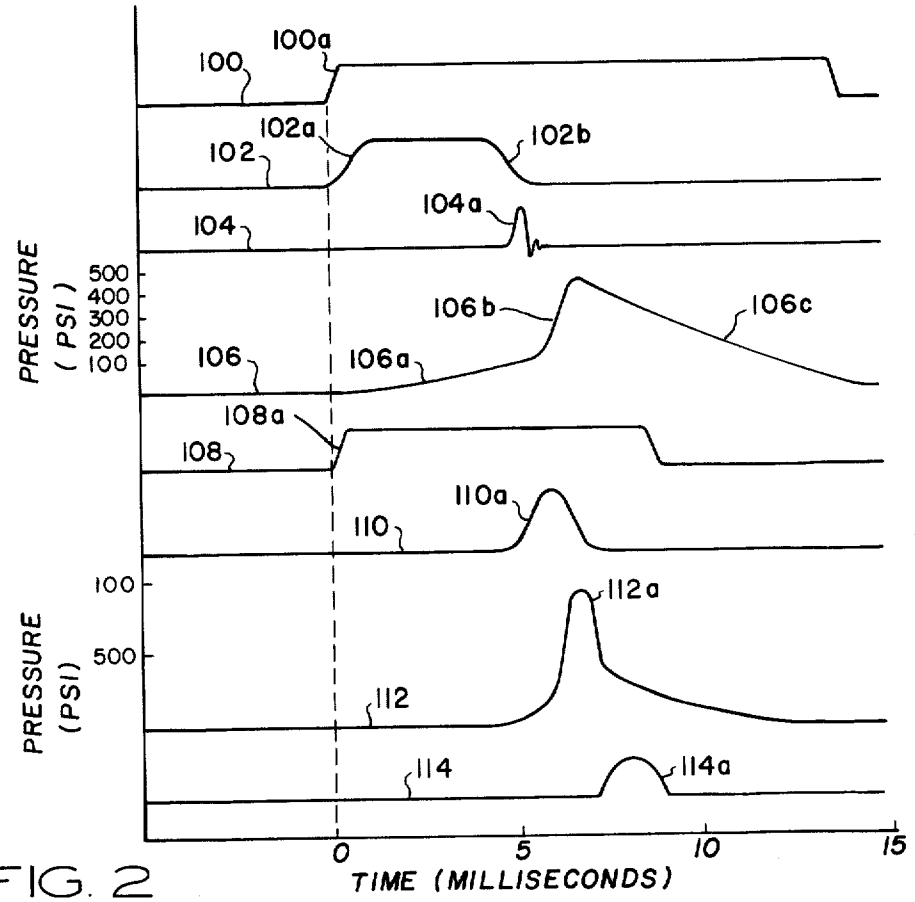

100
100a
102
102a
102b
104
104a
PRESSURE (PSI)
500
400
300
200
100
106
106a
106b
106c
108
108a
110
110a
100
500
PRESSURE (PSI)
112
112a
114
114a
0
5
10
15
TIME (MILLISECONDS)

FIG. 2

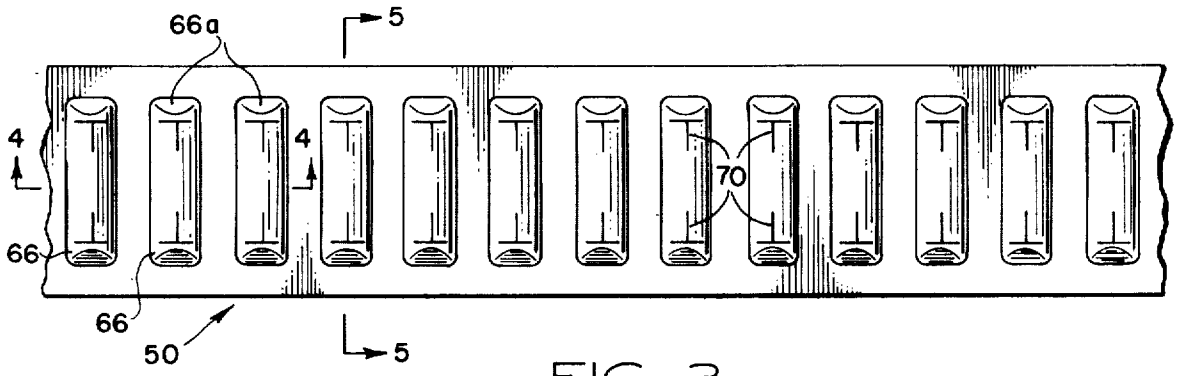


FIG. 3

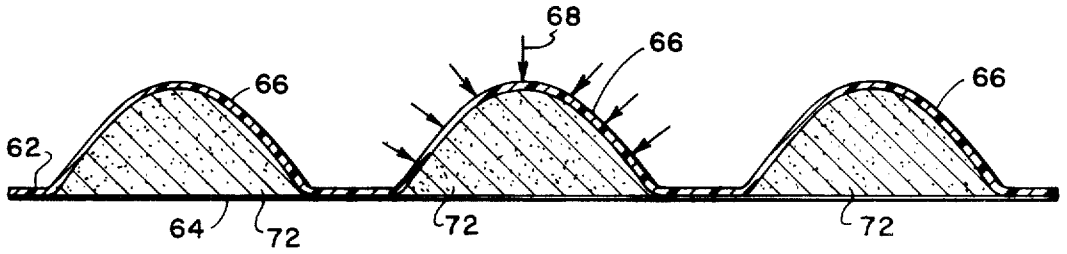


FIG. 4

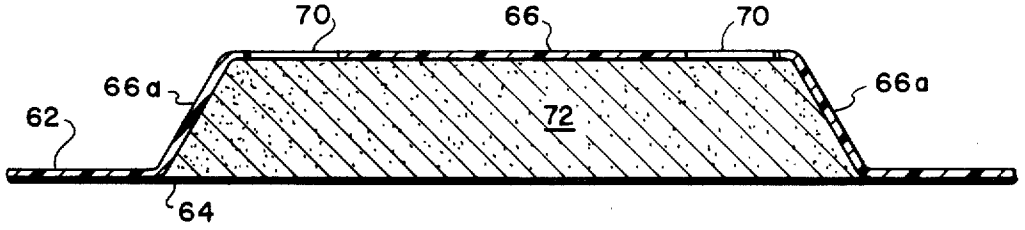


FIG. 5

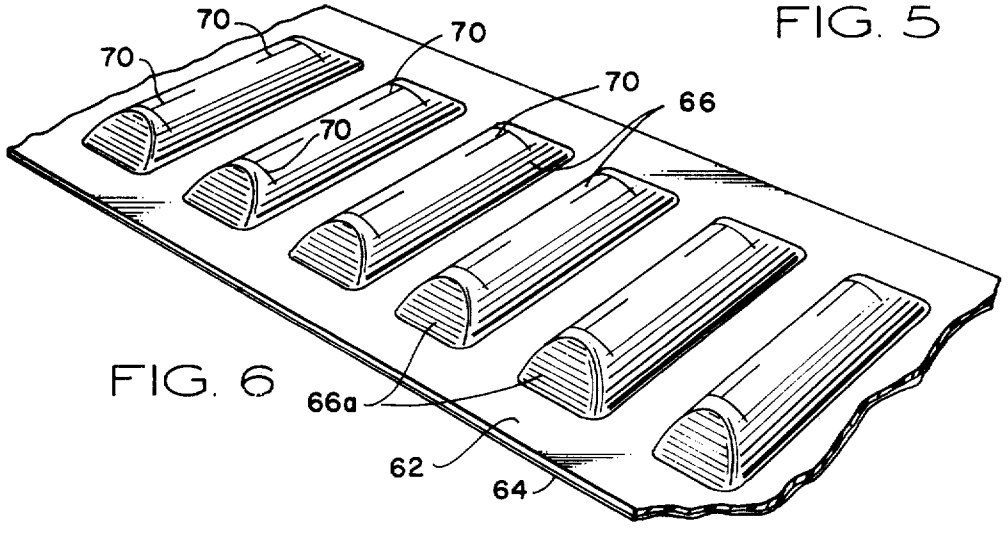


FIG. 6

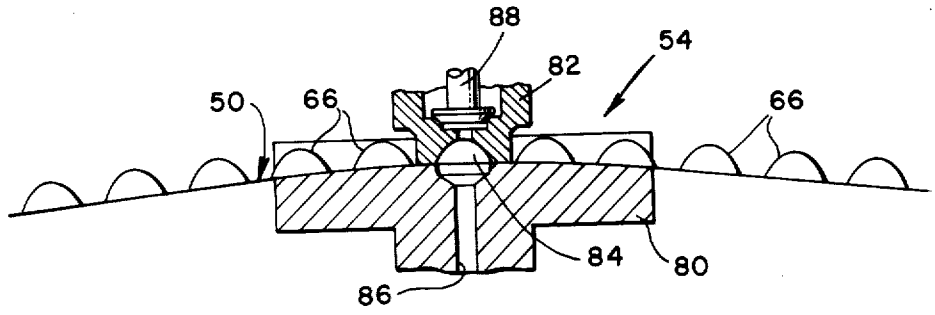


FIG. 7

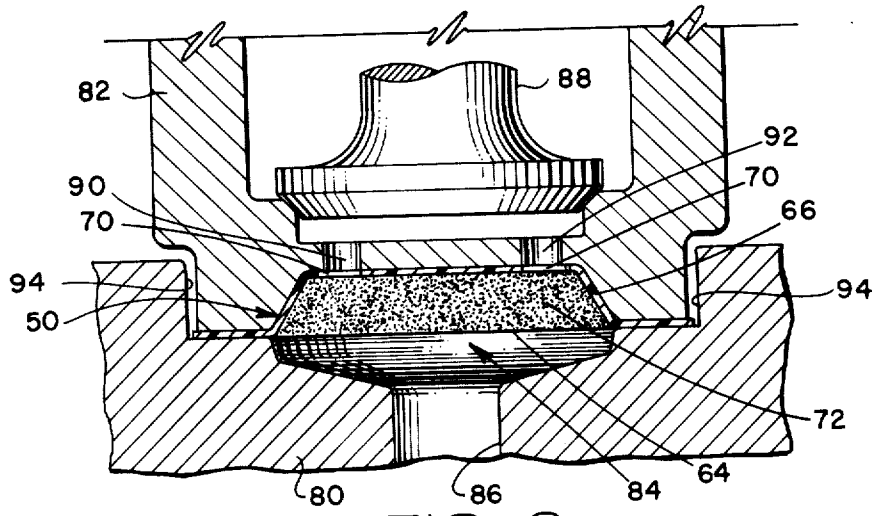


FIG. 8

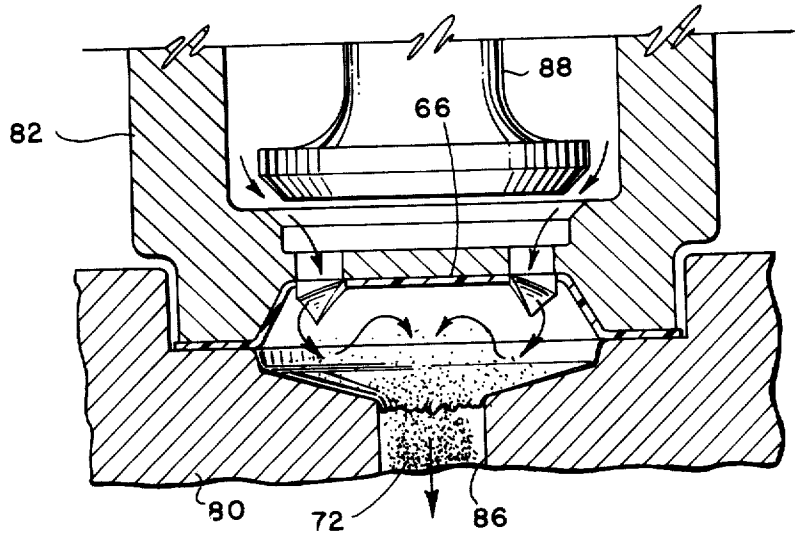


FIG. 9

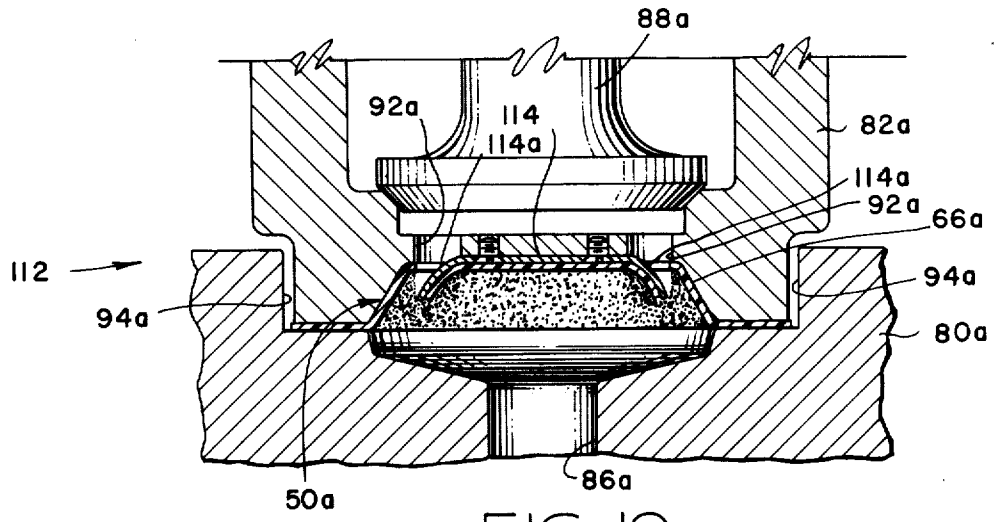


FIG. 10

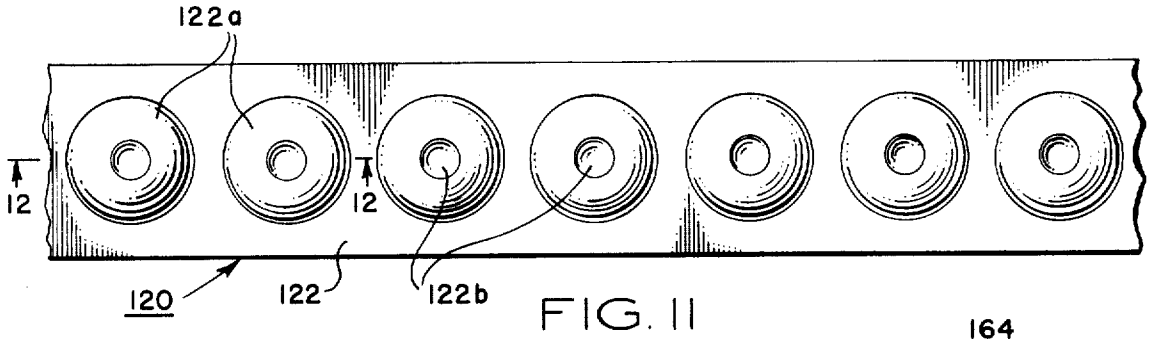


FIG. 11

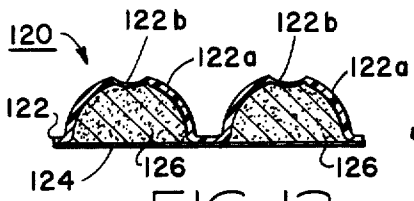


FIG. 12

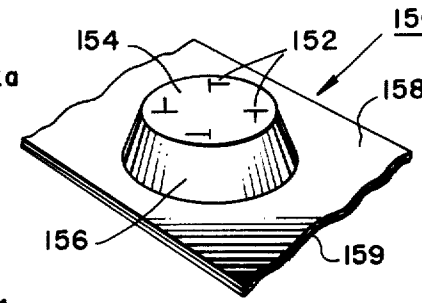


FIG. 15

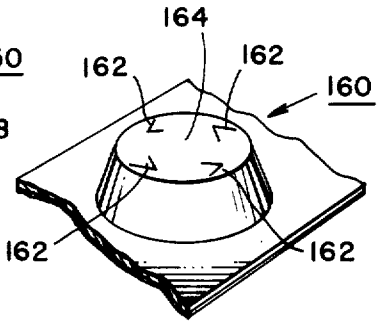


FIG. 16

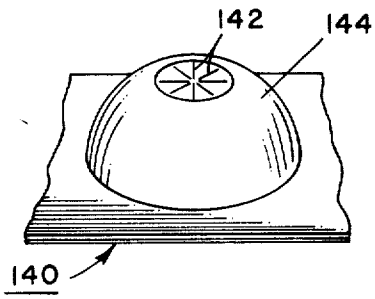


FIG. 14

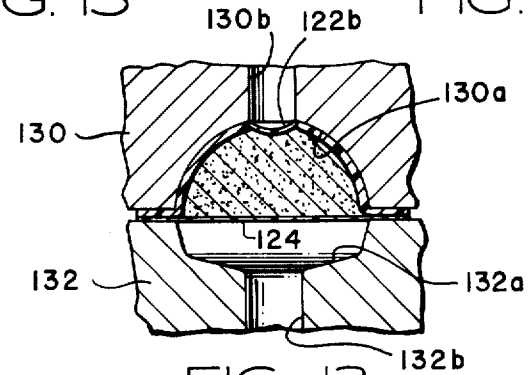


FIG. 13

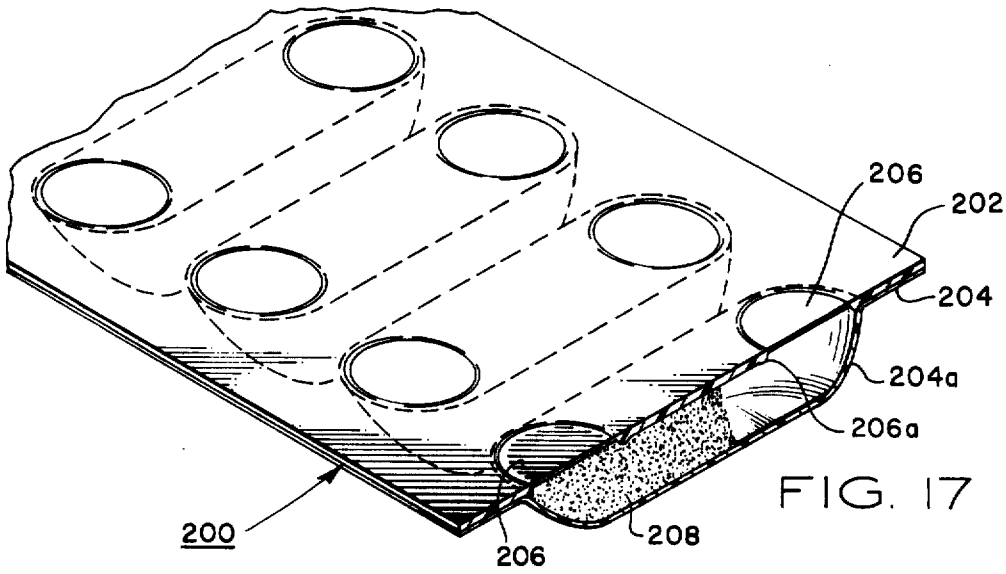


FIG. 17

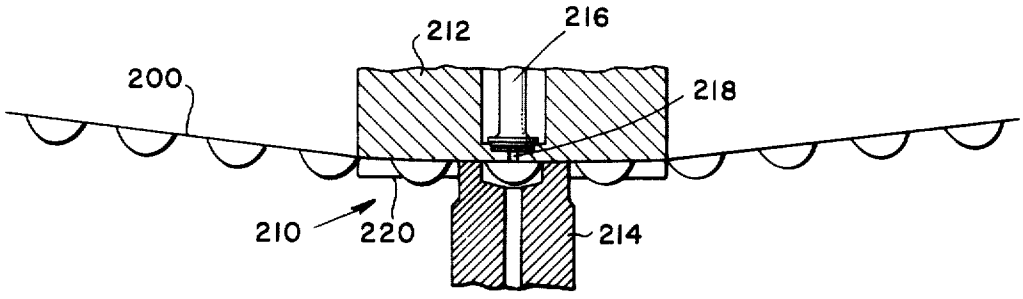


FIG. 18

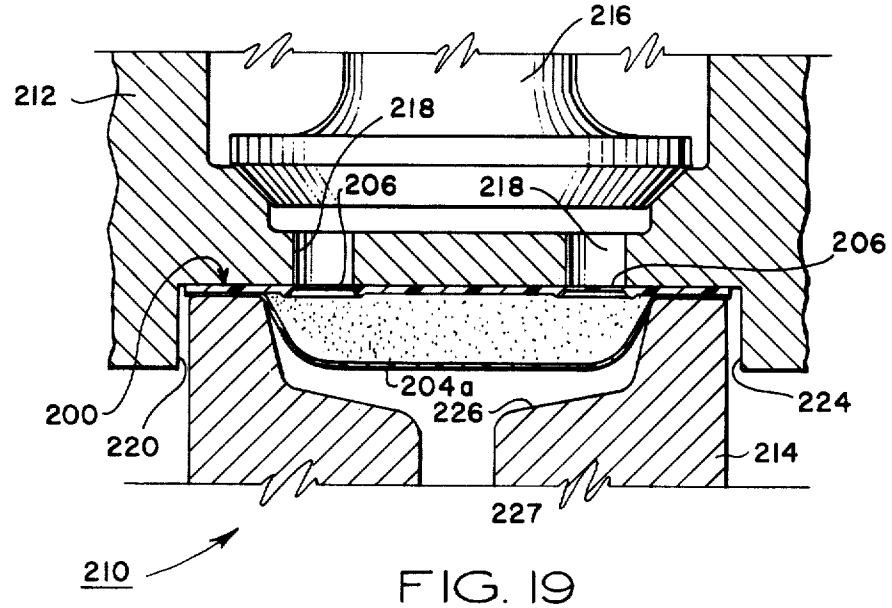


FIG. 19

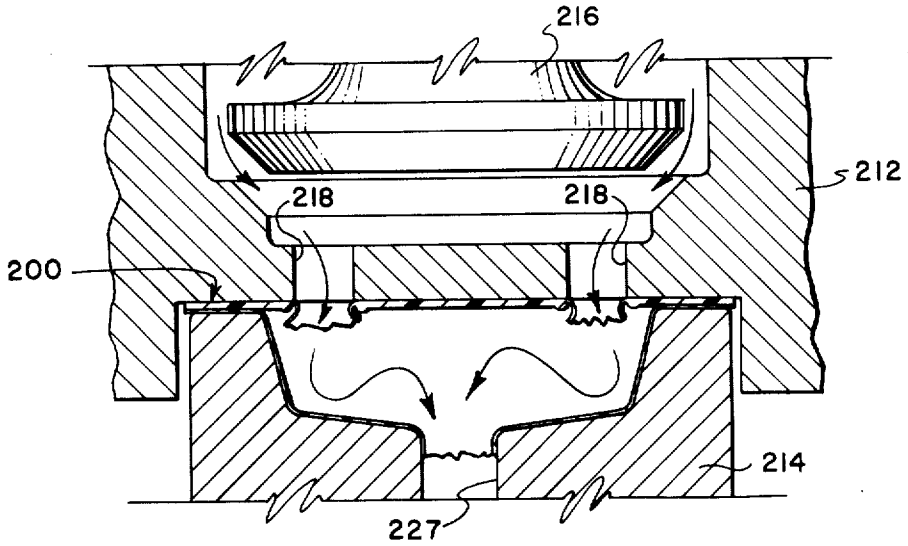


FIG. 20

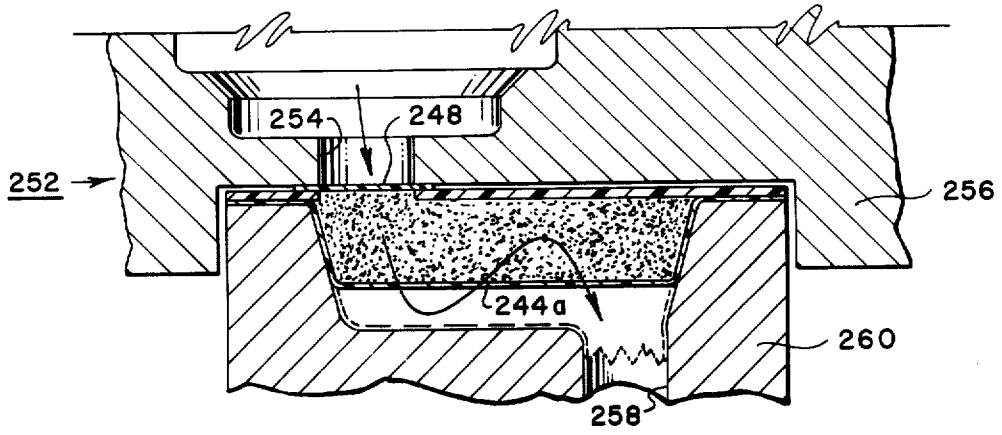


FIG. 22

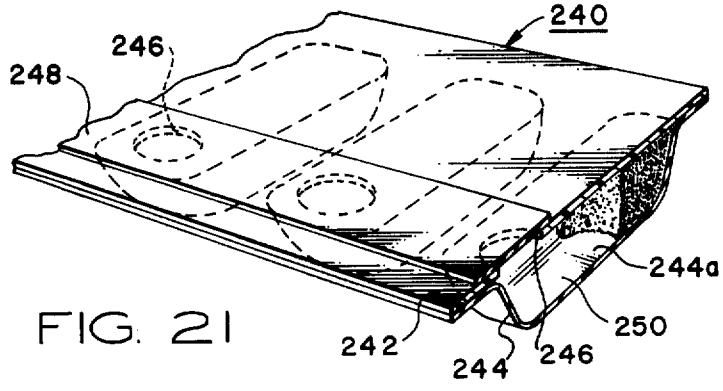


FIG. 21

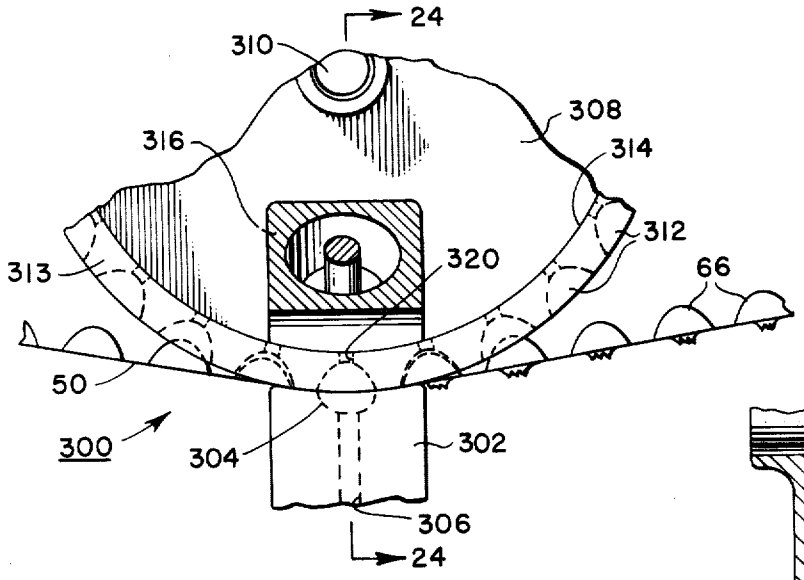


FIG. 23

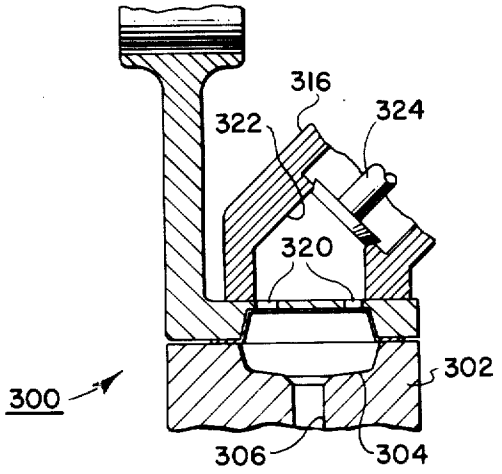


FIG. 24

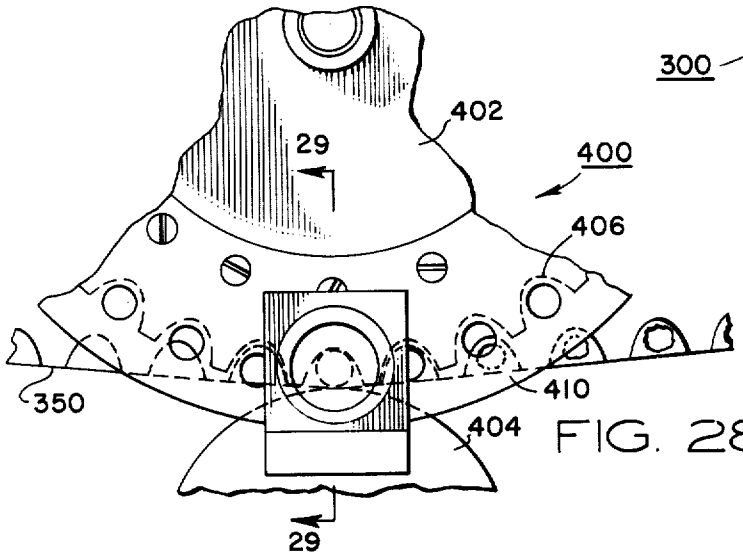


FIG. 28

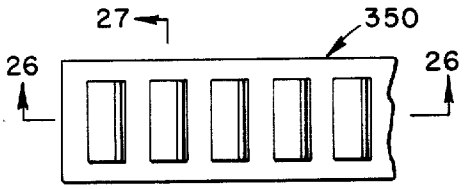


FIG. 25



FIG. 26

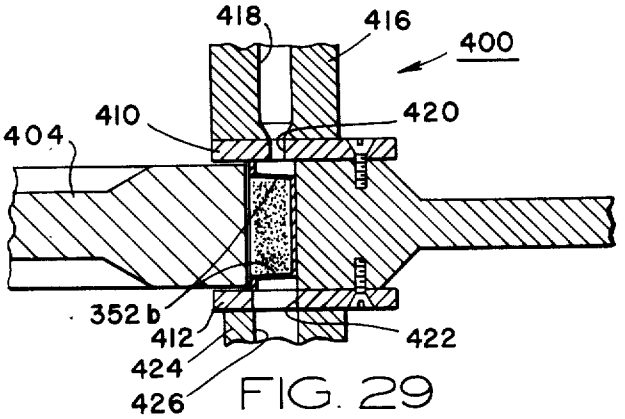


FIG. 29

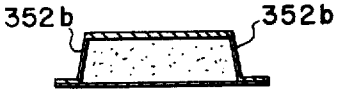


FIG. 27

SYSTEM FOR INJECTING PARTICULATE MATERIAL INTO THE COMBUSTION CHAMBER OF A REPETITIVE COMBUSTION COATING APPARATUS

The present invention relates generally to systems for coating work pieces with particulate material, and more particularly relates to an improved system for commercially distributing the particulate material from the manufacturer, storing the particulate material in a protected environment, handling the particulate material prior to its use in a coating apparatus, and injecting a controlled quantity of the particulate material at a precisely controlled instant and location in the combustion chamber of a repetitive pulse coating apparatus to produce a coating of improved quality.

Co-pending application Ser. No. 198,806,entitled "Method and Apparatus for Applying Particulate Coating Material to a Piece of Work", filed on Nov. 15, 1971 on behalf of Melton, et al., and assigned to the assignee of the present invention, and U.S. Pat. No. 2,972,500, disclose systems for applying particulate coating material, such as tungsden carbide, to a work piece in a series of pulses.

The system disclosed in the former utilizes a combustible fuel-air mixture which is introduced to a combustion chamber having a restricted outlet nozzle at a sufficient rate to increase the pressure substantially above atmospheric pressure. The inlet valve is then closed and the mixture ignited while the pressure is still at a high level. The resulting combustion produces a still higher pressure as a result of confinement by the restricted outlet nozzle, and the hot gases of combustion then exit through the restricted outlet nozzle at a high velocity during a blow-down period. Particulate material is injected into the combustion chamber, preferably near the end of combustion, and before the peak pressure has been materially reduced. As a result, the particulate material is both heated and propelled from the nozzle against the work piece at a high velocity where the particulate material flattens and adheres to the work piece to form the coating.

The system disclosed in U.S. Pat. No. 2,972,550 utilizes somewhat the same technique, except that a detonatable mixture must be used in a long, open-ended tubular combustion chamber designed to sustain a detonation wave. The detonation wave results in a substantially instantaneous pressure rise within the chamber as a result of the very rapid combustion. Again, the hot gases heat the particles, which must be injected just prior to detonation, and the high pressure causes the gases to rush from the open end of the tube thus propelling the particles at high velocity against the work piece.

In each of these systems, the repetitive rate of the combustion pulses is relatively high, on the order of 10 per second, for example. Both the coating efficiency, i.e., the percent of particles which adhere to the work piece, and the quantity of the coat are highly dependent upon injecting the particles into the combustion chamber in uniformly repetitive quantities at precisely the right instant. One of the principal difficulties with each of the previous systems resided in the particle injection systems employed. Each system has utilized a bulk hopper for the particulate material and some type of mechanical-pneumatic dispensing system for measuring and injecting the very small quantity of particulate material required for each "shot". Bulk handling of the particulate material results in undesirable segregation of large particles from small particles. Such systems are also generally unreliable because the particulate material tends to cake and feed unevenly from the bulk hopper. Further, the high speed pneumatic transport of the highly abrasive particulate material results in extremely rapid abrasion of the penumatic valving and conduits which often fail. Further, many particulate materials are subject to oxidation and other adverse effects as a result of being subjected to humidity of the atmosphere, and protection from oxidation is very difficult during bulk handling of these materials at the coating site.

U.S. Pat. No. 3,461,268 discloses a system wherein particulate material is encapsulated in pockets of a tape and positioned at the outlet end of a high voltage spark chamber. The spark in the chamber results in an explosion which propells both the heated particles and the material forming the package against the work piece to form a coating. While such a spark system may be suitable for some types of coating, the entrainment of the material forming the encapsulating tape materially and adversely affects the quality of the type of coatings of interest in the present application.

The present invention is concerned with improved encapsulating tapes, improved particulate powder injection stations adapted to use the improved encapsulating tape, coating systems having an improved control system which is responsive to the position of the encapsulating tape, and methods relating thereto.

The system of the present invention utilizes a method which comprises encapsulating the particulate material in an enclosure having inlet and outlet faces, injecting air pressure through the inlet face into the interior of the capsule to expand the capsule and burst the outlet face, and directing the entrained particulate material into co-mingling relationship with hot gases which heat and accelerate the particulate material against a work piece.

In accordance with another aspect of the invention, the encapsulating tape is formed of two film strips, one of which is configured in such a manner as to facilitate the passage of pneumatic pressure into the interior of the capsule so that the outlet face can be burst by the pneumatic pressure. Preferential pneumatic penetration points, either openings or weakened areas, in the inlet face can be formed on the tape during manufacture or can be initiated mechanically at the stripping station.

In accordance with another aspect of the invention, the stripping station and tape are configured in such a manner as to facilitate selective penetration of the inlet face of the capsule by the air pressure and bursting of a preselected area of the outlet face so as to establish a turbulent flow path within the capsule by the air to encourage complete scavenging of the particulate material from the capsule.

The invention further contemplates a control system wherein the encapsulating tape is pulled past the stripping station with a continuous uniform force. The position of a capsule as it approaches the stripping station is sensed and a combustion cycle initiated in response to the capsule arriving at the predetermined point. The tape is momentarily clamped at the stripping station while the particulate material is pneumatically stripped

from the interior of the capsule and injected into the combustion chamber.

The invention also contemplates a rotary system for stationing the capsules of the encapsulating tape at the stripping station to permit high repetition rates of the combustion cycle, and special tape configuration suitable for use with such systems.

The novel features believed characteristic of this invention are set forth in the appended claims. The invention itself, however, as well as other objects and advantages thereof, may best be understood by reference to the following detailed description of illustrative embodiments, when read in conjunction with the accompanying drawings, wherein:

FIG. **1** is a schematic block diagram of a system for coating a work piece with particulate material which utilizes the present invention;

FIG. **2** is a timing diagram which serves to illustrate the operation of the system of FIG. **1**;

FIG. **3** is a plan view of an encapsulating tape in accordance with the present invention;

FIG. **4** is a sectional view taken substantially along lines **4—4** of FIG. **3**;

FIG. **5** is a sectional view taken substantially along lines **5—5** of FIG. **3**;

FIG. **6** is a perspective view of the encapsulating tape of FIG. **3**;

FIG. **7** is a simplfied sectional view of the tape stripping station of the system of FIG. **1**, with the sectional view taken through the center of the stripping station in a direction extending longitudinally of the encapsulating tape;

FIG. **8** is a sectional view extending through the center of the stripping station, and taken at right angles to the sectional view of FIG. **7**;

FIG. **9** is a sectional view similar to FIG. **8** illustrating the operation of the stripping station;

FIG. **10** is a sectional view similar to FIG. **8** showing another stripping station in accordance with the present invention;

FIG. **11** is a plan view of another encapsulating tape in accordance with the present invention;

FIG. **12** is a sectional view taken substantially on lines **12—12** of FIG. **11**;

FIG. **13** is a sectional view of another stripping station in accordance with the present invention for the encapsulating tape of FIG. **11**;

FIG. **14** is a perspective view of still another encapsulating tape in accordance with the present invention;

FIG. **15** is a perspective view of yet another encapsulating tape in accordance with the present invention;

FIG. **16** is a perspective view showing still another encapsulating tape in accordance with the present invention;

FIG. **17** is a perspective view, partially broken away, illustrating another encapsulating tape in accordance with the present invention;

FIG. **18** is a sectional view similar to FIG. **7** illustrating another stripping station in accordance with the present invention for use with the encapsulating tape of FIG. **17**;

FIG. **19** is a sectional view taken at right angles to the sectional view of FIG. **18** and extending through the center of the stripping station;

FIG. **20** is a view similar to FIG. **19** illustrating the operation of the stripping station of FIG. **18**;

FIG. **21** is a perspective view, partially broken away, of still another encapsulating tape in accordance with the present invention;

FIG. **22** is a sectional view similar to FIG. **8** illustrating a stripping station for use with the encapsulating tape of FIG. **21**;

FIG. **23** is a simplified side view, partially in section of another stripping station in accordance with the present invention;

FIG. **24** is a sectional view taken substantially on lines **24—24** of FIG. **23**;

FIG. **25** is a plan view of another encapsulating tape in accordance with the present invention;

FIG. **26** is a sectional view taken substantially on lines **26—26** of FIG. **25**;

FIG. **27** is a sectional view taken substantially on lines **27—27** of FIG. **25**;

FIG. **28** is a simplified plan view illustrating a stripping station designed to utilize the encapsulating tape of FIG. **25**; and

FIG. **29** is a sectional view taken substantially on lines **29—29** of FIG. **28**.

Referring now to the drawings, a system for coating particulate material on a work piece **10** is indicated generally by the reference numeral **12** in FIG. **1**. The system **12** includes a combustion chamber **14** having a restricted outlet nozzle **16**. A combustible fuel-air mixture is formed by means of a carburator **18** which mixes fuel a source **20** with compressed air from a source **22**. The fuel-air mixture is fed into the combustion chamber through an inlet valve **18** and is ignited by the spark plug **24** of an ignition system **26**.

A particulate material injector system indicated generally by the reference numeral **30** injects measured quantities of particulate material into the combustion chamber **14**. The injector system **30** includes a reel of encapsulating tape **50** which is fed through a capsule sensor **52** past a stripping station **54** and over a tensioning idler roller **56** to a take-up reel **58**. A control circuit **60** responds to a signal from the sensor **52** and initiates the proper sequence of operation for each combustion cycle as will hereafter be described in greater detail.

The encapsulating tape **50** is shown in greater detail in FIGS. **3–6**, and includes a relatively thick plastic film strip **62** and a relatively thin plastic film strip **64**. Each of the film strips may conveniently be polyethylene or a similar plastic material preferably of the type which can be heat welded. The relatively thick film strip **62** is embossed with a series of elongated pockets **66** extending transversely of the tape. Each of the pockets has an arcuate cross-section as illustrated in FIG. **4** with generally flattened ends **66***a* as can best be seen in FIGS. **5–6**. The effect of the arcuate cross-section and flattened ends of the pockets **66** is to provide a structure which is resistant to crushing under a pressure load applied in a direction indicated by the arrows **68** in FIG. **4** when the flat portion of the tape **62** is clamped between inlet and outlet manifolds as will presently be described. A pair of T-cuts **70** in each end of each of the pockets **66** extend completely through the film strip **62** and form a pair of flaps which can open when subjected to the air pressure represented by the arrows **68**, but which are normally resistant to movement in the opposite direction by the curvature of the arcuate portions of the pockets so as to retain the particulate material. The relatively thin film strip **64** is sealed to the relatively thick film strip **62** by a thermal weld extending

around the entire periphery of each of the pockets **66** to form a capsule encapsulating a quantity of particulate material **72.**

It is desirable that the material selected for the thin film strip **64** tear, but not fragment, when subjected to a sudden blast of very high pressure air to prevent pieces of the material from entering the combustion chamber. Polyethylene film on the order of 0.0005 inches thick may be used for this purpose. The thicker film **62** may also be polyethylene on the order of 0.004 inches thick. The total width of the encapsulating tape may be on the order of 0.375 inches and each pocket on the order of 0.280 inches and 0.080 inches wide. Of course, the size and shape of the pockets may vary widely depending upon the amount of particulate material which is to be injected during each combustion cycle as will presently be described.

Referring now to FIG. **7**, the stripping station **54** includes an output manifold **80** and an input manifold **82** which together form a pneumatic stripping chamber **84.** The output manifold **80** has a short passageway **86** leading directly into the combustion chamber as can be seen in FIG. **1.** The input header **82** may be raised to permit the successive capsules of the encapsulating tape **50** to be indexed into position in the stripping chamber, then lowered to clamp the tape around the periphery of the respective capsules as will presently be described. A valve **88** admits high pressure air from the compressed air source **22** to the stripping chamber **84.** The injection port **86** is continually open to the combustion chamber.

The input manifold **82** has a cavity configured to closely receive each of the pockets **66** as illustrated in FIG. **8.** The output header **80** has a cavity configured as illustrated in the sectional views of FIGS. **7** and **8** to permit expansion of the outlet face to provide free particle circulation within the expanded capsule, yet confine the expanding force sufficiently to cause it to rupture over the port **86.** The input manifold **82** has a pair of orifices **90** and **92** disposed over the T-cuts **70** at the ends of the capsules. The output manifold **80** has a pair of opposite shoulders **94** to guide the encapsulating tape **50** as it is moved past the stripping station.

In the operation of the system **12,** the leader from the encapsulating tape **50** is threaded through the sensor **52,** through the stripping station **54** and over the idler roller **56** to the take-up reel **58.** When it is desired to initiate coating, the take-up reel **58** is actuated to begin pulling the tape **50** through the stripping station **54** at a uniform rate. When the sensor **52** detects the presence of a capsule **66,** the sequence of events illustrated in FIG. **2** is initiated. The event **100**a on the top line **100** represents when a capsule **66** is approaching the stripping chamber. The inlet valve **19** begins to open as represented by event **102***a* on the time line **102.** As the valve **19** is closing at event **102***b*, the voltage is applied by the ignition system **26** to the spark plug **24** is represented by event **104***a* on time line **104.** The combination of the valve **19** opening and the spark from the spark plug **24** results in a pressure within the chamber represented by line **106.** The gradually sloping segment **106***a* represents the period while the pressure in the chamber rises due to the fuel-air mixture being input through the valve **19,** the sharp rising segment **106***b* represents the pressure rise due to combustion of the mixture in the chamber, and the declining segment **106***c* represents the period during which the gases of combustion blow out through the nozzle **16.**

At some time before application of the ignition voltage, the inlet manifold **82** is moved downwardly to clamp the encapsulating tape as represented by event **108***a* on time line **108.** As soon as the tape has been clamped, the injection valve **88** is opened as represented by event **110***a* on time line **110.** As a result, the very high pressure air, represented by event **112***a* on time line **112,** jets through the orifices **90** and the pressure and impact deflects the flaps formed by the T-cuts **70,** and the capsule is pressurized. This pressure stretches the thin film **64** downwardly against the lower face of the stripping chamber formed by the outlet manifold **80** and the thin film is stretched until it bursts over the outlet **86.** The turbulent conditions of the air within the capsule very effectively and very instantly purge all of the particulate material from the capsule and pneumatically convey it out through the passageway **86.** The coating period is represented by event **114***a* on time line **114.**

As a result of the resistance of the arcuate pocket **66** to being collapsed by the pressure applied to the top, and because of the preferential entry of the pressure through the T-cuts into the interior of the capsule, the two films cannot be held together by the flow of air to trap particles between the films. The very low volume of the cavity between the valve **88** and the stripping chamber assures a very high response rate to the opening of the valve **88,** so that the particulate material **72** is injected into the combustion chamber in a very short period of time. This assists in insuring that all of the particles are heated to the same extent and are propelled out of the combustion chamber at nearly the same velocity so as to provide a high coating efficiency and a coating of improved quality.

An alternative embodiment of the stripping station is indicated generally by the reference numeral **112** in FIG. **10.** The stripping station **112** may utilize an encapsulating tape **50***a* which may be identical to the encapsulating tape **50,** except that the T-cuts **70** are eliminated. The station **112** may be substantially identical to the station **54** and, accordingly, corresponding components are designated by the same reference numerals followed by the reference character *a*. The only significant difference in the station **100** from that of the station **54** is that a piercing device **114** is provided to mechanically puncture the ends of the capsules of the tape **50***a*, in lieu of the T-cuts. The piercing device **114** has a pair of downturned sharp prongs **114***a* which pierce the capsules **66***a* as the inlet header **82***a* is lowered to clamp the tape prior to opening the valve **88***a*. The archshaped configuration of the capsules and the particulate material provides sufficient resistance to crushing to permit the prongs **114***a* to penetrate the relatively thick film. This structure permits the high pressure air to gain access to the interior of the capsule without crushing the upper film so that the particulate material is scavenged from the interior of the pocket as previously described in connection with FIG. **9.**

Another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral **120** in FIGS. **11** and **12.** The encapsulating tape **120** is formed by a relatively thick film strip **122** which is embossed to provide a series of dome-shaped pockets **122***a* and a relatively thin film **124** which seals a measured quantity of particulate material

126 in each of the dome-shaped pockets. The top of each dome-shaped pocket 122*a* is dimpled to provide a very thin section 122*b* which will yield and be perforated by high pressure applied to the surface of the dome before the dome collapses.

The encapsulating tape 120 may be used in a stripping station, such as station 54, having input and output manifolds 130 and 132, respectively, configured as illustrated in FIG. 13. The manifolds have circular cavities 130*a* and 132*a*, respectively, and inlet and outlet orifices 130*b* and 132*b*, respectively. When high pressure is applied through inlet orifice 130*b*, the high pressure penetrates the thin dimpled section 122*b* so that the pressure enters the interior of the capsule, expanding the lower film 124 downwardly until it bursts over the outlet orifice 132*b*.

Another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral 140 in FIG. 14. The encapsulating tape 140 may be identical to the encapsulating tape 120 except that the top of the dome is provided with a series of line cuts 142 to facilitate entry of the high pressure air into the interior of the capsule before the dome 144 collapses. The pie shaped flaps formed by the line cuts 142 function somewhat as a checkvalve to hold the particulate material inside the dome, yet admit air pressure from outside the dome.

Still another encapsulating tape in accordance with the present invention is indicated generally by the reference number 150 in FIG. 15. Encapsulating tape 150 has a series of T-cuts 152 disposed around the periphery of a generally flat surface 154 of a dome 156 impressed in a relatively thick film strip 158. Particulate material is encapsulated inside the dome 156 by a relatively thin film strip 159. The encapsulating tape 150 may also be used in a stripping station having manifolds similar to that illustrated in FIG. 13.

It will be noted that the T-cuts 152 are arranged so that when subjected to high pressure above the dome, the flaps formed by the T-cuts tends to divert the air tangentially around the interior of the dome, thereby imparting a swirling motion to the air to facilitate complete scavenging of the particulate material from the interior of the dome. Further, the swirling motion of the air imparts a swirling motion to the particles as they pass through the outlet orifice 132*b*. The swirling trajectory of the particles cause the particles to be sprayed outwardly within the combustion chamber to increase retention time in the combustion chamber, and thus heating.

Still another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral 160 in FIG. 16. The encapsulating tape 160 is similar to the encapsulating tape 150, except that V-shaped cuts 162 are made around the periphery of the flat surface 164 rather than the T-shaped cuts 152 of the tape 150. The operation of the pie-shaped flaps formed by the cuts 162 is substantially the same as that of the T-cuts 152.

Another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral 200 in FIG. 17. The encapsulating tape 200 has a relatively thick film strip 202 which is flat, and a relatively thin film strip 204 which is indented to form a series of pockets 204*a* extending transversely of the tape. The two film strips are bonded around the pocket 204*a* to form discrete capsules each containing a particulate coating material. The relatively thick film strip 202 has embossed areas 206 at each end of each of the pockets 204*a* which are substantially thinner than the remainder of the film strip 202. The embossed areas 206 are formed by a hot die applied to the thick film strip 202 before the particulate material 208 is sealed in the capsules so that a thickened ridge 206*a* is formed around the periphery of the areas.

The encapsulating tape 200 may be used in the stripping station indicated generally by the reference numeral 210 in FIG. 18. The stripping station 210 has an inlet manifold 212 and an outlet manifold 214. The inlet manifold 212 may be raised and lowered relative to the output manifold 214, which may be stationary relative to the combustion chamber. The inlet header includes a valve 216, which controls the application of pneumatic pressure to a pair of ports 218 which are best illustrated in FIG. 19. The input manifold 212 may have side rails 220 and 224 to guide the tape 200. The cavity 226 formed in the outlet manifold 214 is sized somewhat larger than the pocket 204*a*.

The operation of the stripping station 210 and the encapsulating tape 200 is illustrated in FIG. 20. The inlet manifold 212 is first lowered against the outlet manifold 214 to clamp the encapsulating tape 200 around the periphery of the capsule formed by pocket 204*a*. Then the valve 216 is opened to admit air through the ports 218. The high pressure, together with the impact of the high velocity air, causes the embossed areas 206 to rupture and admit air into the interior of the capsule. The air expands the relatively thin film forming the pocket 204*a* until the film ruptures over the outlet port 227. The particulate material is then swept out through the port 227 and injected into the combustion chamber as previously described. The indirect route the air must follow from inlet ports 218 to output port 227 causes considerable turbulence and complete scavenging of the particulate material from the interior of the chamber.

Still another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral 240 in FIG. 21. The encapsulating tape 240 includes a relatively thick film strip 242 and a thin strip 244 as heretofore described. The thin film strip 244 is indented to form pockets 244*a* which are elongated and extend transversely of the encapsulating tape as heretofore described in connection with the encapsulating tape 200. The relatively thick film strip 242 has a single aperture 246 cut over one end of each of the pockets 244*a*, and the aperatures 246 are sealed by a second thin film strip 248 bonded to the relatively thick film strip.

The particulate material 250 may be stripped from the encapsulating tape 240 using a stripping station indicated generally by the reference numeral 252 in FIG. 22. The stripping station 252 may be very similar to the stripping station 210 except that a single inlet port 254 is provieed in the inlet manifold 256, and the outlet port 258 of the outlet manifold 260 is located at the opposite end of the stripping chamber. As a result, when high pressure air is applied to the thin film strip 248, the thin film breaks first admitting air into the interior of the capsule. The air pressure then expands the thin film forming pocket 244*a* until it bursts over the outlet port 258. The offset between the inlet and outlet ports results in longitudinal flow through the capsule and high turbulence within the stripping chamber, thus

completely scavenging the particulate material from the capsule.

Another stripping station in accordance with the present invention which may be used to strip particulate material from the encapsulating tape **50** is indicated generally by the reference numeral **300** in FIGS. **23** and **24.** The stripping station **300** includes an output manifold **302** having a cavity **304** which communicates with an outlet port **306** leading to the combustion chamber. A turret **308** is journaled on an axle **310** and has an outer surface which comes in close proximity to the end of the outlet manifold **302.** A plurality of inlet manifold cavities **312** are formed in the outer surface of the rim **313** of the turret **308** and are spaced to receive the successive capsules **66** of the tape **50.** The inside surface **314** of the rim **313** provides a cylindrical sealing surface which mates with an inlet header assembly **316** to provide a sliding seal. Each of the cavities **312** communicate with the sealing surface **314** through a pair of ports **320** which are best seen in FIG. **24.** The header assembly **316** has a port **322** which registers with a pair of ports **320** disposed at the stripping station and communicates through a valve **324** to the high pressure pneumatic source. The entire turret **308** and input header assembly **316** may be moved toward the output mandril **302** to clamp the tape and effect a peripheral seal or the peripheral seal may be provided by the tape being wedged between the outer surface of the rim **313** and the output manifold assembly **302.** In operation, the turret **308** preferably rotates at a constant speed with the combustion cycle initiated at the appropriate time by the control system so that the capsule **66** will be positioned over the stripping cavity **304** at the instant when the powder is to be injected into the combustion chamber. The valve **324** is then merely opened and the high pressure gases pass through the ports **320** and through the capsule as previously described in connection with FIG. **9.**

Another encapsulating tape in accordance with the present invention is indicated generally by the reference numeral **350** in FIG. **25.** The tape **350** is comprised of a pair of film strips **352** and **354** which may be heat welded together. The flat film strip **354** may be of about the same thickness as film strip **354.** The film strip **352** has a series of deep draw pockets **352***a* having a generally rectangular configuration extending transversely of the tape as illustrated in FIG. **25,** and an arcuate cross-section as illustrated in FIG. **26.** The end surfaces **352***b* are disposed at near right angles to the plane of the tape **350** so that the deep draw pockets cause the end surfaces to be relatively thin compared to the portion of the pocket forming the arch. The end surfaces thus become preferential pneumatic fail points when the tape is used in the stripping station indicated generally by the reference numeral **400** in FIGS. **28** and **29.**

In the stripping station **400,** the tape **350** is passed between a rotary turret **402** and a rotary back-up wheel **404.** The rim of the turret **402** is provided with a plurality of cavities **406** sized and spaced to closely receive the capsules **352***a* of the tape **350.** The back-up wheel **404** may be spring biased toward the rim of the turret **402** to clamp the web of the tape **350** and form a peripheral seal around each capsule. A pair of valve plates **410** and **412** are mounted on opposite edges of the rim of the turret **402.** An inlet header **416** has a port **418** which communicates with the high pressure air source. The valve plate **410** has a port **420** associated with each of the cavities **406.** Similarly, the valve plate **412** has an outlet port **422** which communicates with each of the cavities **406.** The outlet manifold **424** has a port **426** which communicates directly with the combustion chamber.

In operation, the turret **402** and the back-up wheel **404** are rotated at a uniform speed. The combustion cycle of the system is initiated at the proper point of travel of the turret **402** so that the port **420** will be aligned with the port **418** at the instant when it is desired to inject the powder into the combustion chamber. Thus, as each successive port **420** registers with the port **418,** high pressure air is valved into the sealed chamber formed by the turret **402** and the back-up wheel **404.** The high pressure on the weakened end faces **352***b* of the capsule burst as a result of the pressure and the powder is blown through the port **426** and injected in the combustion chamber.

From the above detailed description of preferred embodiments of the invention, it will be appreciated by those skilled in the art that a system has been described wherein particulate material can be injected into a high pressure combustion chamber of a combustion-type coating system over a very short interval of time initiated at the precise instant required to optimize coating efficiency. Additionally, the system promotes complete scavenging of the capsule without entraining the material forming the capsule in the pneumatic stream for injection into the combustion chamber, thus assuring that the encapsulating material will not interfere with the quality of the coat being applied to the work piece. Where desired, the particulate material may be encapsulated in a moisture-proof encapsulating tape at the material manufacturing plant to protect the particulate material from moisture and oxidation. The encapsulation also prevents segregation of the different sizes of particulate material, and further insures an even and controlled feed of the particulate material to enhance the control which can be exercised in maintaining a uniform coating thickness.

Although preferred embodiments of the invention have been described in detail, it is to be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A system for injecting predetermined quantities of particulate coating material into a chamber of hot gases which comprises:

an elongated tape forming a plurality of discrete capsules each containing a predetermined quantity of particulate coating material, each capsule having an inlet face and an outlet face,

an inlet manifold and an outlet manifold for sequentially clamping the tape to seal the inlet face from the outlet face,

the outlet manifold having a chamber configured to permit expansion of the outlet face of each capsule and including an outlet port having an area less than the area of the outlet face of the capsule,

the inlet manifold including valve means for applying a pneumatic pulse to the inlet face of the capsule of sufficiently higher pressure to pass through the inlet face and burst the outlet face thereby stripping the particulate material from the tape and pro-

pelling the particulate material out through the outlet port.

2. The system of claim 1 wherein the outlet manifold is configured to restrain deformation of the outlet face of the capsule to limit bursting of the outlet face of the capsule except over the outlet port.

3. The system of claim 1 wherein

each capsule is elongated, and

the inlet manifold has an inlet port offset longitudinally of the elongated capsule from the outlet port of the outlet manifold.

4. The system of claim 1 wherein the inlet manifold includes means for piercing the inlet face of the capsule to permit the pneumatic pulse to enter the capsule.

5. A system for injecting predetermined quantities of particulate coating material into a chamber from an elongated tape forming a plurality of discrete capsules, each encapsulating a predetermined quantity of particulate coating material, each capsule having an inlet face and an outlet face, said system comprising

an inlet manifold and an outlet manifold for sequentially forming a seal between the inlet face from the outlet face of successive capsules,

the outlet manifold having a chamber configured to permit expansion of the outlet face of each capsule and including and outlet port having an area less than the area of the outlet face,

the inlet manifold including valve means for applying a pneumatic pulse to the inlet face of the pocket of sufficient magnitude to pass through the inlet face and burst the outlet face thereby stripping the particulate material from the tape and propelling the particulate material out through the outlet port.

6. The system of claim 5 wherein the outlet manifold is configures to restrain deformation of the outlet face of the capsule to limit bursting of the outlet face of the capsule except over the outlet port.

7. The system of claim 5 wherein

each capsule is elongated, and

the inlet manifold has an inlet port offset longitudinally of the elongated capsule from the outlet port of the outlet manifold.

8. The system of claim 5 wherein the inlet manifold includes means for piercing the inlet face of the capsule to permit the pneumatic pulse to enter the capsule.

9. The system of claim 5 wherein

the inlet and outlet manifolds form an elongated chamber adapted to receive an elongated capsule, and

the inlet manifold has an inlet port offset longitudinally from the outlet port of the outlet manifold.

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