

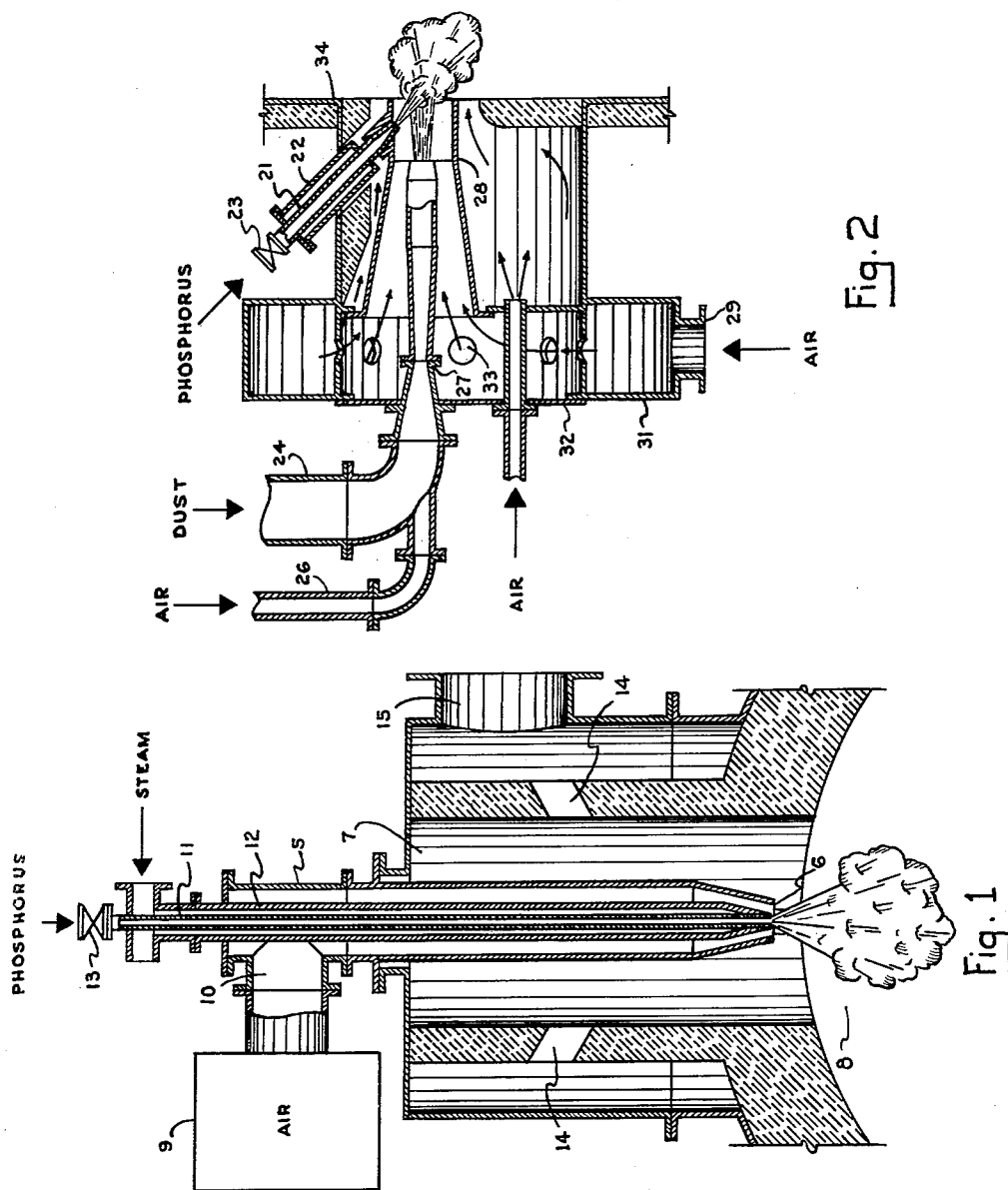
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PHOSPHORUS BURNER ASSEMBLY

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PHOSPHORUS BURNER ASSEMBLY

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1 Claim. (Cl. 23-277)

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The invention herein described may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty therefor.

This invention is an improved phosphorus burner assembly. It is particularly useful in the production of phosphorus pentoxide for the manufacture of phosphoric acid, calcium or potassium metaphosphate, and other products formed by the reaction of phosphorus pentoxide and alkali or metal oxides or salts.

In the manufacture of phosphoric acid, metaphosphates, and similar materials, phosphorus is burned to produce phosphorus pentoxide. Although phosphorus ignites spontaneously upon exposure to air, it is a very difficult material to burn completely to form phosphorus pentoxide containing no appreciable proportions of lower oxides of phosphorus. Burners of very special types are required.

These burners usually are of extremely complicated design and require the use of air under high pressure of approximately 100 pounds per square inch in order to atomize phosphorus. It is customary to introduce molten phosphorus through a central chamber and through a nozzle at the outlet of such burners. Compressed air flows through a concentric outer chamber and passes through ports so that jets of compressed air strike the phosphorus stream at an angle of about 45 degrees and thereby atomize the molten phosphorus. A steam jacket is provided around the phosphorus chamber to heat the phosphorus and maintain its molten state. It has been necessary to have a water jacket to keep the burner assembly cool and prevent damage from the high temperatures inside a phosphorus combustion chamber.

Only a small proportion of the air required for complete combustion of phosphorus has been introduced through the burner. It has been customary to add secondary air through ports in a combustion chamber and to mix atomized phosphorus in the combustion chamber by natural turbulence and the combustion that occurs. The efficiency of phosphorus combustion with such conventional burners depends on the degree of atomization imparted to the phosphorus by the small quantity of atomizing air and the relative position of the burner assembly with respect to secondary air ports and the combustion chamber proper, which govern the subsequent mixing of air and atomized phosphorus by turbulence. These conditions and the capacity limitations inherent in the design of conventional burners contribute to inefficient combustion with the formation of objectionable lower oxides of phosphorus in the phosphoric acid produced.

Some conventional burners, such as that illustrated and described in U.S. Patent 2,355,080, assigned to the assignee of the present invention, depend on back pressure imposed by atomizing air on the phosphorus feed to regulate the burning rate. With phosphorus of variable qualities, properties such as density, tackiness, viscosity, water and dirt content, often change rapidly; and this type of flow control permits variations in phosphorus rates which result in inefficient combustion or loss of heat control.

It is an object of this invention to provide a phosphorus burner assembly which is simple and cheap in construction,

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has greatly increased capacity, and permits more efficient combustion of phosphorus.

Another object is to provide such phosphorus burner assembly which permits efficient burning of phosphorus of variable qualities over a wide range of combustion rates under close control.

Another object is to provide such phosphorus burner assembly which eliminates the presence of lower oxides of phosphorus in the phosphorus pentoxide produced.

Another object is to provide such phosphorus burner assembly wherein phosphorus is burned more rapidly and more completely with a shorter flame.

Another object is to provide such phosphorus burner assembly which will give improved reaction between phosphorus pentoxide and phosphate dust or other solid reactants.

Another object is to provide such phosphorus burner assembly which eliminates the need for careful cleaning of phosphorus before burning.

Another object is to provide such phosphorus burner assembly which gives improved control of phosphorus burning rate.

Still another object is to provide such phosphorus burner assembly in which the requirement for high pressure air is eliminated.

Other objects and advantages of our invention will become apparent as this disclosure proceeds.

We have found that these objects are attained in a phosphorus burner assembly comprising in combination an air duct having an inlet and an outlet, a source of low-pressure air having sufficient capacity to maintain a flow of air through the duct at a velocity in excess of 250 linear feet per second connected to the inlet of the air duct, said air duct being large enough to carry a major proportion of all air required for combustion of phosphorus at said velocity and under low pressure, and means for injecting molten phosphorus into the stream of air flowing through the duct at a point within the duct and adjacent to the outlet thereof.

We have found that when the air stream in such a burner assembly is maintained above the critical velocity of about 250 feet per second the phosphorus is broken up, or atomized, into fine droplets, which are burned immediately since no further mixing of phosphorus and air is necessary. Also, we have found that finely divided solid material such as phosphate rock, metals, or alkali salts can be suspended in the air supplied to the burner, and there will react with the P_2O_5 formed more efficiently than when they are fed to the reaction chamber through separate devices.

In the attached drawing, FIGURE 1 illustrates diagrammatically a burner assembly according to the principles of our invention disposed for the production of phosphorus pentoxide such as is used frequently in the production of phosphoric acid. FIGURE 2 illustrates a phosphorus burner assembly of similar type disposed for simultaneous production of phosphorus pentoxide and reaction of P_2O_5 produced with phosphate dust or other solid reactants.

In FIGURE 1 the reference numeral 5 designates an air duct preferably ending in a tapered nozzle 6. Nozzle 6 may be tapered or not, as desired. Duct 5 is disposed through port 7 in any suitable furnace in such manner as to direct a blast of air into combustion chamber 8. The diameters of duct 5 and nozzle 6 are such that air pressure of approximately 3 pounds per square inch, or in the range from 2 to 5 pounds per square inch, is sufficient to pass at least a major part of the air needed for complete combustion of phosphorus through air duct 5 at a linear velocity exceeding 250 linear feet per second, and preferably in the range from 250 to 500 linear feet per second. There is no operable upper limit on the velocity of such

air other than that imposed by its cost and by undesirable dilution of phosphorus pentoxide formed.

Air duct 5 has an inlet 10 connected by any suitable means to a source of low-pressure air 9 having sufficient capacity to maintain a flow of air through duct 5 at a velocity in excess of 250 linear feet per second. A heated tube 11 is disposed to inject a stream of molten phosphorus into a stream of air flowing in duct 5 at a point within the duct and adjacent to the outlet of nozzle 6. The location of the tip of tube 11 is immaterial within certain limits. It must not be too far back in duct 5 to permit a flame of burning phosphorus to contact nozzle 6, which would become overheated and burn off. The tip of tube 11 should not be farther out than the end of nozzle 6, where great turbulence and decreased velocity occur, but should be within duct 5 where there is little turbulence, and atomization of phosphorus injected is caused by acceleration by air at high velocity and not by turbulence.

We have found that in a burner of this type water jackets or other means for cooling are unnecessary, since the high velocity flow of air within duct 5 performs the cooling function.

Tube 11 is heated preferably by means of steam jacket 12. The rate of flow of phosphorus may be controlled by any suitable means therefor, illustrated as valve 13.

In operation, a flow of air is started through duct 5 at a linear velocity in excess of 250 feet per second, and preferably in the range from about 250 to 500 feet per second. Steam is admitted to steam jacket 12 and, when tube 11 is hot, molten phosphorus is introduced via valve 13. The flow of phosphorus can be controlled accurately by valve 13 and, since tube 11 does not end in a fine orifice, dirty phosphorus feeds almost as well as clean phosphorus. We prefer to introduce all the air required for complete combustion through air duct 5. Air flowing at high velocity in duct 5 atomizes the phosphorus completely as it emerges from tube 11. The phosphorus burns completely to phosphorus pentoxide with a very short flame, thus reducing the size of furnace required or, conversely, greatly increasing the capacity of a furnace of given size. Substantially no lower oxides of phosphorus are formed.

The burner may be operated so that all or only part of the air required for combustion is used for atomizing the phosphorus. For example, a burner with a normal burning rate of 2500 pounds per hour with all the air used as atomizing air may be operated at a rate of 4000 pounds per hour by increasing the rate of flow of phosphorus to the desired extent and supplying additional secondary air for combustion. In this case the air flowing through duct 5 is insufficient for complete combustion of phosphorus, but this may be supplemented by secondary air admitted through a line 15 and secondary ports 14. When secondary air and ports are used, the flame is not as short as that obtained when all air required is admitted through duct 5; but atomization of entering phosphorus is complete when a major portion of the air required for complete combustion of phosphorus flows through duct 5 at proper velocity. The secondary air entering from ports 14 then can be mixed with the atomized phosphorus-air mixture by turbulence in the furnace combustion chamber.

The high velocity air stream flowing through duct 5 violently accelerates and disrupts phosphorus into very small droplets. In this finely atomized condition the phosphorus immediately begins to burn, because the atomizing force also supplies the oxygen necessary for combustion. The size of the atomized droplets of phosphorus varies inversely with air velocity. Therefore, rapid combustion is promoted by high air velocity. We have found that a minimum air velocity in duct 5 in the range from about 250 to 300 linear feet per second results in efficient combustion of phosphorus.

The simplicity of the principle of this high velocity

burner assembly permits wide latitude in the details of design within the limits of practical air velocity and phosphorus-air ratios. The phosphorus may be injected into the high velocity air stream by one or more tubes equivalent to tube 11, which may be centrally located as illustrated in duct 5, or may enter duct 5 from the outside at any angle up to 90 degree. The velocity at which the phosphorus is injected is not critical except when not centrally located, when it must be sufficient to penetrate into the air stream but not great enough to pass through the air stream as a single stream or jet. We have found that 25 to 30 linear feet per second velocity of phosphorus emerging from a line disposed at an angle to the flow of air in duct 5 is sufficient when the air flows at a rate of approximately 300 linear feet per second.

The simplicity of the principle of the high-velocity burner permits its ready adaptation to processes for reacting phosphorus pentoxide with other materials by injecting the desired reactant into the system by means of the high velocity air stream. The burner operation imposes no back pressure on the phosphorus feed line. The phosphorus rate may be controlled independently of air volume, thereby permitting close control of the combustion rates. This also reduces the pressure requirements for the feed system used. Operation of a given high-velocity burner is practical over a very wide range of phosphorus-burning rates without significant sacrifices in combustion efficiency.

FIGURE 2 illustrates an application of our high-velocity burner assembly to the production of calcium metaphosphate or other products from simultaneous combustion of phosphorus and reaction of phosphorus pentoxide formed with other reactants. Therein the reference numeral 21 indicates a phosphorus tube heated by a steam jacket 22. Flow of phosphorus through this tube is controlled by a valve 23. Phosphate rock dust or other reactant desired is fed from a hopper, not shown, through line 24. Compressed air, from a source not shown, enters via line 26 and picks up and fluidizes the solid reactant. This airborne mixture passes through a venturi 27 and is discharged into an air duct 28 at a point upstream of the entrance of phosphorus through line 21.

Low-pressure air, from a source not shown, enters via line 29 into an annular chamber 31 and passes from chamber 31 to chamber 32 via ports 33. Chamber 32 communicates with air duct 28. The source of low-pressure air and ports 33 are of such capacity that air flows through duct 28 at a velocity in excess of 250 linear feet per second into a furnace 34. In this arrangement, phosphorus is injected into the high-velocity mixture of phosphate dust and air. Rapid and complete combustion of phosphorus takes place. In addition, intimate mixing and reaction of the P_2O_5 vapor and phosphate dust is promoted by the high velocity air stream and by contact at the point of maximum temperature.

We have constructed a burner of the type shown in FIGURE 2 and applied it to the manufacture of calcium metaphosphate according to the process shown and described in U.S. Patent 2,589,272. We have found that this burner gives better contact between phosphorus pentoxide and phosphate dust in the combustion chamber, and the improvement in reaction gives a metaphosphate product of improved quality with lower citrate-insoluble P_2O_5 than it was possible to produce in the same furnace with conventional separate burners and dust injector. The improvement in reaction taking place in the combustion chamber with the combination burner-dust injector resulted in a larger proportion of the total reaction taking place with the dust and a smaller proportion in the tower charge. Use of this type burner assembly reduced the activity in the furnace tower and the effects of variations in operating conditions on trouble in the tower. We have found that the burners arranged as described were more suitable for burning phosphorus containing sludge, since troubles due to stopping of air orifices were eliminated.

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Such burners are easier to control, simple to construct, and require less maintenance than conventional burners and, as an additional advantage, do not require high-pressure air for atomization of phosphorus.

We do not mean to limit ourselves to the use of a single burner in connection with one furnace. Multiple burners often may be desirable and more efficient than use of a single burner.

Many minor modifications of the burner shown will readily suggest themselves to the average engineer concerned with the production of phosphorus pentoxide. Our invention contemplates the use of many minor variations and is limited only by the following claim.

We claim as our invention:

A burner structure for efficiently eliminating the presence of lower oxides of phosphorus in the production of phosphorus pentoxide powders produced by mixing a stream of molten phosphorus and a stream of air which comprises a substantially cylindrical inner-body member having a central duct terminating in a first outlet for the passage of a stream of first reactant therethrough, a substantially cylindrical first outer-body member of larger diameter than said inner-body member and disposed about said inner-body member to define a first annular passageway therebetween and terminating in the form of a first inwardly flared passageway coaxial with and extending from the periphery of said first outer-body member inwardly to juxtaposed relationship with the peripheral terminating surface of said inner-body member, said first flared passageway being in the form of the peripheral surface of a frustum of a cone coinciding at its maximum diameter with said first outer-body member and coinciding at its minimum diameter with said inner-body member, whereby said first defined annular passageway contains a fluid heating medium which circulates therethrough and which medium is restrained from contact with materials to be mixed by such burner structure, a substantially cylindrical second outer-body member of larger diameter than said first outer-body member and disposed about said first outer-body member to define a second

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annular passageway therebetween and terminating in a second outlet adjacent to said first outlet for the passage of a stream of second reactant therethrough, said second outlet having the form of a second inwardly flared passageway coaxial with and extending inwardly from the periphery of said second outer-body member, said second flared passageway being in the form of the peripheral surface of a frustum of a cone, the largest diameter of which coincides with said second outer-body member, the smallest diameter of which is substantially equal to the outer diameter of said first outer-body member, said second flared passageway being coaxial with said first outer-body member, and having an apex angle substantially equal to the apex angle of said first inwardly flared passageway, said burner structure in combination with a furnace having a port in a wall thereof, said burner structure disposed through said port, said first and second outlets in said burner assembly disposed within said furnace, and first and second reactant-supply means disposed outside of said furnace, said first reactant-supply means communicating with said central duct, said second reactant-supply means communicating with said second annular passageway, auxiliary air-supply means in combination with said burner structure, said auxiliary air supply means disposed adjacent to and in communication with said port, means independent of said air-supply means for controlling the flow of first reactant through said central duct, and means in combination with said burner structure for introducing an air-borne solid reactant to said auxiliary air-supply means upstream of said first and second reactant outlets.

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